# Section I: Ecological Integrity and Sustainability

*Cloud in San Francisco Box by Micah Kiesow*

# Chapter 1. Ecological Integrity and Sustainability

## Introduction

An ecosystem is a spatially explicit, relatively homogeneous unit of the Earth that includes all inter-acting organisms and elements of the abiotic environment within its boundaries (36 CFR 219.19). Ecosystem or ecological integrity is the quality or condition of an ecosystem, when its dominant ecological characteristics (e.g., composition, structure, function, connectivity, and species composition and diversity) act to maintain that quality or condition and maximize its ability to withstand or recover from perturbations imposed by natural environmental dynamics or human influence. Ecosystem sustainability is the capability of an ecosystem to meet the needs of the present generation, without compromising the ability to meet their needs of future generations. Ecosystem sustainability refers to the capability of ecosystems to maintain ecological integrity (36 CFR 219.19).

## Structure of the Ecological Section

This introductory chapter defines and describes the general concepts and approach to the ecological assessment outlined in the Forest Service directives that accompany the 2012 Planning Rule including: key ecosystem characteristics; reference conditions, departure and trend; risk to ecological integrity and sustainability; system drivers and stressors; and spatial scales of analysis. The Ecological Response Unit (ERU) framework developed and employed by the Forest Service Southwestern Region is also presented. After the introductory chapter, the section proceeds with the assessment of key ecosystem characteristics relative to upland vegetation, baseline carbon stocks, upland soils, air, water, riparian, aquatic and at-risk species (i.e. resource areas). Each resource area chapter describes: ecosystem services; the data and analysis approach, including disclosure of assumptions, limitations and uncertainty; reference and current conditions, and trends related to key ecosystem characteristics; pertinent system drivers and stressors; and evaluation of risk related to each characteristic; and stakeholder input received during the assessment. The structure of each of these chapter varies to accommodate the data and analysis methods and requirements of the 2012 planning rule and directives. Following the resource area chapters is a chapter describing the reference, historic (aka. legacy) and current system drivers and stressors, and their ecological effects and influence on departure, trend and risk associated with key ecosystem characteristics.

## Key Ecosystem Characteristics

Ecological integrity is a relatively simple concept to define, but more difficult in practice to assess. Ecosystem characteristics are specific components of ecological conditions that sustain ecological integrity (FSH 1909.12, Chap. 10). A key ecosystem characteristic describes the composition, structure, connectivity, and/or function of an ecosystem. Key ecosystem characteristics are identified and evaluated for each ecosystem, but not all possible characteristics of ecosystems are identified or evaluated. Only those characteristics needed to provide the conditions necessary to maintain or restore the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the plan area are considered in the assessment (36 CFR 219.8). A limited suite of characteristics are selected to assess ecological integrity based on whether or not the characteristic is relevant and/or needed to assess other characteristics (e.g. at-risk species and habitat), and if information is readily available.

## Reference Conditions, Departure and Trend

Reference conditions are the environmental conditions that infer ecological sustainability. In order to manage the ecosystems of today, it is important to know as much as possible about past ecosystem conditions, especially the conditions that existed before forest structure, composition, function, processes and disturbances were altered by Euro-American settlers (Moore et al. 1999; Friederici 2004). Such conditions were not unchanging, but were sustained across what has been called a “natural range of

variability" (NRV) (Falk 1990; Landres et al. 1999). According to Schussman and Smith (2006a; 2006b), NRV is a description of change over time and space in the ecological condition of an ecosystem type, and the ecological processes that shape those types. Reference conditions generally estimate pre-European settlement conditions (Dillon et al. 2005; Winthers et al. 2005). NRV is the reference condition for many of the ecosystem characteristics analyzed.

NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions. Where the characteristic or the data describing it do not lend themselves to the NRV reference condition, alternative reference conditions are defined based on the current understanding of conditions that would sustain ecological integrity (FSH 1909.12, Chap. 10, Sec. 12.15b). Those reference conditions are described in this section where they are used.

Reference conditions are a tool for assessing ecological integrity and do not necessarily constitute a management target or desired condition. The comparison between reference and current conditions is used to determine the degree of departure and whether the trend is away or toward reference. Trends are a projection of future conditions under current disturbance and management activities. In some cases, the trend may be stable or not discernible given the nature of the data. Where this is the case, assumptions are made and discussed.

Departure measures the degree to which the current condition of a key ecosystem characteristic is unlike the reference condition. When departure can be quantified, it is rated in this assessment on a scale from 0 to 100 percent, where 0 to 33 percent is considered "low", and within NRV. The "moderate" (34 to 66%) and "high" (67 to 100%) classes are outside of NRV, are uncharacteristic for the system and considered significant in terms of risk.

## System Drivers and Stressors

System drivers are factors or processes that act on ecosystem characteristics and contribute to the natural range of variability in conditions. Examples include natural vegetation succession, predominant climatic regime, and broad-scale disturbance regimes such as wildfire, flooding and insects and disease. Stressors are natural or human caused alterations in system drivers that may directly or indirectly threaten ecological integrity and sustainability. Examples include invasive species, altered fire regimes, and climate change.

Management actions may act as system drivers or stressors depending on the duration, intensity and magnitude of those actions. These may include timber harvest, prescribed burning, permitted grazing, water developments, seeding, and road construction among others including legacy management that is no longer currently practiced. Examining system drivers and stressors across the reference and current time periods provides the "why" to the departure and trend analysis and informs the preliminary ecological need for change.

The System Drivers and Stressors Chapter is dedicated to that discussion and is referred to throughout this section. Drivers and stressors that may exist but are not included in that chapter are identified and discussed relative to the specific characteristic(s) to which they apply.

## Assessing Risk to Ecological Integrity and Sustainability

Risk is defined by the likelihood and severity of a negative ecological outcome. Ecological risk is the product of departure, trends and stressors (threats). The purpose of this assessment is to document whether or not the ecological resource characteristics analyzed are at ecological risk or not, and explore contributing factors. Risk is assessed on NFS lands, as it relates to systems and processes that are under agency control

and/or authority. However, to understand risk to those lands, systems, and processes, they are assessed in the context of the larger landscape to the extent possible.

Risk is assessed for each ecosystem characteristic by weighing current departure from reference conditions against trend for that resource using a decision matrix. The matrix used to determine risk varies by characteristic, available data and the method of analysis. Table 1 provides an example of a decision matrix.

**Table 1. Example of a decision matrix to assess Ecological Response Unit (ERU) risk**

| Current ERU Departure from Reference Condition | ERU Trend after 100 Years (departure from Reference Condition) | | |
|---|---|---|---|
| | toward Reference Condition (> 5% change) | static, neither toward nor away (± 5% change) | away from Reference Condition (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management | potential risk due to legacy of past management or deviation due to ongoing activities | potential for high risk |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk |

Individual ecosystem characteristic risk assessments are conducted at multiple spatial scales. Where there is risk, there is an ecological need for change. Risk can be mitigated if the characteristic is within agency authority and control, and the trend and condition can be improved or reversed.

## Spatial Scales of Analysis

Spatial scales to be considered in the analysis by topic should: 1) be sufficiently large to adequately address the interrelationships between conditions in the Gila NF and the broader landscape, but not so large that these interrelationships lose relevance in guiding land management planning; and 2) consider the extent to which ecological attributes of the broader landscape support, or are supported by, conditions in the Gila NF. The area of analysis for the assessment should also be large enough to capture: 1) characteristics (composition, structure, function, and connectivity) and geographic scale of relevant ecosystems; 2) fire and other forms or patterns of disturbance; 3) landform patterns or landtype associations; and 4) plant, animal, species, or community distribution and abundance (FSH 1909.12, Chap. 10). In addition, the area of analysis should also be large enough to capture broad-scale trends and encompass the natural range of variation in disturbance intensity, frequency, and areal extent. For most characteristics, it is possible and valuable to consider multiple scales for the assessment.

This assessment utilizes three spatial scales: context, plan and local. Context scale is needed to put the Forest's conditions in perspective with the surrounding landscape, including lands beyond the Forest boundary, and is necessary for determining the opportunities or limitation of the Gila NF to contribute to the sustainability of broader ecological systems. In some instances, a unique role or "spatial niche" of the Gila NF may become apparent at this scale. Context scale analysis can also identify impacts of the broader landscape on the sustainability of resources within the plan area (FSH 1909.12, Chap. 10).

Plan scale displays current conditions and trends as an average of conditions across the Gila NF. This scale drives the ecological need for change. Local scale subdivides the plan scale to identify any patterns that could inform priority setting. The local scale may drive Forest Plan components, but is not as likely to drive ecological need for change.

The majority of the ecological assessment uses the ecoregion sections and subsections of the National Hierarchical Framework of Ecological Units (ECOMAP, 1993; Cleland et al., 1997)[4] for the context scale, the Gila NF for the plan scale and local units within the Forest delineated based on a rule set guiding the aggregation of watersheds. This rule set is included as Appendix A.

Water and air resource data and analysis do not lend themselves well to the ECOMAP delineations and instead, use watersheds and airsheds. The water analysis uses subbasins (4th level watersheds) for context scale analysis and watersheds and subwatersheds (5th and 6th level watersheds) for plan scale analysis. The local scale analysis uses the same units described above. The air analysis identifies a single relevant airshed. These spatial scales are described in more detail in those chapters.

## Ecological Response Unit Framework

The assessment of terrestrial and riparian ecosystems and at-risk species, including key habitat, vegetation and soil characteristics, is stratified using the Ecological Response Unit (ERU) classification system. This system was developed and is employed by the USFS Southwestern Region (R3) to facilitate landscape scale analysis and planning. The ERU framework represents all major ecological types of R3 and represent a stratification of biophysical themes, similar to LANDFIRE biophysical settings. ERUs are map unit constructs that combine themes of site potential, historic disturbance regimes, and natural succession (USDA FS 2015a). Site potential is a term used to describe the characteristic ecological conditions at the latest successional state, resulting from interactions among climate, soil, and vegetation.

While the ERU map is ultimately a remote sensing product, on Forest Service lands the Terrestrial Ecological Unit Inventory (TEUI), formerly known as the Terrestrial Ecosystem Survey (TES) is the foundational dataset for ERU mapping. This includes data from the Gila NF's draft TEUI. The TEUI maps relationships between climate, soil and vegetation and is described in more detail in the Soil Chapter. Data from the Southwest Biotic Communities, Integrated Landscape Assessment Project (ILAP), Regional Riparian Mapping Project (RMAP), climate gradient analysis and neighbor analysis corrections, as well as collaboration with the Universities of Arizona and New Mexico were also important in developing the ERU map (USDA FS 2015a).

[4] Ecoregions are ecosystems of regional extent. Using the National Hierarchical Framework of Ecological Units (ECOMAP, 1993; Cleland et al., 1997) an analysis of the landscapes surrounding the Gila NF was completed using the ecological section and subsection units. This broad-scale analysis was done to set the context for the contributions the Gila NF makes to ecological sustainability. As described by Bailey (1980, 1983, 1985, 1998), ecoregions distinguish areas that share common climatic and vegetation characteristics (Cleland et al., 1997). Ecoregions are subdivided into provinces, which are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soils. Sections are a subdivision of provinces, described by broad areas of similar subregional climate, geomorphic process, geology, geologic origin, topography, and drainage networks. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings such as those mapped by Küchler (1964). Ecological subsections are a further division of sections, and described by areas with similar surface geology, geomorphic process, soil groups, subregional climate, and potential natural vegetation communities (McNab and Avers, 1994). Because subsections are smaller in size they are more useful in planning at a smaller scale.

Each ERU concept is supported by the best available science describing its distribution, dominant plant species, natural disturbances, seral state proportions, coarse woody debris and snags per acres, fire regime, and patch size under reference conditions (USDA FS 2015a). The Gila NF contains 14 upland ERUs that make up approximately 98 percent of the Forest and 12 riparian ERUs that make approximately two percent of the Forest. These ERUs and the percentage of the Forest they represent are displayed in the following table.

**Table 2. Ecological Response Units of the Gila National Forest**

| Ecological Response Unit | Percentage of Gila NF |
|---|---|
| *Forests* | |
| Ponderosa Pine Forest (PPF) | 19 |
| Mixed Conifer-Frequent Fire Forest (MCD) | 12 |
| Ponderosa Pine-Evergreen Oak Forest (PPE) | 12 |
| Mixed Conifer w/ Aspen Forest (MCW) | 2 |
| Spruce-Fir Forest (SFF) | 1 |
| *Woodlands* | |
| Piñon-Juniper Woodland (PJO) | 26 |
| Piñon-Juniper Grass Woodland (PJG) | 9 |
| Juniper-Grass Woodland (JUG) | 4 |
| Madrean Piñon-Oak Woodland (MPO) | 1 |
| Piñon-Juniper/Evergreen Shrub Woodland (PJC) | 1 |
| *Shrublands* | |
| Mountain Mahogany Mixed Shrubland | 5 |
| *Grasslands* | |
| Montane/Subalpine Grasslands (MSG) | 4 |
| Colorado Plateau/Great Basin Grasslands (CPGB) | 3 |
| Semi-desert Grassland (SDG) | 2 |
| *Riparian* | |
| Fremont Cottonwood/Oak (FCO) | 0.003 |
| Fremont Cottonwood/Shrub (FCS) | 0.06 |
| Narrowleaf Cottonwood/Shrub (NCS) | 0.7 |
| Sycamore-Fremont Cottonwood (SFC) | 0.2 |
| Desert Willow (DW) | 0.3 |
| Arizona Alder-Willow (AAW) | 0.1 |
| Upper Montane/Conifer-Willow (UMCW) | 0.02 |
| Willow-Thinleaf Alder (WTA) | 0.03 |
| Ponderosa Pine/Willow (PPW) | 0.03 |
| Herbaceous/Wetland Riparian (HWR) | 0.001 |
| Arizona Walnut (AW) | 0.0004 |

# Chapter 2. Upland Vegetation

## Introduction

Terrestrial ecosystems are assessed using key ecosystem characteristics related to upland vegetation. To evaluate ecological integrity, vegetation on the Forest was subdivided into smaller ecosystem types based on ecosystem potential and typical disturbances. These smaller subdivisions are ecological response units (ERUs). Ecological response units will be defined more completely and discussed below.

The vegetation ecological assessment includes characterizations of current condition and trend for specific ecosystem characteristics. For each characteristic, where available, the following information is evaluated:

- Reference condition (Environmental conditions prior to Euro-American settlement and under the current climatic period)
- Deviation of current condition from reference condition (departure)
- Predicted future departure (trend)

This chapter assesses current and expected future departure (the degree to which the integrity of a system has been compromised) by comparing the results of current Gila NF management to a defined reference conditions for each ecosystem type. Departed current condition, or a trend toward higher departure suggests that ecological integrity and associated ecosystem services are at risk. Current conditions and reference conditions rely on regional summaries of best available scientific information (BASI), other scientific information that is more specific and appropriate for the forest; Gila NF developed and maintained databases; Forest specialist knowledge; and additional information provided through stakeholder engagement.

## Ecosystem Services of Upland Vegetation

Other than eastern Arizona, the Gila NF is more mountainous with higher average elevations than the surrounding landscape. There are broad uninterrupted expanses of native forests, woodlands, shrublands, and grasslands that provide habitat for wildlife, solitude for hikers, and fuel for woodstoves. Snow in the winter and rain during the summer monsoons fall on the high peaks and feed the major rivers that flow to nearby towns, through New Mexico, into Arizona, and beyond. From the top of Whitewater Baldy to the edge of the Plains of San Agustin, visitors, local residents, and the many people who live downstream, downhill, and downwind all obtain benefits from intact and functional ecosystems on the Gila NF (ecosystem services). Ecosystem services that vegetation and soils provide benefit people by supporting other ecosystem services, including (Chapin 2009; FSH 1909.12):

- **Supporting** services are the fundamental ecological processes that control the structure and functioning of ecosystems; i.e., pollination, seed dispersal, soil formation, and nutrient cycling. .
- **Regulating** services influence processes beyond boarders of ecosystems where they originate; i.e., long-term storage of carbon; climate regulation; water filtration, purification, and storage; soil stabilization; flood and drought control; and disease regulation.
- **Provisioning** services are the goods produced by ecosystems that are consumed by society; i.e., clean air and fresh water, energy, food, fuel, forage, wood products or fiber, and minerals.

- **Cultural** services, which are nonmaterial benefits that are important to society's well-being; i.e., educational, aesthetic, spiritual, and cultural heritage values, recreational experiences, and tourism opportunities.[5]

## Ecological Response Units and Terrestrial Ecosystem Units

The assessment of terrestrial ecosystem condition is stratified using the ERU classification system, which is a grouping of sites that are each similar in plant species composition, succession patterns, and disturbance regimes (USDA FS 2015a). According to the Forest Service (USDA FS 2015a), the ERU system is a stratification of units that are similar in plant indicator species, successional patterns, and disturbance regimes that in concept and resolution are most useful to management. Because ERUs provide the foundational unit for the analysis of vegetative attributes and associated ecosystem services at the landscape and strategic planning scale (USDA FS 2015a), the USFS has employed the ERU concept in the Southwestern Region.

The ERU framework describes all major ecosystem types found in the region based on a coarse stratification of biophysical themes. The ERUs are map unit constructs, technical groupings of finer vegetation classes, with similar site potential and disturbance history. In other words, it is the range of plant associations (USDA FS 1997), along with structure and process characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006b). Similar to LANDFIRE biophysical settings (NIFTT 2010), ERUs combine themes of site potential (plant communities that may become established on an ecological site, they also reflect the current climate and physical environment, as well as the competitive potential of native plant species.) and historic fire regime:

*Ecological Response Unit = Site Potential + Historic Disturbance Regime*

Each ERU characterizes sites with similar composition, structure, function, and connectivity, and defines their spatial distribution on the landscape.

Stratifying terrestrial ecosystems based on vegetation characteristics and function is appropriate for two reasons. First, vegetation is the primary terrestrial and biological ecosystem component that is manipulated through management and affected by natural processes. Second, it represents habitat for wildlife and provides the required link to species diversity. The chapter on “At-Risk Species” is based on these ERUs, ecosystem characteristics, and ecological integrity.

Upland ERUs on the Gila NF are derived from the Terrestrial Ecosystems Survey (TES) of the Gila NF (GNF Draft, 2015), an inventory of soil types or terrestrial ecosystem units (TEUs). The TEUs maps the relationships between climate, soil and vegetation communities (USDA FS 1986a). They are summarized by ERU for some key ecosystem characteristics, particularly those that are soil related. Boundaries are coincident between upland ERUs and TEUs, such that any TEU fits into only one ERU. The ERUs for other non-NFS lands in Arizona and New Mexico are mapped by the Integrated Lands Assessment Project (ILAP). LANDFIRE Biophysical Model Settings (LANDFIRE, various dates), along with reference conditions developed by the Nature Conservancy (Schussman and Gori 2006) are cross-walked to the ERUs. This cross-walking is done to derive reference conditions which are needed to calculate departure (USDA FS 2015a). No other data provides analogous TEU soil information for lands outside the Gila NF.

[5] Many of these ecosystem services are identified by the Millennium Ecosystem Assessment (MEA, 2005a; 2005b), others were discussed during public engagement meetings.

The Gila NF contains 14 upland ERUs[6] that make-up approximately 98 percent of the Forest. They are:

- Forests
  - Ponderosa Pine Forest (PPF)
  - Mixed Conifer-Frequent Fire Forest (MCD)
  - Ponderosa Pine-Evergreen Oak Forest (PPE)
  - Mixed Conifer w/ Aspen Forest (MCW)
  - Spruce-Fir Forest (SFF)
- Woodlands
  - Piñon-Juniper Woodland (PJO)
  - Piñon-Juniper Grass Woodland (PJG)
  - Juniper Grass Woodland (JUG)
  - Madrean Piñon-Oak Woodland (MPO)
  - Piñon-Juniper Evergreen Shrub Woodland (PJC)
- Shrublands
  - Mountain Mahogany Mixed Shrubland (MMS)
- Grasslands
  - Montane/Subalpine Grasslands (MSG)
  - Colorado Plateau/Great Basin Grasslands (CPGB)
  - Semi-desert Grassland (SDG)

## Key Ecosystem Characteristics for Upland Vegetation

Ecosystem characteristics are specific components of ecological conditions that sustain ecological integrity. A key ecosystem characteristic describes the composition, structure, and/or function of an ecosystem that is most dominant. Key ecosystem characteristics are identified and evaluated for each ecosystem, but not all possible characteristics of ecosystems are identified. Only those characteristics needed to provide ecological conditions necessary to maintain or restore the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the plan area are considered in the assessment (36 CFR 219.8). Ecosystem characteristics were selected based on whether information was readily available, relevant to key issues and sensitive to drivers and stressors, and represent elements needed to assess other resource areas (e.g., at-risk species and habitat).

The key ecosystem characteristics for upland vegetation (ERUs) are:

- Seral state proportion/Vegetation structure
- Vegetation ecological status (addressed in Soil Chapter)
- Coarse woody debris

[6] A Gambel Oak Shrubland ERU was not considered in this analysis because it does not actually occur on the Gila NF. The total acres (51,106) of this ERU represented less than two percent of the Forest. The TEUI data supporting this ERU is from within the 1950s McKnight Fire. The TEUI data describes these acres as a fire disclimax with Gambel oak (*Quercus gambelii* Nutt.)-New Mexico locust (*Robinia neomexicana* A. Gray) or quaking aspen (*Populus tremuloides* Michx.)-New Mexico locust vegetation types, depending on aspect. A fire disclimax is a stable, post-fire vegetation community that is different from the stable, pre-fire vegetation community. Prior to the 2013 Silver Fire, conifer seedlings and saplings were observed, indicating these acres more likely represented a relatively early successional stage in the Mixed Conifer with Frequent Fire and Mixed Conifer with Aspen ERUs, rather than a fire disclimax. Fifty-seven percent of this ERU's acres (29,131) were allocated to the MCD ERU and 43 percent (21,976 ac.) were allocated to MCW ERU based on Midscale data dominant tree types, elevation and aspect.

- Snag density
- Patch size
- Fire regime (fire frequency and fire severity)
- Fire regime condition class
- Insects and disease

Not all key ecosystem characteristics apply to all ERUs. Coarse woody debris and snag density are not relevant or applicable to grassland and shrubland systems.

**Seral state proportion/Vegetation structure** is the percent of ERU in each seral state and is assessed at context, plan, and local scales. Each ERU can manifest in a range of potential overstory vegetative conditions, each representing a unique phase in the overall ecology of the system (Weisz et al. 2009). By grouping these phases into seral state classes with unique vegetation characteristics (overstory composition, structure and cover), models can be developed that define transitions among phases. These "state-and-transition" models can be built and adapted so that the dynamics of the system reflect NRV, and the resulting distribution among state classes represents the ERU reference condition (Weisz et al. 2009)[7]. Reference conditions are based on a review of the relevant best available science by the USFS Southwestern Regional Office (USDA FS 2015a), with input from Gila NF specialists. ERU summary tables are footnoted with specific reference condition sources, where applicable. See Table 3 for an example of how vegetation seral states, successional structure, respective compositions and cover, and departure indices from reference conditions (RC) on the Gila NF and within the greater context area (CA) will be displayed for this assessment.

Departure from the reference distribution is quantified by comparing it to the actual current distribution and to future predicted distributions. The closer composition, structure, cover and process are to their historic conditions, the more the system is maintaining ecological integrity, and the more resilient it will be to stress. For each state class, the similarity to reference is equal to the proportion in common that exists either on the current landscape or on the projected future landscape. The similarity value is equal to the lesser value between the current or projected proportion and the reference proportion. The sum of similarity values for an ERU is 100 percent or less, and 100 percent minus the similarity value equals the departure of the ERU (Table 3 has an example calculation). Departure from reference condition is broken into thirds for descriptive purposes (0 to 33% = low departure, 34 to 66% = moderate departure, 67 to 100% = high departure), but is best viewed as varying continuously from low to high. However, all ratings above 33 percent are considered significantly departed.

[7] Also see example in Ryan et al. (2006) and Smith (2006a; 2006b).

**Table 3. Sample vegetation seral states, successional structure and respective composition, cover, and departure index (DIR) from reference condition (RC) for the mountain mahogany mixed shrubland (MMS) ERU on the Gila NF and within the greater context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current | | Gila NF | CA |
| | | | Gila NF | CA | | |
| A | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover | 5 | 2 | 9 | 2 | 5 |
| B, C | Mid- and Late-seral: All size shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 65 | 46 | 23 | 46 | 23 |
| D | Late-seral: All size trees with open or closed woody canopy cover | 30 | 52 | 68 | 30 | 30 |
| Total | | 100 | 100 | 100 | 78 | 58 |

Departure Index Rating† from RC = 100 - ∑ similarity values: Gila NF = (100 – 78) = 22 or LOW; and CA = (100 – 58) = 42 or MODERATE

‡ USDA FS 2015a; and LANDFIRE 2007a

† Similarity value is the lesser of the two proportions (current Gila NF to RC and CA to RC) for a seral state

† Departure index ratings (DIR) from RC are; 0 to 33% = low, 34 to 66% = moderate, and 67 to 100% = high

The assignment of current state class proportions uses regional satellite imagery based classifications of vegetation size class, canopy cover, dominance type, and storiedness (number of tree canopy levels) at a 1:100,000 scale, with extensive photo interpretation and field data collection (Midscale Vegetation Mapping Project (Mellin et al. 2004)). Existing vegetation is assigned to an ERU and then to the appropriate state class within that ERU according to state class descriptions that were developed by the Southwestern Regional Office (USDA FS 2015a).

Projections of future state class proportions are produced using the Vegetation Dynamics Development Tool (VDDT) (ESSA 2006, 2007) and models developed by LANDFIRE (various dates), the Nature Conservancy (Schussman and Gori 2006), and the Integrated Landscape Assessment Project (ILAP) (Hemstrom et al. 2012) and refined by the Southwestern Regional Office, with input from Forest specialists. These VDDT state and transition models both define seral states for each ERU and allow comparison among management scenarios. Model results are not precise predictions, but indicate relative trends and are sensitive to changes in management or disturbance. For this analysis, future trend assumes the continuation of current levels of management indefinitely. Most state transition destinations and probabilities are derived from Forest Vegetation Simulator (FVS) modeling (Dixon 2002). Burn severity information is compiled from Monitoring Trends in Burn Severity (MTBS 2014) records (Eidenshink et al. 2007; Bhattarai et al. 2012; WFLC 2014), and Rapid Assessment of Vegetation Condition after Wildfire (RAVG) data (USDA FS 2015b). Other inputs came directly from Forest management actions, insect and disease surveys, and wildfire data from the past 18 years (1996-2014).

By comparing regional Midscale and ILAP current vegetation information to reference seral state proportions, departure is calculated for the context scale, plan scale, and local scale. The Gila NF only affects management at the plan scale and only collects management information on the Forest; so VDDT models can only be reliably parameterized at the plan scale. Therefore, future trend is modeled only at the plan scale, though trends at the context scale or local scale may be discussed where information suggests they differ. The trend analysis relies mostly on VDDT modeling results, while trend for other characteristics is addressed only when a probable trajectory can be inferred. Seral state proportion trend is presented in the summary graphs and tables for each ERU.

**Coarse woody debris** is defined as tons per acre of dead material greater than three inches in diameter at the plan scale. Coarse woody debris (downed woody material) serves as an important ecological function. It provides wildlife habitat and contributes to the formation of soil organic matter. Coarse woody debris also helps to reduce soil erosion by shielding the soil surface from raindrop impact and interrupting rill and sheet erosion. Current conditions are based on stand exam survey information collected by the Gila NF at the plan scale only. No analogous information is available at the context scale, and plan scale data are not necessarily numerous or well distributed enough to allow local scale analysis.

**Snag density** is defined as the number of stems per acre by diameter classes (i.e., > 8”, > 18”) by ERU at the plan scale. Like coarse woody debris, snags (standing dead trees) serve an important ecological function. Large standing snags provide key habitat for many species, such as woodpeckers that feed on insects dwelling in decomposing wood. Current conditions are based on stand exam survey information collected by the Gila NF at the plan scale only. No analogous information is available at the context scale, and plan scale data are not necessarily numerous or well distributed enough to allow local scale analysis.

Ecologically, a dead tree is as important to the forest ecosystem as a live one (Franklin et al. 1989), and according to Marcot (2002), provide several key ecological functions that influence the ecosystem through trophic relations, species interactions, soil aeration, primary cavity and burrow excavation, and dispersal of fungi, lichens, seeds, fruits, plants, and invertebrates. The importance of coarse woody debris in forests has been partially documented, although much remains to be discovered (Stevens 1997). What is known of these roles is divided into four, inter-related categories: 1) the role in productivity of forest trees; 2) the role in providing habitat and structure to maintain biological diversity; 3) the role in geomorphology of streams and slopes; and 4) the role in long-term carbon storage. The importance of each of these roles to an ecosystem varies throughout the forests by natural disturbance type, biogeoclimatic zone and moisture regime (Stevens 1997).

When snag or live trees fall and become coarse woody debris, they provide habitat for small animals and insects. When these logs rot they store water and provide nutrients for the continued growth of the forest. Dead wood rotting on the forest floor eventually gets incorporated into the soil. This underground wood feeds many insects and bacteria which provide nitrogen (N) to feed the trees and other plants in the forest. Underground wood is the major source of N for dry forests. Coarse woody debris and snags provide important habitat, and can slow surface runoff. Scarce coarse woody debris and snags can indicate a lack of appropriate habitat and inadequate nutrient cycling. An overabundance may indicate underlying stress on an ecosystem, such as drought or insect outbreaks, and potentially increases wildfire severity. Coarse woody debris is higher than reference in all ERUs, where data is available (Table 82). Increased disturbance frequency, such as the several large fires the Gila NF has experienced in recent years could provide a partial explanation for this.

**Patch size** is the average patch size in acres for similar structure types by ERU at the plan scale. A “patch” is a contiguous area of the same system type in the same structural state. Patch size plays a significant role in wildfire behavior. Patch size (and associated heterogeneity) influences wildfire behavior, insect and disease spread and persistence, and wildlife habitat. Larger, more homogeneous patches mean there is less diversity (Turner et al. 2011) in a system than there was historically. Homogeneity is driven by lack of fire disturbance, selective ungulate grazing/browsing, post-harvest single-age regeneration, and woody species expansion. This may mean disturbances can spread more continuously, species composition is more uniform, and there is less edge habitat. In general, the reduction in variety as patch size increases within the forest and woodland ERUs, lowers the adaptive capacity and sustainability of these ecosystems. Historic timber harvest and fire suppression are largely responsible for decreased fire frequency, increased fire severity, and an increase in closed canopies across Rocky Mountain forests (Schoennagel et al. 2004). These changes, where combined with uncharacteristically large patches of contiguous tree canopies, set

the stage for uncharacteristically large, severe wildfires. Patch size is also an important element of wildlife habitat. Each wildlife species has its own patch size preference, and these preferences vary by species. For these reasons, and also for reasons of wildfire behavior, current landscape distribution of patches should resemble the distribution under reference conditions—the conditions to which wildlife species adapted—so as to best accommodate the varying preferences of all wildlife species and simultaneously mimic historic fire behavior. Patch size is calculated based on the average of all patches of an ERU that intersect the plan area. For some ERUs, this means the analysis area may extend significantly into the context landscape. The same analysis at the context scale would similarly extend outside the context scale (where information was not collected as part of this assessment). Departure was calculated by comparing current patch size to the reference range of patch sizes as described in Table 4.

**Table 4. Definition of patch size departure based on current patch size in relation to a reference range of patch sizes.**

| Current Patch Size Range | Reference Patch Size Range | | |
|---|---|---|---|
| | smaller than reference patch size | within reference patch size | larger than reference patch size |
| Departure | $= 1 - \left(\frac{\textit{current patch size}}{\textit{low end of reference range}}\right)$ | 0 | $= 1 - \left(\frac{\textit{high end of reference range}}{\textit{current patch size}}\right)$ |

**Fire regime** combines fire frequency[8] and fire severity, the percent of burns that are non-lethal, mixed severity, and stand replacement Fire frequency is assessed at the context, plan, and local scales. Fire severity is only assessed at the context and plan scales, since burn severity data is limited or unavailable in some local scales on the Gila NF. Fire is an integral component in the function and biodiversity of many natural habitats and organisms, and these communities have adapted to withstand and even to exploit natural wildfire. More generally, fire is regarded as a "natural disturbance", similar to flooding, wind-storms, and landslides, that has driven the evolution of species and controls the characteristics of ecosystems. Each ERU has a characteristic fire regime that is integral to its ecological integrity. If fires are too frequent, plants may be killed before they have matured, or before they have set sufficient seed to ensure population recovery. If fires are too infrequent, plants may mature, senesce, and die, without ever releasing their seeds; or species composition may shift to favor uncharacteristic combinations; or live and dead biomass may simply accumulate to uncharacteristic levels.

Fire severity information was obtained from monitoring trends in burn severity (MTBS) data (all available records collected for Arizona and New Mexico going back to 1984), supplemented by Burned Area Emergency Response (BAER) data, where MTBS was missing or incomplete. Burn severity was summarized by ERU, at the context and plan scales.

Fire frequency at the plan scale is based on Gila NF wildfire history data from the 30 year period between 1984 and 2013. Point data was buffered by acreage and replaced by polygons of known perimeters where available[9]. Fire rotation (FR-average area burned per year) was calculated for each ERU and the total ERU acreage was divided by that average. Fire rotation at the context scale is based on nationally compiled

[8] Reference fire frequency is measured in mean fire return interval (MFRI), or the average number of years between two successive fire events in a given area. Current fire frequency is measured slightly differently, using fire rotation (FR). Fire rotation is the number of years it would take for an area equal to the entire ERU to burn. Both a shorter MFRI or FR indicate more frequent fire in the system; however, they are calculated from different measurements and are not equivalent, but can still be compared to infer trends.

[9] The Gila NF collects actual perimeters (polygon data) for all fires over 10 acres, smaller fires are recorded only as a point and acreage.

federal agency wildfire occurrences point information[10], which was buffered by acreage and replaced by actual fire perimeters, when available. Fire perimeters were obtained from Gila NF data at the plan scale and a combination of Apache-Sitgreaves, Coconino, Coronado, Kaibab, Lincoln, and Tonto NFs, and MTBS perimeters elsewhere within the context area. MTBS only maps fires over 1,000 acres as far back as 1984. For large parts of the context scale the only source of fire perimeter information is MTBS (2014), data, so the analysis was bounded using its earliest available information (1984-2014). Any discrepancies at the plan scale were resolved in favor of Gila NF data.

Departure was calculated by comparing FR to the reference mean fire return interval (MFRI) as shown in Table 5.

**Table 5. Definitions of fire frequency departure based on current fire return interval in relation to a range of reference mean fire return intervals (MFRI)**

| Current Fire Interval | Reference Mean Fire Return Interval Range | | |
|---|---|---|---|
| | less frequent than reference MFRI | within reference MFRI | more frequent than reference MFRI |
| Departure | $= 1 - \left(\frac{\textit{current fire return}}{\textit{low end of reference range}}\right)$ | 0 | $= 1 - \left(\frac{\textit{high end of reference range}}{\textit{current fire return}}\right)$ |

**Fire regime condition class** (FRCC) is the combination of seral state departure and fire regime departure into a single metric. FRCC is an important tool for measuring the effectiveness of efforts to maintain sustainable landscapes (NIFTT 2010). FRCC ratings describe a level of departure from native ecosystems as they existed prior to Euro-American settlement:

- **FRCC I** – Fire regimes are within the natural or NRV and risk of losing key ecosystem components is low. Vegetation attributes (composition and structure) are intact and functioning (departure ≤ 33%)
- **FRCC II** – Fire regimes have been moderately altered. Risk of losing key ecosystem components is moderate. Fire frequencies may have departed by one or more return intervals (either increased or decreased), potentially resulting in moderate changes in fire and vegetation attributes (34 - 66% departed)
- **FRCC III** – Fire regimes have been substantially altered. Risk of losing key ecosystem components is high. Fire frequencies may have departed by multiple return intervals, potentially resulting in dramatic changes in fire size, fire intensity, and fire severity as well as landscape patterns. Vegetation attributes have been substantially altered (≥ 67% departed) (WFM 2012).

FRCC was calculated at the local scale by averaging seral state proportion departure and fire regime departure. Characteristic fire regime was defined as the average of NRV reported for each ERU. Local scale ratings were area weighted for each ERU to determine a percentage by class at the plan scale. ERUs with higher proportions in FRCC II or III are at higher risk of loss of ecosystem integrity because of uncharacteristic disturbance (Table 6).

**Table 6. Plan scale departure as represented by FRCC classes I through III**

| Less Departed ← | | → More Departed |
|---|---|---|
| FRCC I – 0%[1] | FRCC II – 79% | FRCC III – 21% |

[1]Percentages represent the proportion of the planning area (plan scale) in that FRCC class

[10] The Federal Fire Occurrence Website (FFOW 2016) is maintained by USDI U.S. Geological Survey. Available at: http://wildfire.cr.usgs.gov/firehistory/index.html.

**Insects and disease** are the severity and frequency of outbreaks of damage agents at the plan and local scales. Insects and diseases are important components of forest ecosystems and greatly influence forest structure and species composition over time. They are characteristic to some degree and at some frequency in all ERUs, not only as disturbance agents, but also as significant contributors to ecosystem function. While insect and disease impacts often conflict with human objectives and forest management goals, their effects on the forest may be detrimental or beneficial from an ecological perspective (Ryerson 2015). According to Ryerson (2015), with the exception of nonnative agents such as white pine blister rust, the primary forest insects and diseases in the Southwestern Region and on the Gila NF are native organisms that have long been part of the ecosystem and have evolved with their plant hosts.

The USFS Southwestern Region has evaluated the most common forest insects and diseases on the Gila NF using information from historical reports, published documents, aerial survey information, and USFS specialists' knowledge (Ryerson 2015). Data from Aerial Detection Surveys, conducted by the USFS, are summarized for the Gila NF by ERU for the period 1998-2013. Similar survey data is not available for non-NFS lands, therefore insect and disease outbreaks are discussed qualitatively at the context scale, when information is available. Otherwise, insects and diseases are only assessed at the plan and local scales. Information concerning departure from reference conditions for insects and disease is not available.

## System Drivers and Stressors for Upland Vegetation

System drivers and stressors for upland vegetation are:

- Natural vegetation succession
- Fire
- Insects and diseases
- Ungulate grazing
- Human ground disturbance activities and vegetation manipulation
- Invasive species
- Climate
- Climate change

**Natural vegetation succession** is the progressive change in species composition and structure over time. Early successional stages ("seres" or "states") are often dominated by small, short-lived, poorly competitive, non-woody species (annual forbs and grasses), which take advantage of the available "biological space" and plentiful soil nutrients and sunlight present after a disturbance. As succession proceeds, soil nutrients are converted into plant biomass, and plant community dominance generally shifts toward larger, longer-lived, woody species that are better competitors for limited soil nutrients and sunlight—shrubs, shade-intolerant tree species, and eventually, shade-tolerant tree species. Disturbances like wildfire, drought, and grazing can interrupt or reverse succession.

The shade tolerance and competitive ability of the "highest seral" ("latest seral") species present on a site naturally tend to decrease with decreasing elevation (warmer, drier). For example, the latest-successional plant communities on the highest-elevation (coldest, wettest) sites on the Gila NF tend to be dominated by Engelmann spruce (*Picea engelmannii* Parry ex Engelm.)[11] and corkbark fir (*Abies lasiocarpa* (Hook.) Nutt. var. *arizonica* (Merriam) Lemmon) —highly shade-tolerant tree species that are good competitors for limited soil nutrients. Descending in elevation (progressively warmer, drier), the highest seral species found on a site are mixed-conifer (Rocky Mountain Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco), and white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.)), followed by ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson var. *scopulorum* Engelm.), then piñon-juniper woodland, then shrublands, and finally, desert scrub or grasslands at the lowest elevations. A relatively high seral species on one site is likely to be present as a relatively mid-seral species on a site that is higher in elevation (colder, wetter). For example, Douglas fir may be a climax species in a mixed-conifer forest, but may be present as a mid-seral species in a spruce-fir forest 1,000 feet higher in elevation.

Mature individuals of high-seral species may rarely be (if ever) present on a site where a natural disturbance regime maintains the site in a lower seral state. For example, in the absence of fire, a site could support Douglas fir, but a naturally brief fire return interval periodically interrupts succession by killing Douglas fir seedlings and maintaining dominance by ponderosa pine—early seral, fire-resistant species.

**Fire** is an integral part of many ecosystems on the Gila NF and across the western United States. Wildfire frequency and effects vary from short return intervals and low severity to long return intervals of fires that consume all vegetation (stand-replacing). The fire regime of an ERU is defined by the MFRI, the number of years between fires at any one location, and the severity of these fires, from low to stand-replacing. In fuel types where fires historically burned frequently (like ponderosa pine), the interaction between pattern

[11] All common names and scientific nomenclature follow USDA NRCS 2016. The PLANTS Database (http://plants.usda.gov, 2016). National Plant Data Team, Greensboro, NC 27401-4901 USA.

and process was integral in maintaining characteristic species composition, structure, and spatial pattern. That is, frequent fires removed surface fuels, but maintained forest structure that encouraged continued low-severity fires (Reynolds et al. 2013). In other systems, like spruce-fir forest, or piñon-juniper woodlands, fire was less frequent and had less influence on fine-scale stand structure patterns, but may have significantly influenced landscape scale patterns.

Fire generally reverses succession, by establishing an earlier seral state in infrequent fire forest and woodland types, however, within frequent fire types, fire maintains the current seral state. Each ERU has evolved under a specific fire regime to adapt to the frequency and severity of fire characteristic in that ERU, such that ecological integrity is maintained over time. Multiple interacting influences may alter an ERU's fire regime; some are legacies of past human impacts, while others are still evolving. A history of fire suppression and unmanaged grazing (leading to a lack of fine fuels to carry fire) has resulted in fewer fires since the late-1800s. The subsequent accumulation of live and dead fuels in some ERUs has created the potential for larger and more severe fires. Tree mortality from drought or insect and disease outbreaks contributes to fuel accumulation. Into the future, according to Westerling et al. (2006), changing climate is expected to continue to lengthen the fire season and favor larger fires. Thus, fire may be either a driver or a stressor, depending on whether its effects are characteristic of the system or not. Prescribed fire acts as a driver, if its effects are characteristic of the system. Large, destructive wildfires are in many cases stressors, because their effect can degrade the integrity of the system, and may convert the system to a condition that may never recover (Savage and Mast 2005; Roccaforte et al. 2012).

**Insects and diseases** are important components of forest ecosystems and greatly influence forest structure and species composition over time. While insects and diseases have ecological roles, their impacts often conflict with human objectives and forest management goals. However, whether these effects are detrimental or beneficial to the forest depends on an ecological perspective (Ryerson 2015). Insects and diseases may function as a driver or as a stressor. Forested systems have evolved under endemic pathogen levels that were sustainable historically and may help maintain ecosystem function. An outbreak may have uncharacteristic effects to which the system is not entirely resilient, either because the outbreak is more severe (outside the historical range of variability), or because of confounding factors that amplify damaging effects.

**Ungulate grazing** - The introduction of widespread, substantial domestic livestock grazing in the late 1800s is one of the events that demarks the end of the reference period (Smith 2006a). Though native ungulates, such as deer, were present prior to U.S. settlement, grazing by native species during the reference period differed in degree, foraging pattern, diet, topographic preference and riparian areas, time spent in a single area, soil trampling (Currie 1977; Osmond et al. 2007), and natural death-loss and predation.

There is a long history of ungulate grazing in the southwestern U.S., to which some native plants have adapted (Pieper 1994; Holechek et al. 2010), and grazing animals may play a role in nutrient cycling (Pieper 1994). However, domestic livestock grazing can be a potential stressor to ecosystems. In general, grazing decreases biomass and can reduce the ability of frequent fire ecosystems to carry low intensity fire (Belsky and Blumenthal 1997; Holechek et al. 2010). Herbivory by cattle also reduces competition by grasses with conifer seedlings, allowing them to expand or encroach into grasslands (Dahms and Geils 1997) and forest opening and interspaces (Allen 1984; Moore and Huffman 2004). The removal of vegetative cover, and soil compaction that result from excessive grazing reduces water infiltration, increases runoff, and accelerates erosion (Belsky and Blumenthal 1997; Smith et al. 2009; Holechek et al. 2010). There is evidence that historical heavy grazing has degraded some arid rangelands (Fleischner 1994; Todd and Hoffman 1999; among others). Historical levels of herbivory have had detrimental effects on the composition, structure and function of forested, woodland and grassland ecosystems, and has led to a decrease in native species richness (Fleischner et al. 1994), and tends to homogenize the vegetation understory community across

the landscape (White 2002). Excess abundance of native ungulates (e.g., deer (*Odocoileus hemionus* and *O. virginianus*), or elk (*Cervus elaphus*)), and trespass livestock and feral hogs also add to these impacts.

Current grazing intensity is generally lower than historical levels. Properly managed grazing, with respect to utilization levels, season of use, and type of animal, may minimize impacts to ecosystem function and can be sustainable over the long term (Davies et al. 2011; Holechek et al. 2006; Pieper 1994). Rest from grazing has been shown to reduce ecosystem degradation, especially in riparian areas (Dalldorf et al. 2013; Schulz and Leininger 1990), but alone, even total cessation of all grazing may not return grass systems to a historic reference state (Pieper 1994). According to Holechek et al. (2010), by adaptively varying grazing timing, intensity, and duration, effects to vegetation productivity and species composition can be managed.

**Human ground disturbance activities and vegetation manipulation** - Localized ground disturbance from flooding, landslides, and avalanches would have historically been a minor factor in some ecosystems, but human ground disturbance, mainly road and trail construction, is a stressor. Roads mainly influence water flow and soil erosion, but also provide a vector for invasive species spread. Soil compaction from ground disturbing activities also affects plants ability to germinate, establish, grow and occupy areas.

**Invasive plant species** is a species that grows and spreads rapidly, replacing desired plants. Invasive plants generally have one or more of the following characteristics: aggressive and difficult to manage, poisonous, toxic, parasitic, a carrier or host for serious insects or disease and being non-native or new to or not common to the United States (EO 13112 1999). Invasive plants are defined here as species that were not native to the plan area during the NRV period, and are characterized by a tendency to invade upon and increase in native ecosystems, often with undesirable consequences, such as displacing native species or changing ecological processes and natural disturbance regimes (White 2013).

**Climate** influences all aspects of vegetation potential and expression. Temperature and precipitation patterns define dominant species and productivity of vegetation, nutrient availability, and cycling in soils. The natural range of variation in cyclical drought and temperature fluctuation define a characteristic extent and severity of disturbance from drought, insects and disease, and fire. While climate has varied continually in the past, current vegetation has evolved under a defined average climate with a defined level of variability. Climate becomes a stressor, when the mean, variability, or rate of change shifts outside its historic range.

**Climate Change** - Although regional climates persist for centuries, they do change and vegetation responds on a similar scale (Delcourt and Delcourt 1983). The ecosystems we see today are the products of species evolution and migration over time on a constantly shifting landscape driven by climate. Climates change at a variety of scales. Long-term, persistent trends in temperature and humidity determine the extent and location of various life zones, the elevation at which one biotic community replaces another. Short-term fluctuations in the order of years to decades determine drought cycles, fire frequencies, and pulses of tree reproduction. The Southwest is strongly influenced by oscillation in the Pacific ocean-atmosphere system. El Niño years bring increased annual precipitation, but less rain in the summer, and La Niña years bring the opposite (Betancourt et al. 1993).

The two most important factors for determining fire regimes are vegetation type (or ecosystem), and weather and climate patterns (Sommers et al. 2011). Fire history provides evidence of past relationships between fire and climate. That evidence makes it clear that changing climate will profoundly affect the frequency and severity of fires, and vegetation ultimately, in many regions and ecosystems in response to factors such as earlier snowmelt and more severe or prolonged droughts (Westerling et al. 2006; Bowman et al. 2009; Flannigan et al. 2009). Changing climate will also alter the growth and vigor of existing vegetation, with resulting changes in fuel structure and dead fuel loads. For these reasons, land managers

need to assess ongoing and potential effects of climate change, and coordinate a response for ecosystems, species, and human communities.

See the System Drivers and Stressors Chapter for more details.

## Spatial Scales for Terrestrial Ecosystems

This assessment evaluates terrestrial ecosystems at three spatial scales (Figure 2):

- **Context scale** (CS) = ecoregion sections and subsections
- **Plan scale** (PS) = the Gila NF
- **Local scale** (LS) = subdivisions within the Gila NF

The plan scale of analysis for terrestrial ecosystem characteristics is defined by the administrative Forest boundary of the Gila NF. The context scale of analysis is the cluster of ecoregional subsections (Cleland et al. 1997) that surround the Forest. The local scale of analysis breaks the plan scale into six local units differentiated by level or type of management, level of public visitation, and types of use. The local units were delineated by an aggregation of watersheds and are named Apache, Black Range, Little Colorado-San Agustin Fringe, Lower Gila River, Mogollon Front, and Upper Gila River.

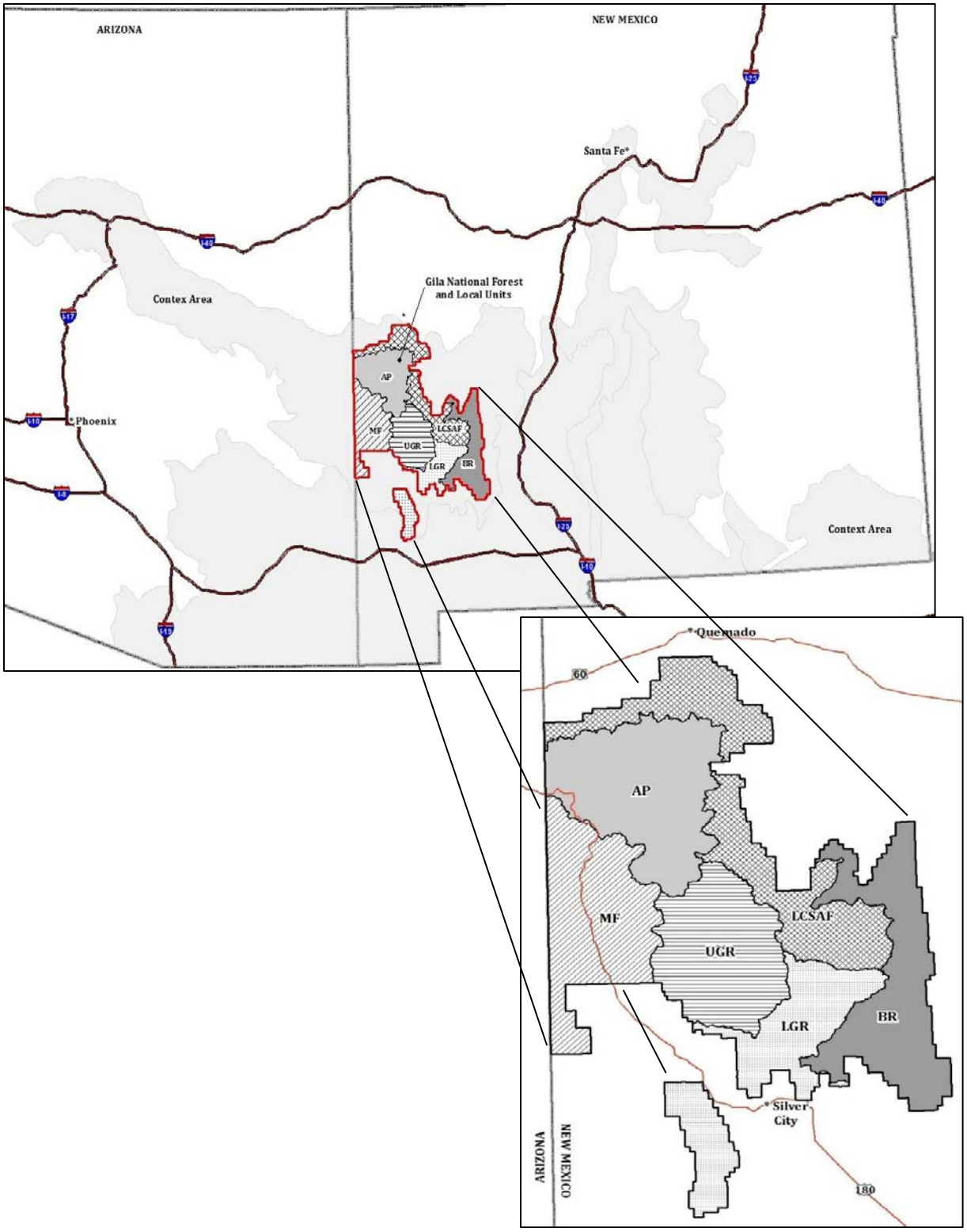


**Figure 2. Relationship of the six local scale units within the Gila NF (plan scale); the Forest's relationship to the context scale area; and the context area's location within in Arizona and New Mexico**

This assessment primarily focuses on the vegetation conditions found within the administrative boundaries of the Gila NF (plan area). An attempt has been made to identify the importance or "contribution to sustainability" of vegetation managed by the Gila NF by comparing the quantity and spatial extent of vegetation within and outside of the Forest administrative boundary. The following discussion places the Gila NF in the broader context of the surrounding landscape (context area) and uses a hierarchical framework of ecological map units including Ecoregion Provinces, Sections, and Subsections as described below.

A scale larger than the Forest is desirable to understand the environmental context, opportunities and limitations of NFS lands to contribute to ecological sustainability. Ecoregions are ecosystems of regional extent. Using the National Hierarchical Framework of Ecological Units (ECOMAP 1993; Cleland et al. 1997) an analysis of the landscapes surrounding the Gila NF was completed using the ecological section and subsection units. This broad-scale analysis was done to set the context for the contributions the Gila NF makes to ecological sustainability. As described by Bailey (1980, 1983, 1985 and 1998), ecoregions distinguish areas that share common climatic and vegetation characteristics (Cleland et al. 1997). Ecoregions are subdivided into provinces, which are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soils. Sections are a subdivision of provinces, described by broad areas of similar subregional climate, geomorphic process, geology, geologic origin, topography, and drainage networks. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings such as those mapped by Küchler (1964). Ecological subsections are a further division of sections, and described by areas with similar surface geology, geomorphic process, soil groups, subregional climate, and potential natural vegetation communities (McNab and Avers 1994). Because subsections are smaller in size they are more useful in planning at a smaller scale.

The Gila NF is located within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow ecoregion province (M313) (McNab and Avers 1994; McNab et al. 2005 and 2007); and is located almost entirely within the province's White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section (M313A), and therefore, is located within a portion of seven subsections in the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section (Figure 3), and contributes 63 acres to Animas Valley Plains Desert Grass-Shrubland (321Ag) subsection within the Basin and Range ecoregion section (321A).

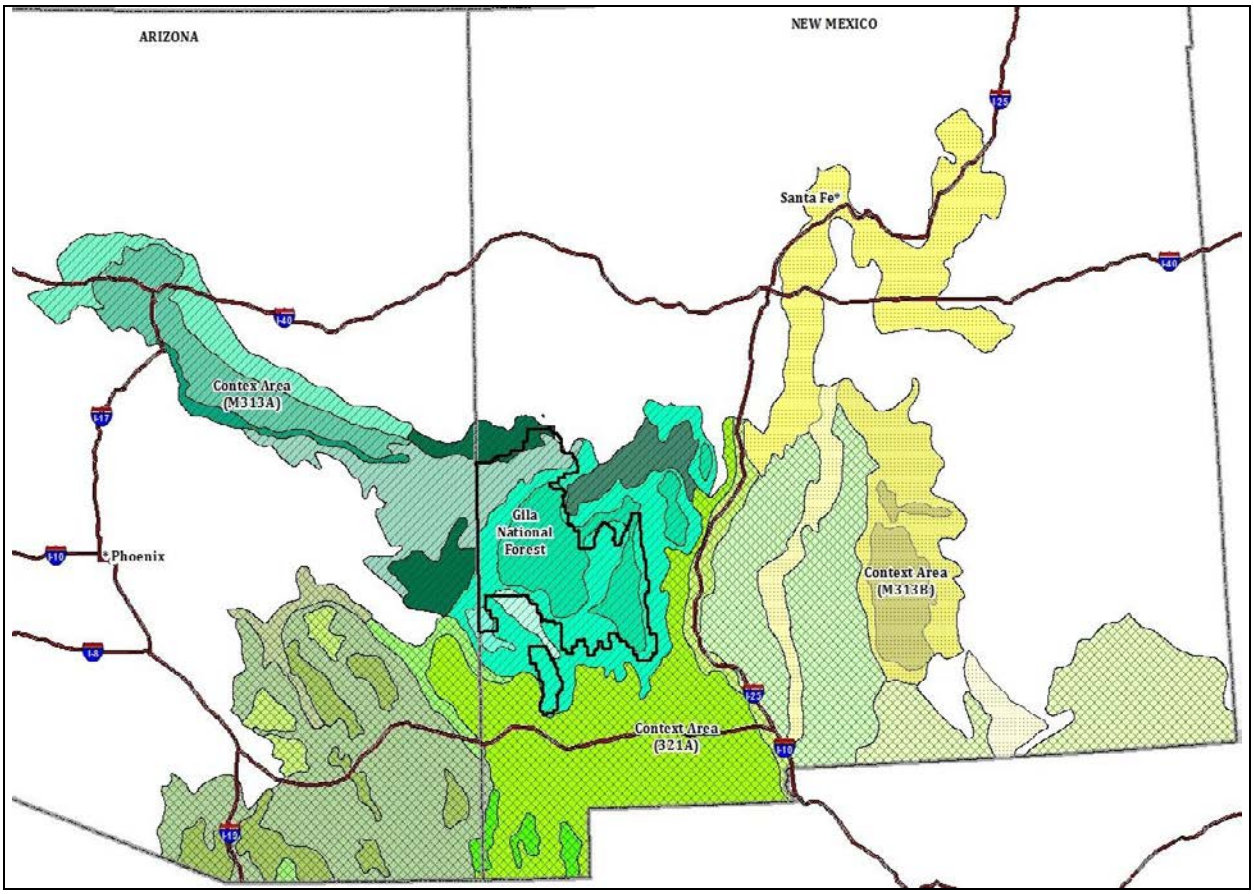


**Figure 3. Gila NF in relation to the analysis context area, of the White Mountains-San Francisco Peaks-Mogollon Rim (M313A), Sacramento-Manzano Mountains (M313B), and Basin and Range (321A) Ecoregion Sections, and their respective ecoregion subsections in setting within Arizona and New Mexico**

Table 7 presents the relationship, in acres, of the Gila NF to the overall context area. Overall, the three ecoregion sections and their 28 subsections total nearly 35.9 million acres within Arizona and New Mexico. The Gila NF occupies seven percent of these total acres. The remaining 93 percent of the lands within the ecoregion sections are owned or managed by a diversity of entities; including the Apache-Sitgreaves, Coconino, Coronado, Kaibab, Lincoln, Prescott and Tonto National Forests, the states of Arizona and New Mexico, Bureau of Land Management, Bureau of Reclamation, Department of Defense, National Park Service, Fish and Wildlife Service, White Mountain, San Carlos and Mescalero Apache Nations, and numerous private organizations and citizens.

**Table 7. Land area, in acres, of the Gila NF in relation to the context area (CA) of the ecoregion sections and 28 subsections in which it occurs**

| CA Ecoregion Sections and Ecoregion Subsections | CA Section and Subsection Acres | Gila NF and CA Overlap (on Forest) | | | Non-Gila NF and CA Overlap (off Forest) | |
|---|---|---|---|---|---|---|
| | | acres | % of Gila NF | % of CA | acres | % of CA |
| **321A-Basin and Range Ecoregion Section** | | | | | | |
| Ecoregion Subsections | | | | | | |
| 321Aa-Big Bend Highlands | 0 | 0 | 0.0 | 0.0 | 0 | 100 |
| 321Ab-Trans-Pecos Isolated Mtn Ranges | 0 | 0 | 0.0 | 0.0 | 0 | 100 |
| 321Ac-Trans-Pecos Desert Shrubland | 3,477,894 | 0 | 0.0 | 0.0 | 3,477,894 | 100 |
| 321Ad-Jornada Plains Desert Grass-Shrubland | 4,862,354 | 0 | 0.0 | 0.0 | 4,862,354 | 100 |
| 321Ae-Sand Hills | 857,436 | 0 | 0.0 | 0.0 | 857,436 | 100 |
| 321Af-San Simon Valley Desert Shrubland | 525,201 | 0 | 0.0 | 0.0 | 525,201 | 100 |
| 321Ag-Animas Valley Plains Desert Grass-Shrubland | 6,389,712 | 62 | < 1 | < 1 | 6,389,648 | > 99 |
| 321Ah-Animas Mtns Oak-Juniper Woodland | 371,168 | 0 | 0.0 | 0.0 | 371,168 | 100 |
| 321Ai-Sulphur Springs Desert Shrubland | 510,031 | 0 | 0.0 | 0.0 | 510,031 | 100 |
| 321Aj-Sulphur Springs Plains Desert Grass-Shrubland | 5,729,764 | 0 | 0.0 | 0.0 | 5,729,764 | 100 |
| 321Ak-Santa Catalina Mtns Sierra Madre Interior Chaparral | 485,800 | 0 | 0.0 | 0.0 | 485,800 | 100 |
| 321Al-San Rafael Sierra Madre High Plains Grassland | 55,116 | 0 | 0.0 | 0.0 | 55,116 | 100 |
| 321Am-Santa Catalina Mtns Encinal Woodland | 1,578,764 | 0 | 0.0 | 0.0 | 1,578,764 | 100 |
| Subtotal | 24,843,240 | 62 | < 1 | < 1 | 24,843,176 | > 99 |
| **M313A-White Mtns-San Francisco Peaks-Mogollon Rim Ecoregion Section** | | | | | | |
| Ecoregion Subsections | | | | | | |
| M313Ab-Mangas High Plains Grassland | 190,546 | 21,804 | < 1 | 11.6 | 168,742 | 88.4 |
| M313Ac-Burro Mtns Oak-Juniper Woodland | 128,506 | 35,069 | 1.1 | 27.8 | 93,437 | 72.2 |
| M313Ad-Mogollon Mtns Woodland | 3,593,438 | 1,272,235 | 39.6 | 36.0 | 2,321,203 | 64.0 |
| M313Ae-Mogollon Mtns Coniferous Forest | 1,790,366 | 1,387,548 | 43.2 | 78.9 | 402,818 | 21.1 |
| M313Af-White Mtns Scarp Woodland-Coniferous Forest | 321,937 | 0 | 0.0 | 0.0 | 321,937 | 100 |
| M313Ag-White Mtns Woodland | 1,057,588 | 66,503 | 2.1 | 6.4 | 991,085 | 93.6 |
| M313Ah-White Mtns Coniferous Forest | 2,124,378 | 426,646 | 13.3 | 20.4 | 1,697,732 | 79.6 |
| M313Ak-Coconino Plateau Woodland | 1,610,863 | 0 | 0.0 | 0.0 | 1,610,863 | 100 |
| M313Al-Coconino Plateau Coniferous Forest | 1,974,410 | 0 | 0.0 | 0.0 | 1,974,410 | 100 |
| M313Am-San Francisco Peaks Coniferous Forest | 683,062 | 558 | < 1 | < 1 | 682,504 | > 99 |
| Subtotal | 13,475,094 | 3,210,364 | > 99 | 24.3 | 10,264,730 | 75.7 |
| **M313B-Sacramento-Monzano Mtns Ecoregion Section** | | | | | | |
| Ecoregion Subsections | | | | | | |
| M313Ba-Guadalupe Mtns Woodland | 869,210 | 0 | 0.0 | 0.0 | 869,210 | 100 |
| M313Bb-San Andres Mtns Woodland | 947,855 | 0 | 0.0 | 0.0 | 947,855 | 100 |
| M313Bd-Manzano Mtns Woodland | 3,727,206 | 0 | 0.0 | 0.0 | 3,727,206 | 100 |
| M313Bf-Sacramento Mtns Woodland | 1,974,956 | 0 | 0.0 | 0.0 | 1,974,956 | 100 |
| M313Bg-Sacramento Mtns Coniferous Forest | 1,095,163 | 0 | 0.0 | 0.0 | 1,095,163 | 100 |
| Subtotal | 8,614,390 | 0 | 0.0 | 0.0 | 8,614,390 | 100 |
| **Total** | **46,932,724** | **3,210,364** | **100** | **7.0** | **43,722,360** | **93.0** |

Table 8 displays the ERUs (USDA FS 2015a) found within the Gila NF and ecoregion sections and what percent of each ERU within the ecoregion sections is contributed by the Gila NF. The Gila NF makes up slightly more than 7 percent of the context landscape by area and is almost entirely located in M313A-White Mtns-San Francisco Peaks-Mogollon Rim Ecoregion Section (greater than 99 percent). The Gila NF's contribution to the context area for each ERU is shown in Table 8. In addition, the relative proportional representativeness within the Forest and ecoregion section is presented. When an ERU is more common at the plan scale than would be expected based on area (which is at or greater than 13% of the total ERU area in the context landscape (Table 8, column 4a), the plan area has a disproportionate influence on

ecological sustainability of the system or greater relative proportional representation. ERUs that are rare at the context scale will be influenced more by conditions at the plan scale than ERUs that are more abundant, for which plan scale conditions may be overwhelmed by off-Forest conditions.

**Table 8. Relative proportional representation of upland ERUs on the Gila NF and within the greater context area (CA) (column 4b) and seral state departure from reference condition (columns 5a and 5b)**

| Gila NF Upland ERUs (column 1) | Total ERU Area on Gila NF (column 2) | | Total ERU Area within CA (column 3) | | Gila NF's Contribution to Total ERU within CA (column 4) | | Seral State Departure from Reference Condition (column 5) | |
|---|---|---|---|---|---|---|---|---|
| | acres (2a) | % of Gila NF (2b) | acres (3a) | % of CA (3b) | from Gila NF (4a) | proportional representation[1] (4b) | Gila NF (5a) | CA (5b) |
| **Forests** | | | | | | | | |
| PPF | 630,280 | 19.3 | 3,805,078 | 8.1 | 16.6 | 0.41 | high | high |
| MCD | 396,244 | 12.1 | 1,174,058 | 2.5 | 33.7 | 0.66 | moderate | moderate |
| PPE | 378,156 | 11.6 | 622,820 | 1.3 | 60.7 | 0.79 | moderate | high |
| MCW | 73,934 | 2.3 | 399,406 | 0.9 | 18.5 | 0.45 | moderate | moderate |
| SFF | 23,779 | 0.7 | 177,491 | 0.4 | 13.4 | 0.32 | moderate | moderate |
| **Woodlands** | | | | | | | | |
| PJO | 848,440 | 25.9 | 2,585,904 | 5.5 | 32.8 | 0.65 | moderate | moderate |
| PJG | 291,649 | 8.9 | 1,411,018 | 3.0 | 20.7 | 0.50 | moderate | moderate |
| JUG | 114,396 | 3.5 | 3,703,181 | 7.9 | 3.1 | -0.39 | low | moderate |
| MPO | 17,361 | 0.5 | 902,219 | 1.9 | 1.9 | -0.57 | moderate | moderate |
| PJC | 10,678 | 0.3 | 401,552 | 0.9 | 2.7 | -0.45 | moderate | moderate |
| **Shrubland** | | | | | | | | |
| MMS | 166,488 | 5.1 | 356,451 | 0.8 | 46.7 | 0.74 | low | moderate |
| **Grasslands** | | | | | | | | |
| MSG | 113,785 | 3.5 | 379,720 | 0.8 | 30.0 | 0.62 | moderate | moderate |
| CPGB | 89,186 | 2.7 | 2,804,141 | 6.0 | 3.2 | -0.37 | high | high |
| SDG | 55,988 | 1.7 | 16,091,824 | 34.3 | 0.3 | -0.90 | high | high |

[1] Relative Proportional Representation (RPR) is calculated using the following formula: *RPR* = ((*% of GNF - % of context area*)/(*% of GNF + % of context area*)). A value of 0 indicates the percent of the forest covered by an ERU is the same as the percent of the context area covered by that ERU; positive values indicate the ERU proportion of the forest is greater than the ERU proportion of the context area, (ERU is greater on forest); and negative values indicate the ERU proportion of the context area is greater than the ERU proportion of the forest (ERU is greater in context area)

The relationship between the upland ERUs found within the context area and occurring on the Gila NF are displayed in Table 8. All of the forested ERUs, and PJO, PJG, MMS and MSG have greater relative proportional representation on the Gila NF than within the overall context area; while ERUs JUG, MPO, PJC, CPGB and SDG have greater relative proportional representation within the context area than on the Gila NF. Additionally, the Gila NF has the greatest contribution of PPE in the context area (nearly 61%), the Forest also contains four other upland ERUs that contribute 30 percent or more to the total ERU acreage within the context area; they are MCD, PJO, MMS and MSG.

To further aid in the resource assessment and to capture local variations in ERUs, the Forest was further subdivided into local units, which were developed based on a rule-set guiding the aggregation of watersheds following three USFS Southwestern Regional Office "rules of thumb". The rules of thumb were: 1) there should be between four and eight units; 2) units should be at least 10 times the historical patch size (minimum size of 400,000 ac.); and 3) try to have representation of each ERU in as many local units as possible. The intent of the local unit scale is to identify any patterns in resource conditions across the Forest that might exist and provide information for consideration in determining future management priorities. Following the rule-set found in Appendix A, the Gila NF was subdivided into six local units:

Apache; Black Range; Little Colorado-San Agustin Fringe; Lower Gila River; Mogollon Front; and Upper Gila River (Figure 4).

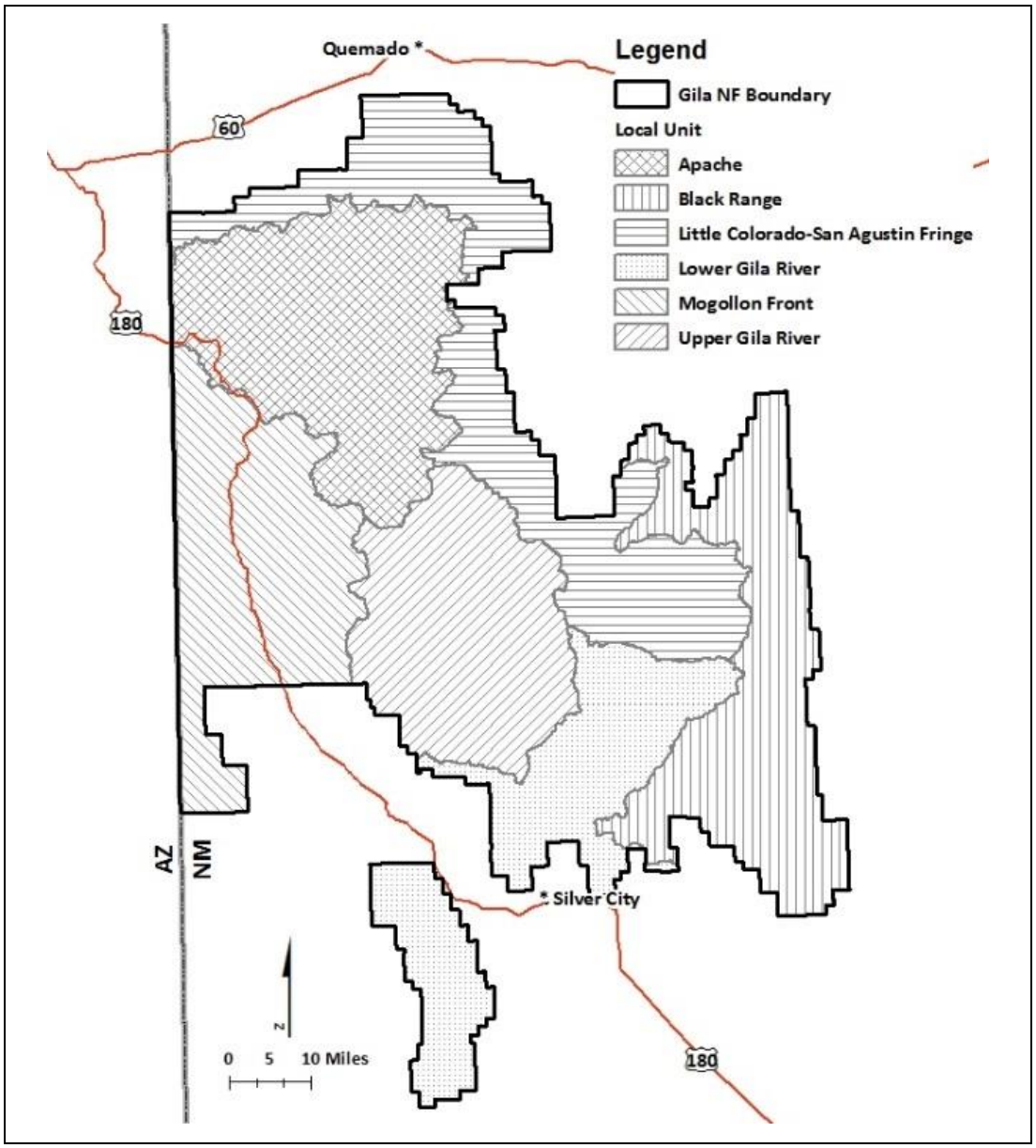


**Figure 4. Gila NF's local unit subdivisions within the framework of the planning area**

Table 9 displays the size of each local unit and the distribution (number and amount) of each upland and riparian ERU contained within. The Little Colorado-San Agustin Fringe local unit is the largest at 625,221 acres, while the Lower Gila River local unit is the smallest at 487,382 acres. Both the Apache and Mogollon Front local units contain all 14 upland ERUs, while the LGR local unit contains the least at 11 ERUs. Nine upland ERUs (PPF, MCD, PPE, MCW, PJO, PJG, MMS, CPGB and SDG) are represented in all local units; while SFF and JUG only occur in four of the six local units. The remaining upland ERUs (MPO, PJC and MSG) occur somewhere in between.

**Table 9. Gila NF's upland ERU acreage distribution at the local unit scale**

| Gila NF Upland ERUs | Gila NF Local Units | | | | | | | | | | | | Gila NF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| **Forests** | | | | | | | | | | | | | |
| PPF | 219,333 | 34.8 | 62,032 | 9.8 | 197,615 | 31.4 | 28,408 | 4.5 | 32,647 | 5.2 | 90,245 | 14.3 | 630,280 |
| MCD | 48,327 | 12.2 | 100,020 | 25.2 | 70,947 | 17.9 | 30,165 | 7.6 | 60,984 | 15.4 | 85,801 | 21.7 | 396,244 |
| PPE | 87,665 | 23.2 | 54,123 | 14.3 | 56,971 | 15.1 | 70,161 | 18.6 | 36,037 | 9.5 | 73,199 | 19.4 | 378,156 |
| MCW | 5,098 | 6.9 | 17,936 | 24.3 | 2,719 | 3.7 | 3,089 | 4.2 | 19,073 | 25.8 | 26,019 | 35.2 | 73,934 |
| SFF | 22 | 0.1 | 630 | 2.6 | 0 | 0.0 | 0 | 0.0 | 8,710 | 36.6 | 14,417 | 60.6 | 23,779 |
| **Woodlands** | | | | | | | | | | | | | |
| PJO | 97,007 | 11.4 | 260,351 | 30.7 | 111,055 | 13.1 | 191,213 | 22.5 | 146,107 | 17.2 | 42,707 | 5.0 | 848,440 |
| PJG | 65,676 | 22.5 | 13,225 | 4.5 | 93,597 | 32.1 | 33,158 | 11.4 | 54,838 | 18.8 | 31,155 | 10.7 | 291,649 |
| JUG | 422 | 0.4 | 0 | 0.0 | 0 | 0.0 | 39,759 | 34.8 | 65,898 | 57.6 | 8,317 | 7.3 | 114,396 |
| MPO | 855 | 4.9 | 252 | 1.5 | 869 | 5.0 | 0 | 0.0 | 13,794 | 79.5 | 1,591 | 9.2 | 17,361 |
| PJC | 909 | 8.5 | 2,100 | 19.7 | 1,449 | 13.6 | 17 | 0.2 | 6,203 | 58.1 | 0 | 0.0 | 10,678 |
| **Shrubland** | | | | | | | | | | | | | |
| MMS | 1,946 | 1.2 | 20,577 | 12.4 | 151 | 0.1 | 45,624 | 27.4 | 32,225 | 19.4 | 65,965 | 39.6 | 166,488 |
| **Grasslands** | | | | | | | | | | | | | |
| MSG | 20,028 | 17.6 | 6,835 | 6.0 | 37,045 | 32.6 | 0 | 0.0 | 137 | 0.1 | 49,740 | 43.7 | 113,785 |
| CPGB | 31,992 | 35.9 | 214 | 0.2 | 38,759 | 43.5 | 3,505 | 3.9 | 12815 | 14.4 | 1,901 | 2.1 | 89,186 |
| SDG | 6,424 | 11.5 | 1,747 | 3.1 | 2,896 | 5.2 | 14,982 | 26.8 | 28,231 | 50.4 | 1,708 | 3.1 | 55,988 |
| **Total** | 585,704 | 18.2 | 540,042 | 16.8 | 614,073 | 19.1 | 460,081 | 14.3 | 517,699 | 16.1 | 492,765 | 15.3 | 3,210,364 |

## Terrestrial Ecosystem Spatial Niche

***Spatial Niche Analysis:*** The spatial niche analysis relates the Gila NF to its surroundings, in this case, the context area landscape. Spatial niche is dependent on the relative spatial distribution of an ERU, as well as the relative spatial distribution of departure within that ERU. The contribution of the Gila NF to the ecological integrity of an ERU in the context of the surrounding landscape is dependent first on the percent of the Forest occupied by the ERU. There must be enough of the ERU on the Forest that it may serve an important ecological role, and enough that its condition can be accurately assessed. The Gila NF's contribution to ecological integrity also depends on the percent of the context landscape occupied by the ERU and the relative proportional representation of the ERU on-Forest to off-Forest (Table 8). Finally, high departure or the loss of ecological integrity suggests risk in a system, and the distribution of that departure defines the Gila NF's role in addressing risk. Departure values are presented below. Their derivation and interpretation will be discussed in the ERU specific sections that follow.

Abundance on the landscape and proportional representation at the plan scale can be combined into a single variable that defines the opportunity for the plan scale to influence context scale conditions. Opportunity for influence is represented in Figure 5. Along the diagonal axis, increasing toward the lower right corner, where ERUs are more common in the plan area than in the context landscape, but are rare overall. Higher opportunity for influence means that the sustainability of the system at the context scale is more sensitive to conditions at the plan scale, and the Gila NF has a unique role in restoring or maintaining integrity when possible.

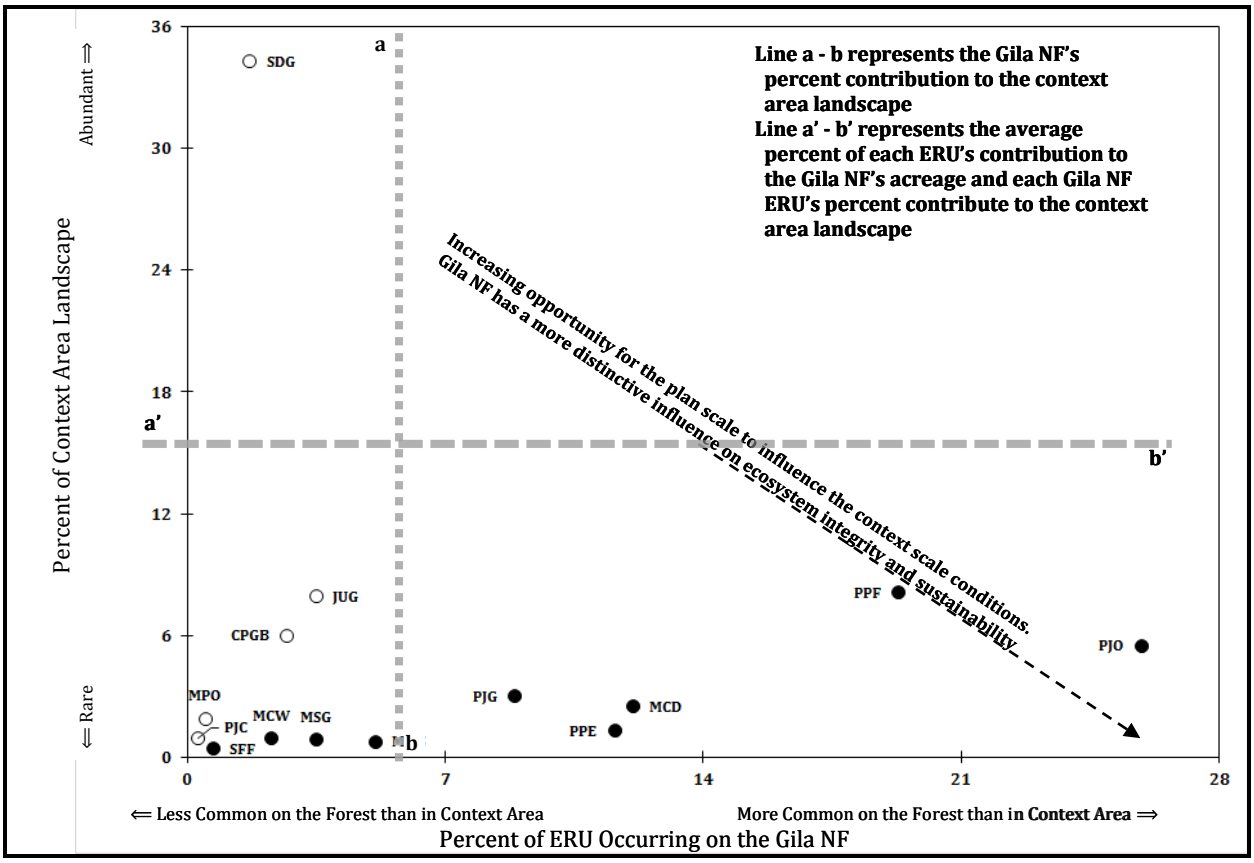


**Figure 5. Gila NF's opportunity to influence ecosystem sustainability and integrity within the context area landscape.**

Note: Black circles represent those ERUs that have a greater proportional representation on the Forest while the white circles represent ERUs that have a greater proportional representation within the context area.

As mentioned earlier, spatial niche analysis occurs within the framework of the context area and comes down to this: when the bulk of the ERU within the context area is located on-Forest (Gila NF), the sustainability analysis' focus is on conditions on-forest. When the bulk of the ERU within the context area is located off-forest, the sustainability analysis' focus is on conditions off-Forest. However, the ecological sustainability analysis will reflect the sum total of conditions of the ERU both on- and off-Forest. Figure 6 is a graphic representation used to determine if the management of lands within the Gila NF is influential to the sustainability of an ERU within the context area.

As can be seen from Figure 6, the importance of the ERUs within the Gila NF to the sustainability of ecosystems represented by these vegetation communities varies with amount and distribution within and outside of the Forest's boundaries within the context area. However, it is evident that the Gila NF contributes to the overall sustainability of all 14 of the upland ERUs represented above. The Gila NF provides three of the 14 ERUs with a high contribution to their sustainability and the remaining 11 with a moderate contribution to their sustainability. As an example, the PPF ERU comprises nearly 19 percent of the Gila NF, but represents only about 11 percent of the overall context area acreage; however, it has a higher proportional representation on the Forest of 0.41 (Table 8), and it also has a significant high level of departure from reference condition (93%). All of these elements contribute to the Gila NF's contribution to its sustainability. Another example is the PPE ERU; it comprises nearly 12 percent of the Forest, but represents just over one percent of the context area; and has a higher proportional representation on the Forest of 0.79 percent. In addition, the Gila NF's contribution of this ERU is nearly 61 percent of all that

occurs within the context area. It also has a significantly high level of departure from reference condition (71%).

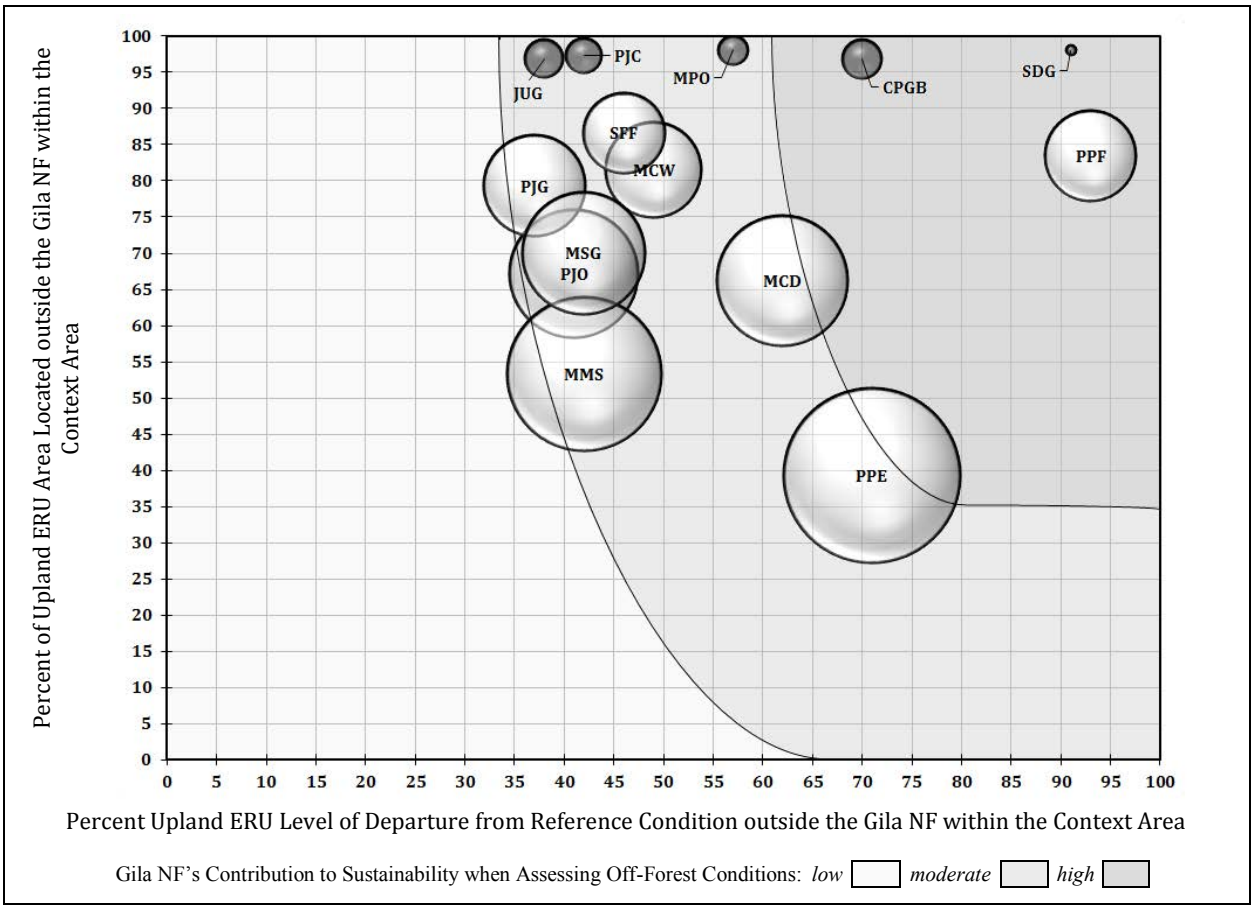


**Figure 6. Spatial niche analysis, potential GNF's contribution to sustainability of upland ERUs off-Forest within the context area.**

Note: Contribution is based on current ERU level of seral state departure from reference conditions within the context area (x-axis) and the percent area of the ERU off-Forest (y-axis). The light gray bubbles indicate that the ERU has a greater relative proportional representation on the Gila NF rather than within the context area. While the dark gray bubbles indicate that the ERU has a greater relative proportional representation within the context area rather than the Gila NF. Bubble size shows the Gila NF's percent contribution to the ERU's acreage in the context area.

Several other of the Forest's ERUs have a greater proportional representation than within the context area (Table 10). They are: MMS (0.74); MCD (0.66); PJO (0.65); MSG (0.62); PJG (0.52); MCW (0.45); and SFF (0.32). The amount of proportional representation provides additional evidence for the Gila NF's contribution to the sustainability of these ERUs when coupled with their departure from reference conditions within the context area.

Spatial niche also relates opportunity for influence of an ERU to that ERU's departure and its proportional representation (Figure 7). It describes the Gila NF's impact on the ecological integrity of the landscape and the role it might play in restoring or maintaining ecological sustainability. There is potential for restoration in systems that are highly and/or moderately departed but the role of the Gila NF is also dependent on its opportunity for influence and how departure is distributed (on-forest/off-forest) within the ERU. Figure 7 graphically depicts how terrestrial ecosystems on the Gila NF fit into the context area spatial niche. ERUs in the lower left corner have high ecological integrity and sustainability. Those in the upper right corner

have low ecological integrity and sustainability. ERUs to the left (33% or less) are less departed at the plan scale (possible refuges). All of the context scale ERUs are either moderately or highly departed from reference condition while the Gila NF contains ERUs within all three departure levels. Bubble size corresponds to the opportunity for the Gila NF to influence ERU condition at the context scale.

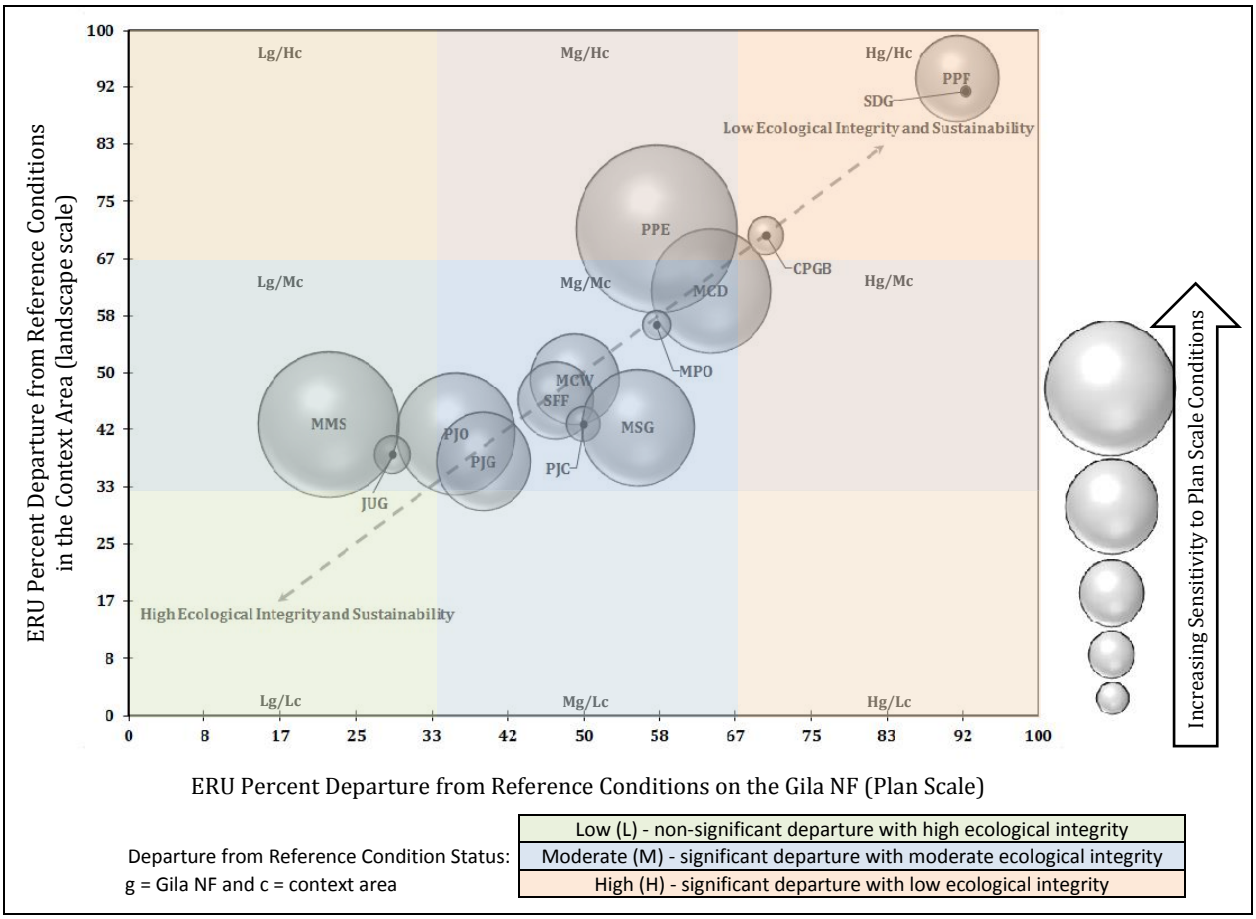


**Figure 7. Gila NF upland ERU spatial niche.**

Note: Bubble size indicates relative proportional representation provided by the Forest. Bubbles with leaders and a center with a black dot represent ERUs with a greater relative proportional representation within the context area.

Three spatial niche scenarios are important to consider:

1. The Gila NF can have a greater influence on ERUs that are uniquely represented on the Forest, either because they are generally rare or because they are proportionally more common at the plan scale. This opportunity for influence variable was displayed in Figure 5, along the diagonal axis. Greater opportunity for influence in an ERU on that graph corresponds to larger bubbles in Figure 7.
2. More highly departed ERUs are of greater concern because existing ecological integrity is already low (upper right corner of Figure 7).
3. If an ERU is less or equally departed at the plan scale than at the context scale, it may be an important refuge, and important to maintain as a functioning system (Table 10).

There are several ERUs that are considered to be rare either on the Forest or within the context area based on their relative abundance. Rarity is defined as contributing one percent or less to the acreage within the Forest and/or within the context area (Table 10).

**Table 10. Rare ERUs within the Forest and/or the context area**

| Upland ERU | Gila NF | | | Context Area | | |
|---|---|---|---|---|---|---|
| | abundance | | departure from RC | abundance | | departure from RC |
| | % | | | % | | |
| MCW | 2.3 | | moderate | 0.9 | rare | moderate |
| SFF | 0.7 | rare | moderate | 0.4 | rare | moderate |
| MPO | 0.5 | rare | moderate | 1.9 | | moderate |
| PJC | 0.3 | rare | moderate | 0.9 | rare | moderate |
| MMS | 5.1 | | low | 0.8 | rare | moderate |
| MSG | 3.5 | | moderate | 0.8 | rare | moderate |

Note: Rare is defined as any ERU that provides less than one percent of the acreage of the Forest and or the context area

Using these scenarios, the ERUs on the Gila NF can be loosely grouped. The SDG, PPF and CPGB ERUs are highly departed (Figure 7), and the Gila NF should have a role in their restoration, however, because the vast majority of SDG and CPGB are off-Forest, the Gila NF's role may be limited and areas on the landscape outside the plan area have a similar or greater influence on the sustainability of those systems.

The Forest may act as refuges for MCW, SFF, PJC, MMS and MSG. Their distribution on the Gila NF may be small however they are rare in the context landscape, and the plan area may play a role by maintaining intact reservoirs. Because four out of the five have moderate, but significant departure (Figure 7) the Forest should have some role in their restoration and maintenance. On the other hand, MPO is common on the landscape and rare at the plan scale, so the role of the Forest may be less.

The PJO, PJG, MCD and PPE are moderately departed (Figure 7), and there is a moderate to high opportunity for the Gila NF to influence their condition. Because of their level of occurrence on the Forest the Gila NF should have some role in their restoration and maintenance. There is a moderate opportunity for the Gila NF to influence JUG's condition, by maintaining its already high ecological integrity on Forest.

## Local Unit Scale Conditions

As mentioned previously, the local unit scale subdivides the plan scale. It is valuable for describing departure patterns for a given characteristic within the planning unit and identifying where particular issues may need attention and drive Forest Plan components. This scale is not as likely to drive ecological need for change, but may drive development of plan components. When information is available, key ecosystem characteristics are assessed at the local scale. Local units were delineated such that they might best capture variations that exist within the Gila NF. Systems may be at risk in some local zones, but not others. For example, stressors may be a concern only on certain parts of the forest. The six local zones are designed to distinguish those differences. Table 11 and Figure 8 display the ERU departure from reference conditions within each of the local units.

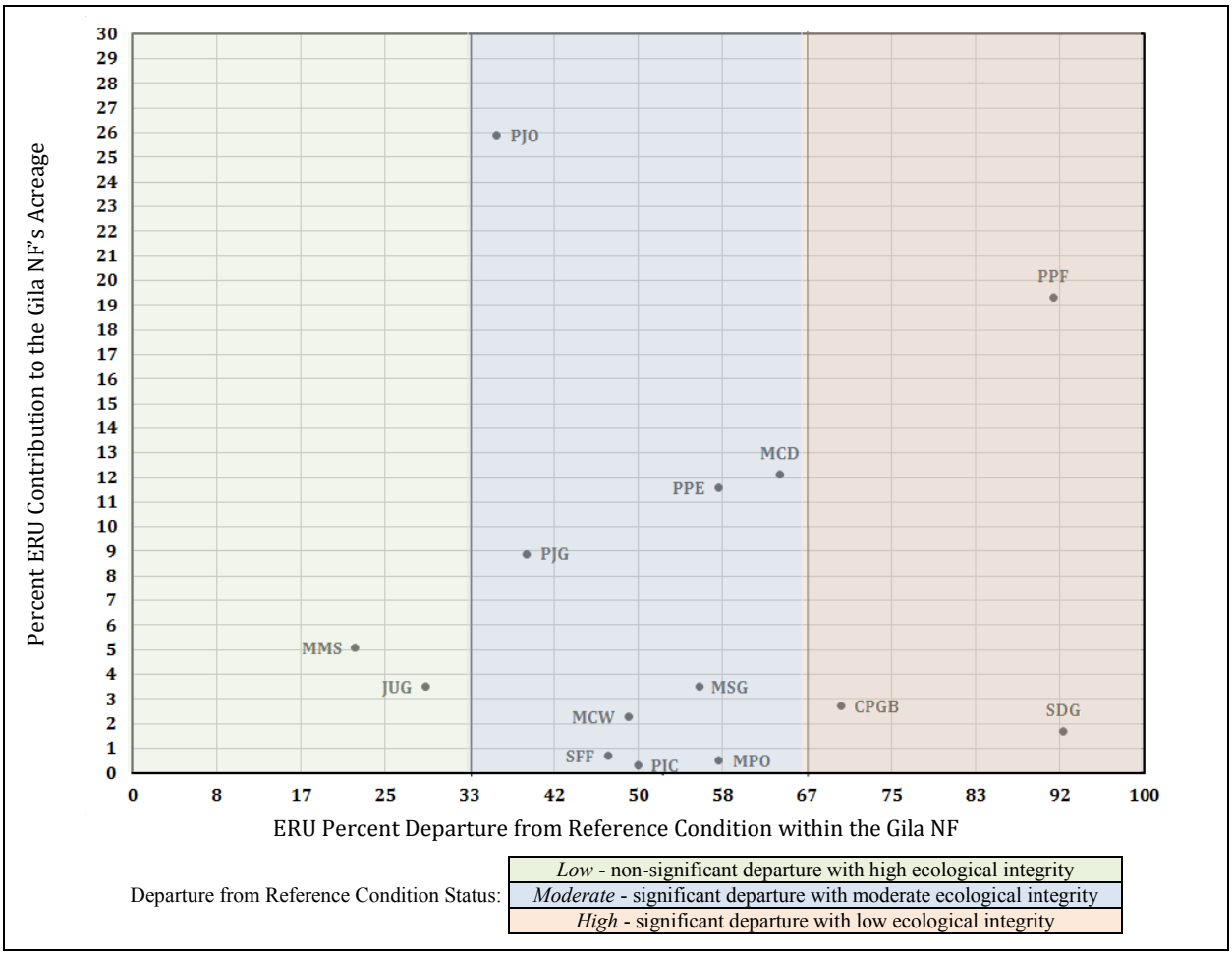


**Figure 8. Gila NF upland ERU departure from reference condition. The greater the departure the less sustainable the system**

PPF, CPGB, and SDG are highly departed across all local units. PPE, SFF, PJC, and MSG range from moderate to high. MCW, JUG, and PJG are moderately departed across all local units. MPO, PJO, and MMS range from low to moderate.

Looking at the variation of departure within an ERU across the Gila NF provides ample evidence that ecological integrity and sustainability varies across the forest. PJC displays the widest range of departure across the Forest (a 53 point spread) and the ERU with the lowest range of departure across the Forest is SDG (a 3 point spread). However, these are misleading when taken at face value because of the disparity of acres contributed by each ERU between the local units. The reality is that all of the forest and grassland ERUs plus JUG, PJC, and PJG have significantly to highly significantly departure across the local units. While MPO, PJO, and MMS range from non-significant departure to significant departure across the local units. The differences within ERUs between the local units should guide the Forest in further investigate the causal factors of drivers and stressors within and between the local units. Ecological integrity and sustainability need to be addressed.

**Table 11. Variability of upland ERU departure from reference conditions (RC)[1] is displayed**

| GNF Upland ERUs | Local Units | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
| | acres | % departure | acres | % departure | acres | % departure | acres | % departure | acres | % departure | acres | % departure | acres | % departure |
| **Forests** | | | | | | | | | | | | | | |
| MCD | 48,327 | 75 | 100,020 | 47 | 70,947 | 74 | 30,165 | 62 | 60,984 | 56 | 85,801 | 52 | 396,244 | 59 |
| MCW | 5,098 | 49 | 17,936 | 62 | 2,719 | 50 | 3,089 | 60 | 19,073 | 49 | 26,019 | 49 | 73,934 | 55 |
| PPE | 87,665 | 56 | 54,123 | 51 | 56,971 | 57 | 70,161 | 72 | 36,037 | 53 | 73,199 | 57 | 378,156 | 58 |
| PPF | 219,333 | 89 | 62,032 | 85 | 197,615 | 91 | 28,408 | 96 | 32,647 | 92 | 90,245 | 94 | 630,280 | 91 |
| SFF | 22 | 67 | 630 | 48 | 0 | - | 0 | - | 8,710 | 46 | 14,417 | 54 | 23,779 | 51 |
| **Woodlands** | | | | | | | | | | | | | | |
| JUG | 422 | 38 | 0 | - | 0 | - | 39,759 | 44 | 65,898 | 34 | 8,317 | 51 | 114,396 | 44 |
| MPO | 855 | 25 | 252 | 36 | 869 | 49 | 0 | - | 13,794 | 19 | 1,591 | 27 | 17,361 | 22 |
| PJC | 909 | 96 | 2,100 | 76 | 1,449 | 62 | 17 | 100 | 6,203 | 46 | 0 | - | 10,678 | 48 |
| PJG | 65,676 | 42 | 13,225 | 37 | 93,597 | 43 | 33,158 | 47 | 54,838 | 37 | 31,155 | 49 | 291,649 | 42 |
| PJO | 97,007 | 39 | 260,351 | 39 | 111,055 | 30 | 191,213 | 32 | 146,107 | 45 | 42,707 | 36 | 848,440 | 37 |
| **Shrubland** | | | | | | | | | | | | | | |
| MMS | 1,946 | 55 | 20,577 | 28 | 151 | 60 | 45,624 | 28 | 32,225 | 28 | 65,965 | 40 | 166,488 | 34 |
| **Grasslands** | | | | | | | | | | | | | | |
| CPGB | 31,992 | 74 | 214 | 84 | 38,759 | 74 | 3,505 | 75 | 12,815 | 75 | 1,901 | 75 | 89,186 | 75 |
| MSG | 20,028 | 63 | 6,835 | 61 | 37,045 | 62 | 0 | - | 137 | 91 | 49,740 | 61 | 113,785 | 65 |
| SDG | 6,424 | 91 | 1,747 | 94 | 2,896 | 92 | 14,982 | 94 | 28,231 | 92 | 1,708 | 93 | 55,988 | 93 |
| Overall rating | 585,704 | 67 | 540,042 | 48 | 614,073 | 64 | 460,081 | 48 | 517,699 | 49 | 492,765 | 58 | 3,210,364 | 56 |

[1] RC = reference conditions: Departure ratings from references conditions are, overall rating is an area weighted average based on ERU acreage contribution to each local unit:

| 0 to 33% = Low | 34 to 66% = Moderate | 67 to 100% = High |
|---|---|---|

## Climate Change

The USDA FS Southwestern Regional Office has compiled the best available science (BASI) for climate change relevant to forest planning in the Southwest (USDA FS 2010a). Climate scientists agree that the earth is undergoing a warming trend and human-caused elevations in atmospheric concentrations of carbon dioxide ($CO_2$) and other greenhouse gases are chief among the potential causes of global temperature increases. The concentrations of these greenhouse gases are projected to increase into the future. Climate change may intensify the risk of ecosystem change for terrestrial and aquatic systems, affecting ecosystem structure, function, and productivity (USDA FS 2010a). In broad terms it may be helpful to think of future climate simply as a potential stressor of significant change (Triepke 2015).

USDA FS Southwestern Regional Office has compiled a climate change vulnerability assessment (Triepke 2015). The Climate Change Vulnerability Assessment (CCVA) was an ecosystems approach to predicting vulnerability based on climate change projections at the year 2090. Much of the underpinning knowledge and geography of vegetation-climate relationships stems from the Terrestrial Ecological Unit Inventory (TEUI) of the Forest Service Southwestern Region (USDA FS 1986a; Winthers et al. 2005). In order to adequately predict vulnerability, the landscape was first stratified into recognizable ecosystem strata, or Ecological Response Units (ERUs), that repeat across the landscape. Then, base level polygons (segments) were generated for the entire analysis area by USDA FS Remote Sensing Application Center (RSAC), with

each segment representing similar site potential at the scale of individual plant communities. Segments were attributed with biophysical, contemporary climate, and projected climate variables. Climate envelopes were then developed for each ERU using contemporary climate data, according to the most discriminating climate variables. Finally, each segment was assigned a vulnerability score based on the projected departure in future climate from the current climate envelope of the given ERU. From the resulting vulnerability surface, departure scores are averaged together across a report area, such as a watershed or administrative unit, for each major ERU in the reporting areas. The resulting assessment provides a measure of vulnerability for major upland ecosystems, expressed in graphics and tabular summaries for each requested reporting area.[12]

The study (Triepke 2015) resulted in an all-lands vulnerability assessment for upland ecosystems of Arizona and New Mexico. Based on the anticipated climate change effects to vegetation site potential in the late 21st Century, individual plant communities were assessed and scored according to the degree by which the characteristic climate envelope of the ecosystem was exceeded with future climate model projections. The vulnerability results were validated based on known climate patterns among major ecosystem types, and based on similar assessments for the Southwest.

Table 12 displays the results of the assessment for the Gila NF. The SFF ERU has the greatest level of vulnerability and the lowest level of uncertainty.

**Table 12. Climate change vulnerability assessment rating for the upland ERUs on the Gila NF along with an uncertainty qualifier.**

| GNF Upland ERUs | Gila NF Local Units | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
| | CCV | CCUN | CCV | CCUN | CCV | CCUN | CCV | CCUN | CCV | CCUN | CCV | CCUN | CCV | CCUN |
| **Forests** | | | | | | | | | | | | | | |
| MCD | M | M-H | H-VH | L-M | M-H | M-H | H-VH | L-M | M | M | M-H | M | M-H | M |
| MCW | M-H | M | H-VH | L-M | | | | | M | M | M-H | M-H | M-VH | L-M |
| PPE | M | M-H | M-H | M | M | M | M | M-H | M-H | M | M | M | M | M |
| PPF | M | M | H | M | M-H | M | VH | L | M-VH | L-M | M-H | M | M-H | M |
| SFF | | | | | | | | | VH | L | VH | L | VH | L |
| **Woodlands** | | | | | | | | | | | | | | |
| JUG | | | | | | | H | M | M | M | M | M-H | M-H | M |
| MPO | | | | | | | | | L | M | | | L-M | M |
| PJC | | | | | | | | | | | | | | |
| PJG | M-H | M | M | M | L | M | H-VH | L-M | M-H | M | M-H | M | M | M |
| PJO | L-M | M | | | L | M | H | M | M | M | L | M | L-M | M |
| **Shrubland** | | | | | | | | | | | | | | |
| MMS | | | L | M | | | M-H | M | L | M | L-M | M | L-M | M |
| **Grasslands** | | | | | | | | | | | | | | |
| CPGB | M | M-H | | | L-M | M-H | M-H | M | VH | L | | | M | M |
| MSG | M | M-H | M-H | M | M | M-H | | | | | M | M | M | M-H |
| SDG | L-M | M | | | | | M | M | M | M | | | L-M | M |
| Overall rating | L-M | M | M | M | M | M | M | M | L-M | M | M-H | M | M | M |

USDA FS 2013a, 2015a; Triepke 2015. Climate change vulnerability (CCV) and uncertainty (CCUN) ratings are: low vulnerability (L); moderate vulnerability (M); high vulnerability (H); and very high vulnerability (VH). Overall rating is an area weighted average based on ERU acreage contribution to each local unit. Empty cells represent no data for that particular variable within the local units

[12] See USDA FS 2013a and 2015a; Triepke et al. 2014; Triepke 2015 for a more complete description of the development of the climate change vulnerability assessment process.

Those ERUs with high vulnerability have lower resilience to regain and maintain their structure, composition and function that are characteristic of the system. Resilience may be reduced as departure in important ecosystem characteristics increase (e.g., MCD, MCW, PPF, PPE, SFF, MPO). The differences in climate change vulnerability within ERUs between the local units should guide the Forest to further investigate the causal factors of drivers and stressors and the compounding factor of future climate change within and between the local units. More information can be found in the System Drivers and Stressors Chapter.

# Individual Ecosystem Response Unit Analysis – Upland Vegetation

The following upland vegetation discussion focuses on each individual ecological response unit (ERU) and will detail the characteristics of:

- Spatial niche/description
- Seral state proportion (i.e. vegetation structure)
- Coarse woody debris
- Snag density
- Patch size
- Fire regime (fire frequency and fire severity)
- Fire regime condition class
- Insect and disease
- Climate change vulnerability

Each ERU will be evaluated for departure of current conditions from reference conditions and trends described for those relationships. Finally a risk assessment to ecological integrity and sustainability will be completed for each ERU.

## Forested ERUs

### *PONDEROSA PINE FOREST (PPF) ERU:*

#### Spatial Niche

The PPF is widespread and at 3,805,078 acres (8.1%) within the context area and 630,280 acres (19.3%) of the Gila NF, represents the second largest ERU within both the context area and Forest. The Gila NF's niche for this ERU is approximately 17% of the ERU within the ecoregion sections. However, it has a greater proportional representation on the Forest (0.41) than in the context area. This ERU has a 91% departure rating at the plan scale (Table 14), however, within the PPF, across the Forest this varies from a low of 85% to a high of 96% within the Black Range and Lower Gila River local units, respectively. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the high departure rating of this ERU within the context area, 93%. Seral state representation within the context area follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally large size tree-open canopy nature to a medium sized tree-closed canopy condition throughout its range within the ecoregion.

Figure 10 and Figure 11 show that the majority of this ERU occurs in the northern portion of both the context area and Forest. Table 13 displays the acreage and proportion of the PPF ERU within the local units and Forest.

**Table 13. PPF ERU acreage and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 219,333 | 34.8 | 62,032 | 9.8 | 197,615 | 31.4 | 28,408 | 4.5 | 32,647 | 5.2 | 90,245 | 14.3 | 630,280 | 19.3 |

This ERU ranges from a high 219,333 acres (34.8%) to a low of 28,408 acres (4.5%) in the Apache and Mogollon Front, respectively. Over half of the ERU, nearly 70% occurs within two local units, the Apache and Little Colorado-San Agustin Fringe.

## General Description

This ERU (Figure 9) generally occurs on loose, well-drained soils derived from igneous, metamorphic, and sedimentary parent material at elevation ranging from 6,000 to 10,000 feet. Ponderosa pine forest is typically bounded at the upper elevation by mixed conifer forest, and at the lower elevation by grasslands or piñon-juniper woodlands, although extensive intergrading of species may occur at ecotone boundaries along gradients of slope, elevation, aspect, and moisture (Moir 1993). Generally, annual precipitation ranges from 17 to 28 inches, with 45 to 55% coming between October 1st and March 31st. The dominant species in this system is ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson var. *scopulorum* Engelm. [13]). Other trees, such as Gambel oak (*Quercus gambelii* Nutt.), Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco), twoneedle piñon pine (*Pinus edulis* Engelm.), and junipers (*Juniperus* spp. L.) may be present. There is typically a shrubby understory; such as currants/gooseberries (*Ribes* spp. L.), and buckbrush (*Ceanothus* spp. L.), mixed with a variety of grasses and forbs, such as Arizona fescue (*Festuca arizonica* Vasey), mountain muhly (*Muhlenbergia montana* (Nutt.) Hitchc.), pine dropseed (*Blepharoneuron tricholepis* (Torr.) Nash), blue grama (*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths), fleabanes (*Erigeron* spp. L.), pussytoes (*Antennaria* spp. Gaertn.), and others. This ERU sometimes occurs as savannah with extensive grasslands interspersed between widely spaced clumps or individual trees. This system is adapted to drought during the growing season, and has evolved several mechanisms to tolerate frequent, low intensity surface fires.

**Figure 9. Ponderosa pine forest (PPF) ERU (M.R. White 2002)**

[13] All common names and scientific nomenclature follow USDA NRCS 2016. The PLANTS Database (http://plants.usda.gov, 2016). National Plant Data Team, Greensboro, NC 27401-4901 USA.

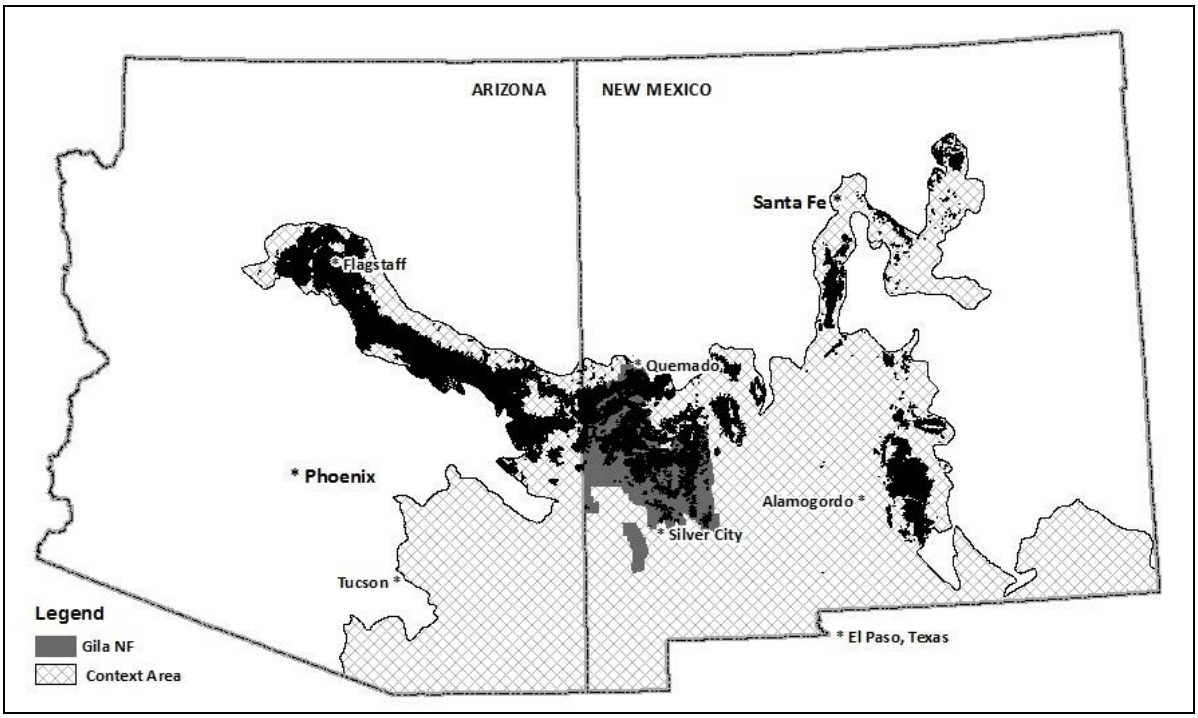


**Figure 10. General location (in black) of the ponderosa pine forest (PPF) ERU within the context area**

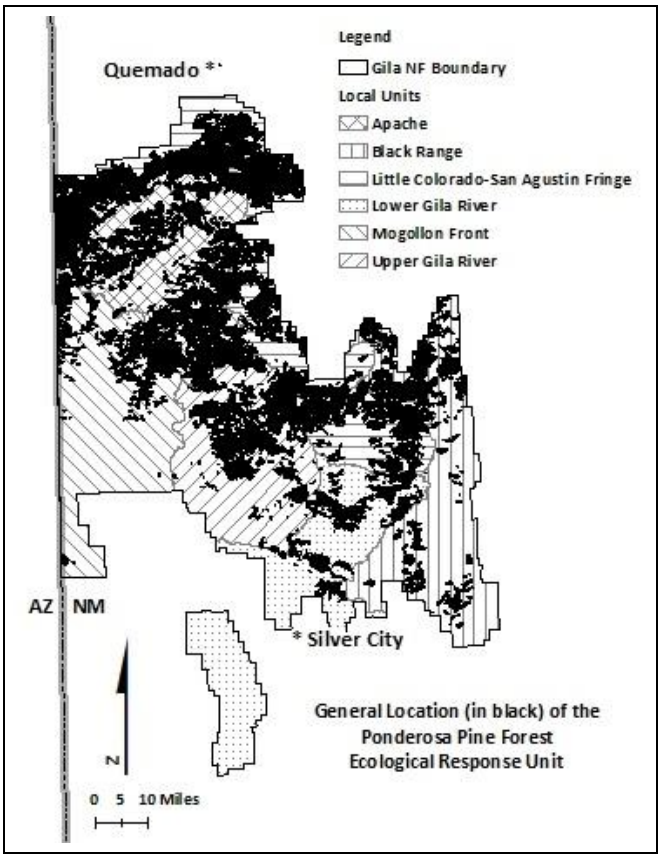


**Figure 11. General location (in black) of the ponderosa pine forest (PPF) ERU within the Gila NF and the six local units**

The PPF ERU contains two subclasses:
*Ponderosa Pine/Bunchgrass*: This subclass makes-up roughly 54% or 340,300 acres of the PPF. It is characterized by open stands supporting an understory of primarily herbaceous species, and is commonly found above the Mogollon Rim on Mollisol soils. A grassy understory, and ample needle cast/duff are the primary carriers of fire, and support frequent, non-lethal fires. The role of fire in this subclass is essential to maintain canopy openings and prevent excess young tree establishment. Common grass species include blue grama, Arizona fescue, and mountain muhly.

*Ponderosa Pine/Gambel Oak*: This subclass makes-up roughly 46% or 290,000 acres of the PPF. While structurally similar to its counterpart subclass, the ponderosa pine/Gambel oak subclass is typically found on Alfisols or Inceptisol soils and is primarily distinguished by the presence of the deciduous Gambel oak in the sub-canopy. Other common species include alligator juniper (*Juniperus deppeana* Steud.), twoneedle piñon, and New Mexico locust (*Robinia neomexicana* A. Gray).

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the PPF ERU was comprised of multistoried, medium to very large size trees with typically an open canopy nature (Table 14). Historically these forests were dominated by very shade intolerant and shade intolerant shrub and tree species that were adapted to the open canopy characteristics. Fire suppression has allowed the development of several younger age classes of trees and the accumulation of dead material on the forest floor (Covington and Moore 1992).

**Table 14. Seral state make-up of the PPF ERU under reference condition (RC) and current conditions for both the Gila NF and context area (CA).**

| Seral State | Seral State Structure, Composition and Cover Class Description | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC‡ | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A, B, F, N | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs, seedling/sapling size (< 5" dbh/drc[14]) trees with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 4 | 12 | 0 | 0 |
| C | Mid-seral: Small size (≥ 5" & < 10" dbh/drc) trees with open woody canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 4 | 5 | 0 | 0 |
| D, E | Late-seral: Medium to very large size (≥ 10" dbh/drc) trees, single storied with open woody canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 11 | 7 | 0 | 0 |
| G | Mid-seral: Small size trees with closed woody canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 11 | 15 | 0 | 0 |
| H, I, L, M | Late-seral: Medium to very large size trees, single storied or uneven-aged stands (multi-storied) with closed woody canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 61 | 55 | 0 | 0 |
| J, K | Medium to very large size trees, uneven-aged stands (multi-storied) with open woody canopy cover | 100 | 9 | 6 | 9 | 6 |
| Total | | 100 | 100 | 100 | 9 | 6 |
| Departure Index Rating† from RC = 100 - ∑ similarity values: Gila NF = (100-9) = 91% = HIGH; Context Area = (100-6) = 94% = HIGH | | | | | | |

‡ Smith 2006b; LANDFIRE 2007b; USDA FS 2015a
† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)
† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

[14] Diameter at breast height (dbh), tree diameter in inches outside bark at breast height (4½ feet aboveground) on uphill side. All timber species are measured at dbh. Diameter at root collar (drc), tree diameter in inches outside bark at root collar or at the point nearest the ground line (whichever is higher). For multi-stemmed trees, drc is calculated from an equation that incorporates the individual stem measurements. All woodland species are measured at drc (Morgan et al. 2005).

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Highly significant. Currently there is a sizeable over representation of small and medium size trees, single or multi-storied with closed woody canopy cover (seral states G, H, I, L, M) and a significant under representation of medium to very large size trees, multi-storied with open woody canopy cover (seral states J, K). There is almost no (≅ 0.02%) representation of very large size trees (20 in. +). This is also the case within the context area landscape, which has an even greater departure rating than the Gila NF (Table 14). Natural succession in the absence of fire, human ground disturbance and vegetation manipulation, ungulate grazing/browsing, and the influence of a changing climate have been the primary system drivers and stressors.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 85% in the Black Range local unit to a high of 96% in the Lower Gila River local unit (Figure 12). Regardless of the differences between the local units, all of them have a significantly high level of departure from reference condition.

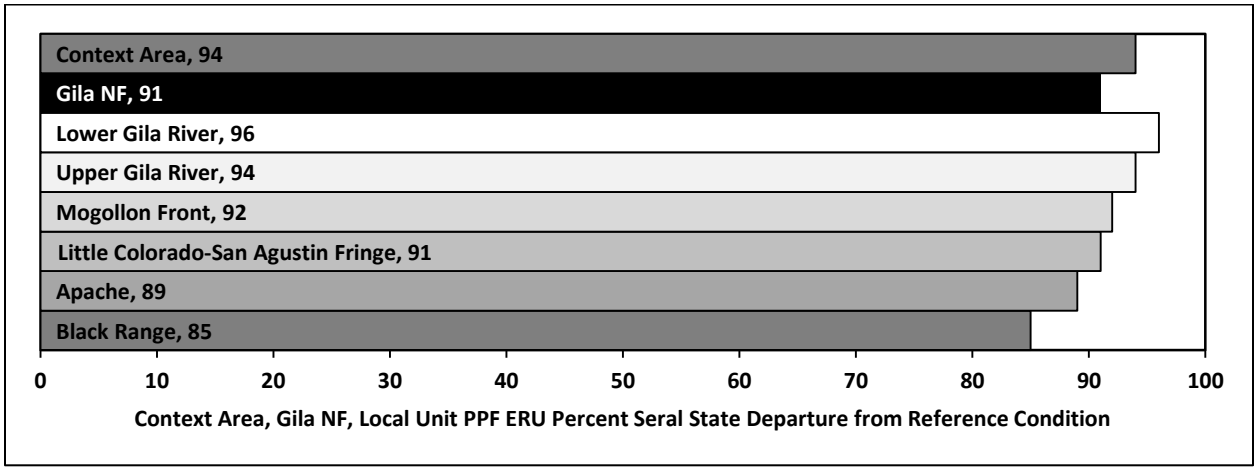


**Figure 12. Variations in seral state departure from reference condition for PPF ERU at the context area, Forest and local unit scales**

### Climate Change Vulnerability

Table 15 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the PPF ranges from moderate to very high, with the greatest level of vulnerability occurring within the Lower Gila River and Black Range local units. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the least within the Lower Gila River and Mogollon Front local units.

**Table 15. Gila NF ponderosa pine forest ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3]**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M | M | H | M | M-H | M | VH | L | M-VH | L-M | M-H | M | M-H | M |

[1] USDA FS 2013a, 2015a; Triepke et al. 2014; and Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

### Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 13 displays the state and transition modeling results for the PPF ERU at the plan scale.

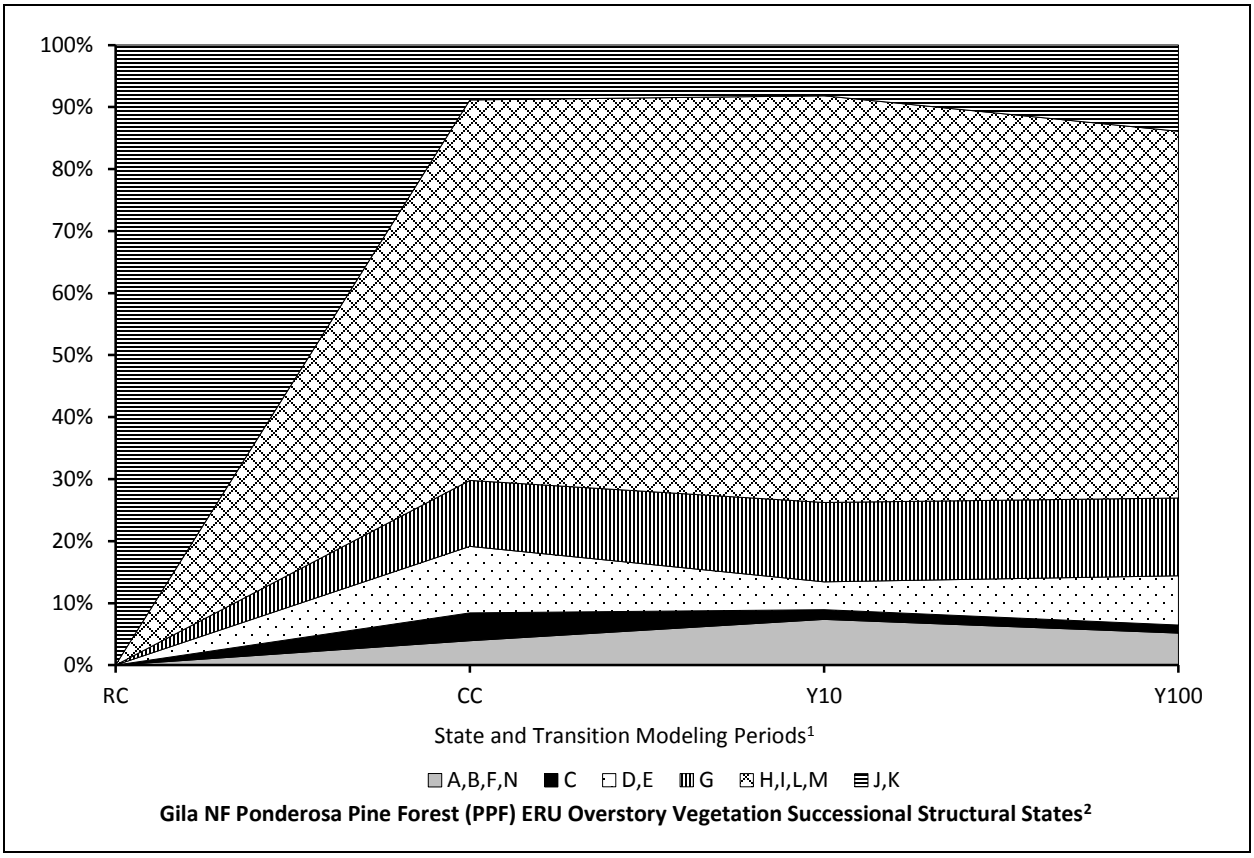


**Figure 13. Gila NF overstory vegetation successional structural states for ponderosa pine forest (PPF) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities.**

[1] RC = Reference conditions
CC = Current conditions = 91% or high departure from RC
Y10 = State and transition modeling results at 10 years = 89% or high departure from RC
Y100 = State and transition modeling results at 100 years = 86% or high departure from RC
[2] See Table 14 for a description of the overstory vegetation successional structural states

The majority of the PPF ERU consists of medium size trees, single or multi-storied with closed woody canopy cover. In addition, this condition occupies most of the modern PPF ERU landscape and was historically rare or much more localized (USDA FS 2014a). Seral states J, K represented the major vegetation state within this ERU under reference conditions. The maintenance of the predominance of seral states H, I, L, M carries on into the future under the continuation of current management with a slight trend towards (91% to 86% - 6 percentage points) reference conditions out to 100 and 1,000 years.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 9 T/ac. | |
| Current: | 35.1 T/ac. | High |
| 100-years: | 35.1 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 1.1/ac. | | 0.8/ac. | |
| Current: | 5.9/ac. | High | 1.5/ac. | Low |
| 100-years: | 5.9/ac. | High/Static | 1.5/ac. | Low/Static |

**Gila NF Mean Patch Size – Reference Conditions and Current Departure**

| | |
|---|---|
| Reference: | 0.02 to 1 ac. |
| Current: | 71 ac. |
| Departure: | High |

**Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS[15])) – Reference Conditions and Current Departure**

Fire frequency is the number of years between two successive fires in a specified area. The size of the area must be clearly specified (McPherson et al. 1990).

| | |
|---|---|
| Reference: | FF‡ = non-lethal rotation 10.5 yrs. |
| Current: | FF = 40 yrs. |
| Departure: | High |

‡ Swetnam and Dieterich 1985; Crane and Fischer 1986; Barrett 1988; Bradley et al. 1992a and 1992b; Brown 1994; Baisan and Swetnam 1995; Morgan et al. 1996; Brown 2000; Sneed et al. 2002; Muldavin et al. 2003; Schussman et al. 2006; Smith 2006b; Abella and Fulé 2008; O'Connor et al. 2014; Krausmann and Triepke 2015; Swetnam and Falk 2015

Stand replacement fires were generally restricted to the closed canopy forest. Topography (aspect, substrate depth, slope, position, etc.) exerted strong control over fire behavior producing spatially and temporally mixed severity regimes (LANDFIRE 2007b). Frequent low intensity fire in gentle topography resulted in stands of large, old-growth trees with high base height and wide canopy spacing (Merriam and Stejneger 1890; Woolsey 1911; Shreve 1915).

[15] Vegetation Burn Severity: The effect of a fire on vegetative ecosystem properties, often defined by the degree of scorch, consumption, and mortality of vegetation and the projected or ultimate vegetative recovery (Lentile et al. 2006; Morgan et al. 2001). The vegetation burn severity of a fire depends on the fire intensity and the degree to which ecosystem properties are (or are not) fire resistant. For example, a fire of exactly the same fireline intensity might kill thin-barked trees but have little effect on thick-barked trees, or it may root-kill rather than canopy-kill trees, which would result in greater mortality than initially observed (Parsons et al. 2010). Burn severity indicators are classified and defined as follows (Parsons et al. 2010): 1) Low Soil Burn Severity - Surface organic layers are not completely consumed and are still recognizable. Structural aggregate stability is not changed from its unburned condition, and roots are generally unchanged because the heat pulse below the soil surface was not great enough to consume or char any underlying organics. The ground surface, including any exposed mineral soil, may appear brown or black (lightly charred), and the canopy and herbaceous understory vegetation will likely appear "green." 2) Moderate Soil Burn Severity - Up to 80 percent of the pre-fire ground cover (litter and ground fuels) may be consumed but generally not all of it. Fine roots (≅ 3/32 in. diameter) may be scorched but are rarely completely consumed over much of the area. The color of the ash on the surface is generally blackened with possible gray patches. There may be potential for recruitment of effective ground cover from scorched needles or leaves remaining in the canopy that will soon fall to the ground. The prevailing color of the site is often "brown" due to canopy needle and other vegetation scorch. Soil structure is generally unchanged. 3) High Soil Burn Severity - All or nearly all of the pre-fire ground cover and surface organic matter (litter, duff, and fine roots) is generally consumed and charring may be visible on larger roots. The prevailing color of the site is often "black" due to extensive charring. Bare soil or ash is exposed and susceptible to erosion, and aggregate structure may be less stable. White or gray ash (up to several centimeters in depth) indicates that considerable ground cover or fuels were consumed. Sometimes very large tree roots (> 3 in. diameter) are entirely burned extending from a charred stump hole. Soil is often gray, orange, or reddish at the ground surface where large fuels were concentrated and consumed.

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfires within the PPF ERU is 15,677 acres; roughly 89% at low severity, 9% at moderate severity and 2% at high severity (Table 16). Fire suppression has resulted in much higher numbers of trees per area and the loss of most openings. And when fires occur, they often are of such intensity that the entire plant community is replaced (Kaufmann et al. 1992). Current fire severity is rated at 17.2%, higher than reference condition's 12.5% (Schussman et al. 2006), nevertheless, giving it a low departure rating.

**Table 16. Gila NF local unit PPF 19-year average annual acres burned by wildfire and percent burn severity by local unit**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 3,085 ac. | | | Black Range 1,886 ac. | | | Little Colorado-San Agustin Fringe 2,888 ac. | | | Lower Gila River 550 ac. | | | Mogollon Front 276 ac. | | | Upper Gila River 6,993 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 90 | 8 | 1 | 83 | 12 | 5 | 88 | 11 | 1 | 83 | 13 | 4 | 85 | 12 | 4 | 92 | 7 | 2 |

‡ 19-year period is 1996 through 2015
† Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC[16]) – Reference Conditions and Current Departure

Describes the patterns of fire seasonality, frequency, size, spatial continuity, intensity, type (crown fire, surface fire, or ground fire), and severity in a particular area or ecosystem (Agee 1994; Mutch 1992; Johnson and Van Wagner 1985; Sugihara et al. 2006). A fire regime is a generalization based on the characteristics of fires that have occurred over a long period. Fire regimes are often described as "cycles" or "rotations" because some parts of the histories usually get repeated, and the repetitions can be counted and measured.

| | | | | |
|---|---|---|---|---|
| Reference: | FRCC I‡ | | | |
| Current: | FRCC I = 0.0% | FRCC II = 14.3% | FRCC III = 76.0% | No data = 9.7% |
| Departure: | High, trend is expected to continue away from reference conditions | | | |

‡ Krausmann and Triepke 2015

In PPF ERU systems (subclass ponderosa pine/bunchgrass) supporting a predominantly grass understory, fire regime condition class (FRCC) I historically burned frequently with low intensity fire. In PPF ERU systems (subclass ponderosa pine/Gambel oak) supporting a more robust shrub component, the FRCC III historically burned with mixed severity (NIFTT 2010; Wahlberg et al. 2014). This ERU has a FRCC of III.

[16] FRCC reflects the degree of departure of the ERU's current fire regime from its reference condition fire regime (Heinselman 1973; Hann and Bunnell 2001; Barrett et al. 2010). Condition classes rank the changes in the fire regime and the resulting proportions of vegetation states, and are represented by one of three classes (Schmidt et al. 2002): FRCC I - Within reference conditions (0-33% departure). Fire regimes within or near historical range (e.g. fire frequencies have departed from historical range by no more than one return interval). There is a low risk of losing key ecosystem components. Vegetation attributes (composition and structure) are intact and functioning within historical range. These areas can be maintained within the historical fire regime by such treatments as fire use; FRCC II - moderately departed from reference conditions (34-66% departure). Fire regimes have been moderately altered from their historical range (e.g. fire frequencies have either increased or decreased from range by more than one interval). Moderate changes in fire size, frequency intensity, severity or landscape pattern has resulted. There is a moderate risk of losing key ecosystem components. Vegetation attributes (composition and structure) have been moderately altered from the historical range. These areas may need moderate levels of restoration treatments, such as fire use, hand or mechanical treatments to be restored to historical regime; and FRCC III - severely departed from reference conditions (67-100% departure). Fire regimes have been significantly altered from their historical range (e.g. fire frequencies have departed from historical range by multiple return intervals). Dramatic changes in fire size, frequency, intensity, severity or landscape pattern has resulted. Vegetation attributes (composition and structure) have been significantly altered from the historical range. These areas may need high levels of restoration treatments, such as hand or mechanical before fire is used to restore to historical fire regimes. The higher the condition class number the more altered the ecosystem is from reference condition.

However, based on the acreage of the two subclasses, there should be a slightly greater amount of FRCC I than FRCC III.

FRCC I characteristics were facilitated by understory vegetation dominated by fine fuels (grasses, sedges (*Carex* spp. L.) and forbs), landscape position and adjacency to other frequent fire ERUs. Much of the forest structure was open canopy overstory that resulted in an understory dominated by healthy and vigorous plants and generally continuous fine fuels layer. These fine fuels facilitated fire spread and thinning of the conifers. Beyond fire studies, little is known about historic disturbance factors that shaped ponderosa pine forests in historic times, because settlement and disturbance disruption occurred simultaneously.

### Gila NF Insects and Disease – Reference and Current Conditions

Over the last 18 years, on an annual average, insects and disease have affected nearly 6,613 acres. The highest level occurred in 2003 at 50,741 acres. Overall, nearly 19% of this ERU has been affected by insect and disease activities since 1997.

There are several species of bark beetles that attack ponderosa pines in the Southwest. The primary species on the Gila NF are: the western pine beetle (*Dendroctonus brevicomis*), the roundheaded pine beetle (*Dendroctonus adjunctus*), numerous species of ips engravers (*Ips* spp.), and less commonly the red turpentine beetle (*Dendroctonus valens*) and the larger Mexican pine beetle (*Dendroctonus approximatus*). Extensive outbreaks of ponderosa pine bark beetles in the Southwest are primarily triggered and sustained by extended drought. Drought-stress appears to make trees more vulnerable to bark beetle attacks, perhaps due to reduced defense capability. Additionally, dense, crowded stand conditions can contribute to greater levels of tree mortality during outbreaks because of tree-to-tree competition for available moisture. Southwestern dwarf mistletoe (*A. vaginatum* ssp. *cryptopodum*), a parasitic plant, is the most damaging pathogen of ponderosa pine on the Gila NF. Surveys in the mid-1980s found 40% of the ponderosa pine on the Gila NF was infected (Maffei et al. 1987), which was slightly higher than the Regional average observed (36%) and higher than results from a survey conducted by Andrews and Daniels in the 1950s. Dwarf mistletoes are a persistent, chronic infection, and the overall incidence (acres affected) changes only slightly from year to year. Horizontal spread through forest stands averages one to two feet per year due to the slow development of mistletoe shoots and explosively dispersed seed (Hawksworth 1961). Dwarf mistletoes usually have a patchy distribution within infested stands and across the landscape. Root diseases typically occur at low levels in ponderosa pine stands in the Southwest, but can be more severe in localized areas. In general, root diseases reduce tree growth and longevity, often resulting in small forest openings. For more information see Ryerson (2015).

### Gila NF Invasive Plant Species[17]

There is no current Forest data that shows how many acres within the PPF ERU that are occupied ny non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein (*Verbascum thapsus* L.), weeping lovegrass (*Eragrostis curvula* (Schrad.) Nees), and bull thistle (*Cirsium vulgare* (Savi) Ten.); occurring at low levels. In addition, many roadsides within this ERU have established populations of sweetclovers (*Melilotus* spp. Mill.).

[17] Invasive plants and weeds of the National Forests and Grasslands in the Southwestern Region have been identified by White (2013). Forest Service policy defines noxious weeds as: “Those plant species designated by the Secretary of Agriculture or by the responsible state official” (FSM 2080). As defined in Executive Order 13112, an “invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. While the typical definition of a “weed” is any undesired, uncultivated plant that grows out of place and competes with other plants for water, nutrients, and space. Noxious weeds and invasive plants are species that grow and spread rapidly, replacing desired plants. Noxious weeds and invasive plants generally pose one or more of the following characteristics: aggressive and difficult to manage, poisonous, toxic, parasitic, a carrier or host for serious insects or disease and being native or new to or not common to the United States or parts thereof.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 17) leading to *potential risk due to legacy of past management or deviation from ongoing activities*; *therefore evaluate stressors and system reversibility* within the ponderosa pine forest ERU.

**Table 17. Gila NF Ponderosa pine forest ERU risk assessment matrix**

| Current PPF ERU Departure from RC (91%, high) | PPF ERU Trend after 100 Years (departure from RC 86%, high) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Most ponderosa pine forests were historically maintained by low intensity, high-frequency fire as open-canopied forests of diverse age structure. However, management practices, which included logging, fire suppression, road building, and livestock grazing, have changed these forests across the region (Cooper, 1960; Covington and Moore 1994; Lynch et al. 2000). Today many of these forests have been transformed into dense, even-aged thickets of young trees that are prone to high-intensity fire.

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors may be reversible such as epidemic insect and disease outbreaks depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *MIXED CONIFER-FREQUENT FIRE FOREST (MCD) ERU*

### Spatial Niche

The *Mixed Conifer-Frequent Fire forest* (Reynolds et al. 2013) is also known as *Warm/Dry Mixed Conifer forest* (Margolis et al. 2013). The MCD ERU is widespread and at roughly 1,174,058 acres (2.5%) of the context area and 396,244 acres (12.1%) of the Gila NF, represents the third largest ERU on the Forest and seventh largest within the context area. The Gila NF's niche for this ERU is approximately 2.5% of the ERU within the ecoregion sections. It has a greater proportional representation on the Forest (0.66) than in the context area. This ERU has a 64% departure rating (Table 19), however, within the MCD, across the Forest this varies from a low of 47% to a high of 75% within the Black Range and Apache local units, respectively. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the moderate departure rating of this ERU within the context area, 62%. However, due to the high proportional representation on the Gila NF, the Forest has a higher level of responsibility for maintenance of this ERU. Seral state representation within the context area follows the same overall pattern as within the Gila NF (Table 19). In general, this ERU has gone from a normally large size tree-open canopy nature to a medium sized tree-closed canopy condition throughout its range within the ecoregion.

Figure 15 and Figure 16 show that the majority of this ERU occurs in the northern and eastern portions of both the context area and Forest. Table 18 displays the acreage and proportion of the MCD ERU within the local units and Forest.

**Table 18. Gila NF MCD ERU acreage and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 48,327 | 12.2 | 100,020 | 25.2 | 70,947 | 17.9 | 30,165 | 7.6 | 60,984 | 15.4 | 85,801 | 21.7 | 396,244 | 12.1 |

This ERU ranges from a high 100,020 acres (25.2%) to a low of 30,165 acres (7.6%) in the Black Range and Lower Gila River, respectively. Over half of the ERU, nearly 59% occurs within three local units, the Black Range, Little Colorado-San Agustin Fringe and Mogollon Front.

### General Description

The MCD ERU (Figure 14) spans a variety of semi-mesic environments in the Rocky Mountain and Madrean Provinces. Generally, annual precipitation ranges from 16 to 32 inches, with 45-55% coming between October 1st and March 31st. In the southwestern US, mixed conifer forests may be found at elevations between 6,000 and 10,000 ft., situated between ponderosa pine, pine-oak, or piñon-juniper woodlands below and spruce-fir forests above. Typically these types were dominated by ponderosa pine in an open forest structure (< 30% tree canopy cover), with minor occurrence

**Figure 14. Mixed conifer-frequent fire forest ERU (Photo by L.J. WhiteTrifaro 2009)**

of aspen (*Populus tremuloides* Michx.), Rocky Mountain Douglas-fir, white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), and southwestern white pine (*Pinus strobiformis* Engelm.). On contemporary landscapes, more shade tolerant conifers, such as Douglas-fir, white fir ((Gord. & Glend.) Lindl. ex Hildebr.), and blue spruce (*Picea pungens* Engelm.), tend to increase in cover in late succession, contrary to conditions under the characteristic fire regime. However, historically, these species could have achieved dominance in localized settings where aspect, soils, and other factors limited the spread of surface fire. Currently, much of this type is dominated by closed structure (> 30% tree canopy cover) and climax species as a result of fire suppression.

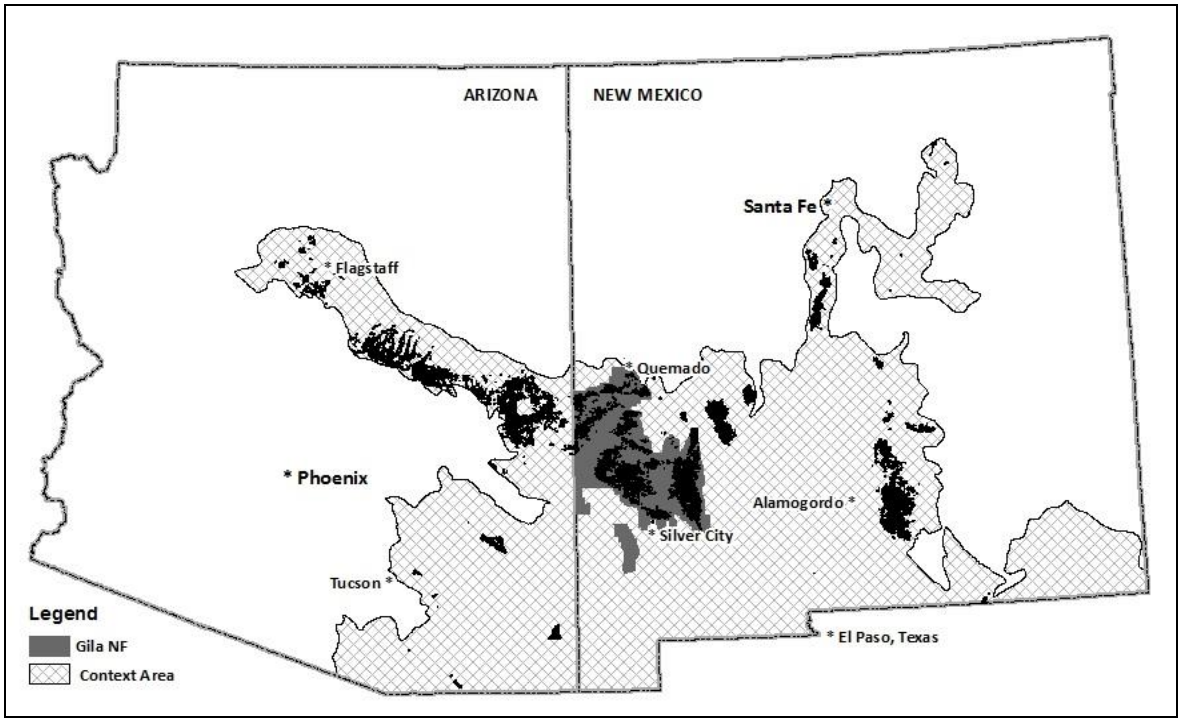


**Figure 15. General location (in black) of the mixed conifer-frequent fire forest (MCD) ERU within the context area**

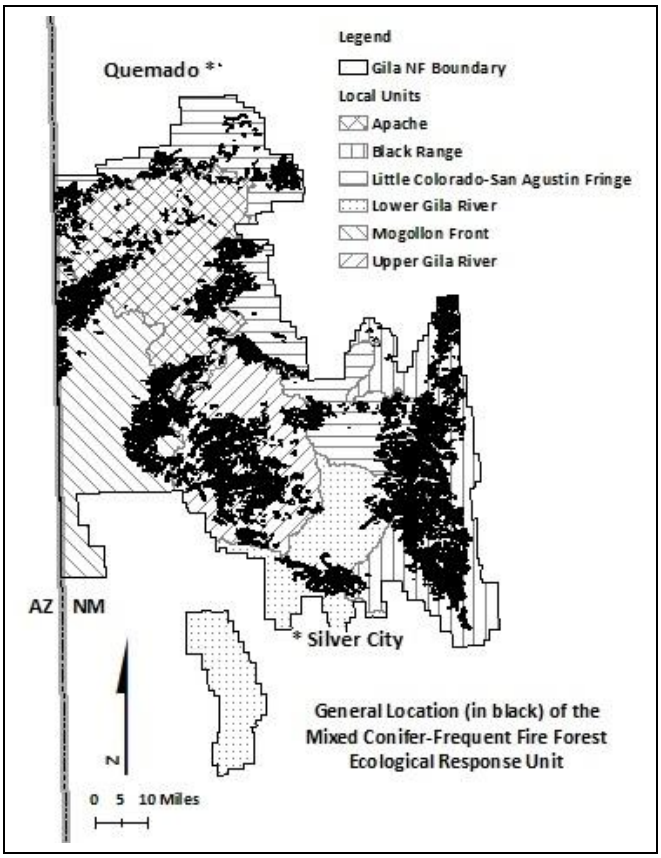


**Figure 16. General location (in black) of the mixed conifer- frequent fire forest (MCD) ERU within the Gila NF and the six local units**

Of special note for the MCD ERU in the Sky Island area of the Southwest and portions of the Gila NF is the occurrence of associations within mild climate zones, distinguished by the presence of Madrean oaks. While not currently treated as a bona-fide subclass of this ERU, the following narrative was adapted from the University of Arizona's description of Sky Island ecosystems (Malusa et al. 2013) to describe Madrean Mixed Conifer:

> The mild mixed conifer type (AKA Madrean Upper Montane Conifer-Oak Forest) occurs from 6,800 to 9,000 feet in elevation. Like the rest of the summit region, this type sits atop volcanic and sub-volcanic (almost but not quite extrusive) rocks from the middle Miocene to Oligocene (15-38 million years ago). However, sites are considerably steeper than the mixed conifer ecosystems situated in higher terrain. While 6 to 8% of the remaining mixed conifer types in the Sky Islands area are on gentle terrain of less than 18% slope, only 1% of the mild type is similarly sited. In other respects, this ecosystem is, as stated in the Nelson et al. (2015), description, "similar to Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland, which typically lacks Madrean elements" (NatureServe 2013). The vegetation is a mosaic of forest dominated by Douglas-fir on mesic slopes with Madrean oaks (silverleaf oak (*Quercus hypoleucoides* A. Camus), netleaf oak (*Q. rugose* Née), and Arizona white oak (*Q. arizonica* Sarg.)) on xeric slopes. White fir and montane pines (ponderosa pine, Arizona pine (*Pinus arizonica* Engelm.), Chihuahuan pine (*P. leiophylla* Carrière), Apache pine (*P. engelmannii* Carrière), and southwestern white pine) can be common. On a gradient between upper and lower slopes, lower elevations express a greater plurality of oaks, while upper slopes express a greater plurality of Douglas-fir and the montane pines. Piñon pine and alligator juniper occur intermittently, often in rocky areas, but are typically not dominants.

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the MCD ERU was comprised of multistoried, medium to very large size trees with typically an open canopy nature (Table 19). Historically these forests were dominated by very shade intolerant and shade intolerant shrub and tree species that were adapted to the open canopy characteristics.

**Table 19. Seral state make-up of the MCD ERU under reference (RC) and current conditions for both the Gila NF and context area (CA).**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A, B, F, N | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs, seedling/sapling size (< 5” dbh/drc) trees with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 20 | 14 | 17 | 14 | 17 |
| C | Mid-seral: Small size (≥ 5” & < 10” dbh/drc) trees with open canopy cover | 10 | 4 | 6 | 4 | 6 |
| D, E | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees, single storied with open canopy cover *(occurs on contemporary landscapes, historically rare/localized)* | 0 | 7 | 4 | 0 | 0 |
| G | Mid-seral: Small size trees with closed canopy cover | 5 | 10 | 12 | 5 | 5 |
| H, I, L, M | Late-seral: Medium to very large size trees, single or uneven-aged (multi-storied) with closed canopy cover | 5 | 57 | 57 | 5 | 5 |
| J, K | Late-seral: Medium to very large size trees, uneven-aged (multi-storied) with open canopy cover | 60 | 7 | 5 | 7 | 5 |
| Total | | 100 | 100 | 100 | 36 | 38 |

Departure Index Rating† from RC = 100 - ∑ similarity values: Plan area = (100-36) = 64% = MODERATE; and Context Area = (100-38) = 62% = MODERATE

‡ Smith 2006a; LANDFIRE 2007c; USDA FS 2013b

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation of small and medium size trees, single or multi-storied with closed woody canopy cover (seral states G, H, I, L, M) and a significant under representation of medium to very large size trees, multi-storied with open woody canopy cover (seral states J, K). This is also the case within the context area landscape; with a slightly lower (2%) departure rating than the Gila NF (Table 19). Natural succession in the absence of fire, human ground disturbance and vegetation manipulation, ungulate grazing/browsing, and the influence of a changing climate have been the primary system drivers and stressors. Fire suppression has allowed the development of several younger age classes of trees and the accumulation of dead material on the forest floor (Covington and Moore 1992).

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 47% in the Black Range local unit to a high of 75% in the Apache local unit (Figure 17). Both the Apache and Little Colorado-San Agustin Fringe local units have high departure while the other four have moderate departure. However, regardless of the differences between the local units, all of them have a significant level of departure from reference condition.

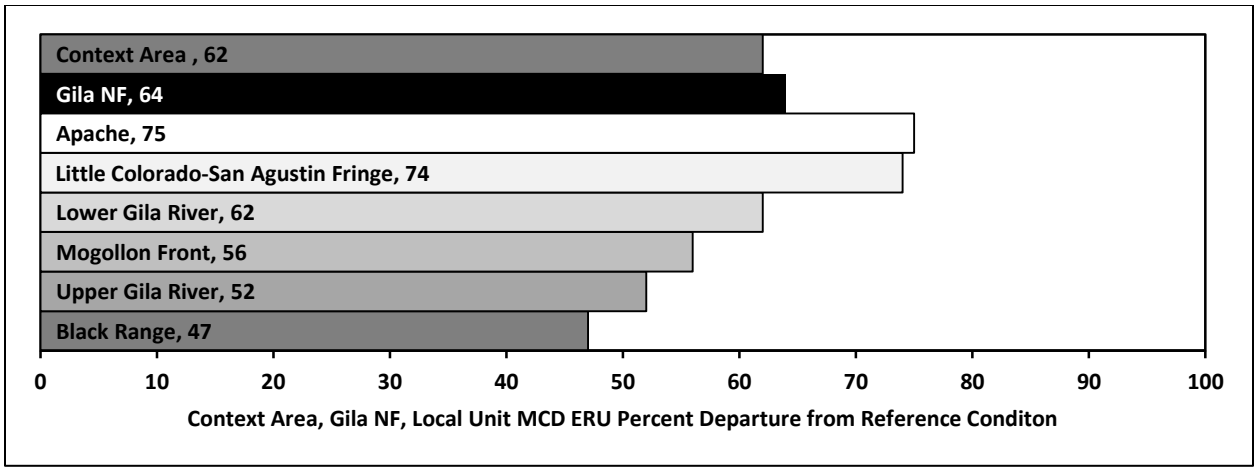


**Figure 17. Variations in seral state departure from reference condition for MCD ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 20 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the MCD ranges from moderate to very high, with the greatest level of vulnerability occurring within the Lower Gila River and Black Range local units. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the least within the Black Range and Lower Gila River local units.

**Table 20. Gila NF mixed conifer-frequent fire forest ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3]**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M | M-H | H-VH | L-M | M-H | M-H | H-VH | L-M | M | M | M-H | M | M-H | M |

[1] USDA FS 2013a, 2015a; Triepke et al. 2014; and Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 18 displays the state and transition modeling results for the MCD ERU at the plan scale.

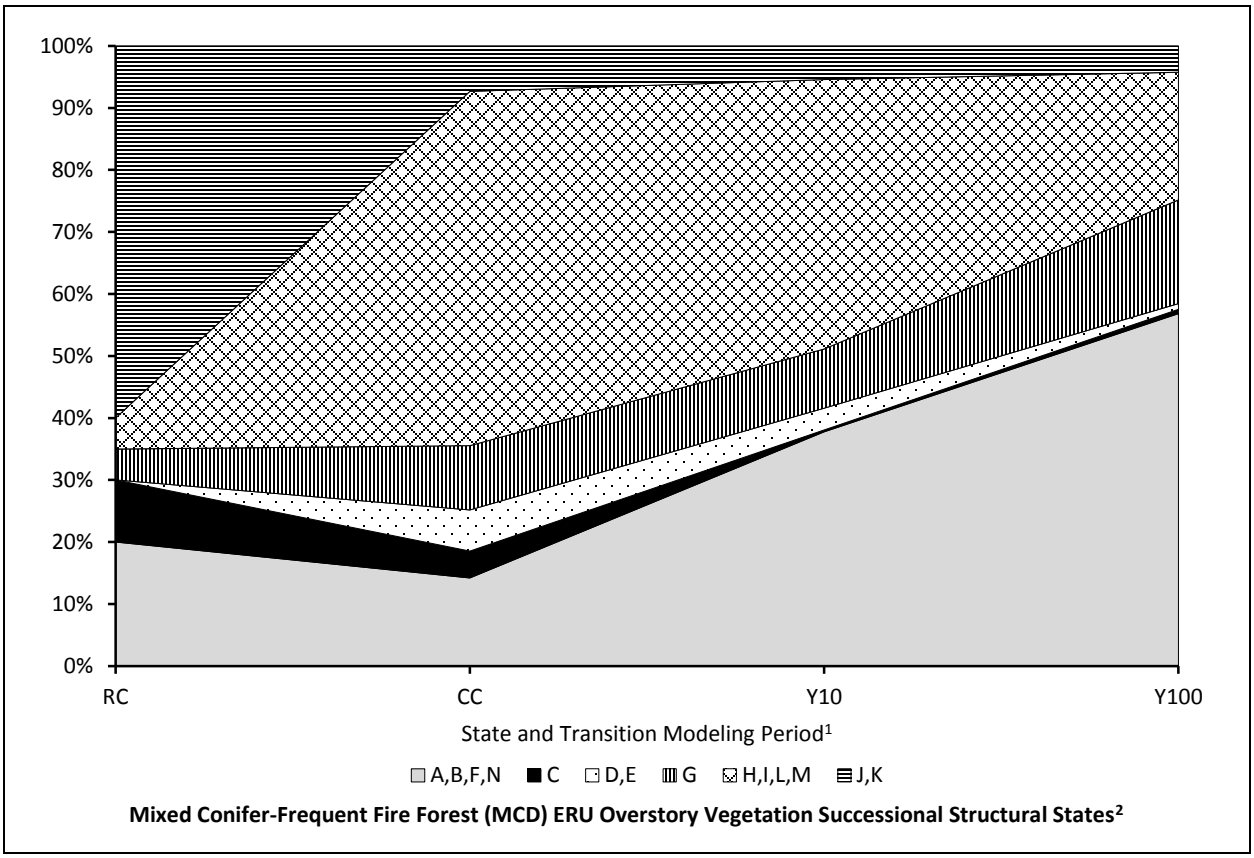


**Figure 18. Gila NF overstory vegetation successional structural states for dry mixed conifer-frequent fire forest (MCD) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities.**

[1] RC = Reference conditions
CC = Current conditions = 64% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 64% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 65% or moderate departure from RC
[2] See Table 19 for a description of the overstory vegetation successional structural states

The majority of the MCD ERU consists of medium size trees, single or multi-storied with closed woody canopy cover. There is almost no (≅ 0.05%) representation of very large size trees (20 in. +). In addition, this condition occupies most of the modern MCD ERU landscape and was historically rare or much more localized (USDA FS 2013b). Seral states J, K represented the major vegetation state within this ERU under reference conditions. The maintenance of the predominance of seral states H, I, L, M carries on into the future under the continuation of current management with a static trend (± 5%) in relation to reference conditions out to 100 years.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 13.7 T/ac. | |
| Current: | 59.1 T/ac. | High |
| 100-years: | 59.1 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 9.0/ac. | | 4.0/ac. | |
| Current: | 19.3/ac. | High | 6.5/ac. | Moderate |
| 100-years: | 19.3/ac. | High/Static | 6.5/ac. | Moderate/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 0.02 to 50 ac.

Current: 64 ac.

Departure: Low

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average rotation 13 yrs. and mixed severity rotation 77 yrs.

Current: FF = 24.4 yrs.

Departure: Moderate

‡ Baisan and Swetnam 1990; Ahlstrand 1980; Grissino-Mayer and Swetnam 1995; Heinlein et al. 2005; Smith 2006a; LANDFIRE 2007c; O'Connor et al. 2014; Huffman et al. 2015; Krausmann and Triepke 2015; Swetnam and Falk 2015

This ERU is characterized by historical FRCC I, with an average fire return frequency of 9-22 years from primarily non-lethal surface fire, though less frequent mixed severity fires also occurred (Wahlberg et al. 2014), intermediate FRI of 45-75 years on average and stand replacement fires were generally restricted to the closed canopy forest and the stand initiation conditions (LANDFIRE 2007c). This is also supported by Vander Lee et al. (2006). Little is known about pre-settlement processes in mixed conifer forests, except regarding fire, drought, insects, and their interaction. Prior to Euro-American settlement times, the fire regime of mixed conifer forests was a mixture of infrequent, small patch size, high intensity crown fires interspersed with more frequent, widespread and low intensity surface fires (Touchan et al. 1996). Additionally, there is some evidence of high-severity fire driven by topography on steep hillslopes in this forest type (Margolis and Balmat 2009; Margolis et al. 2011).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfires within the MCD ERU is 15,051 acres; roughly 68% low severity, 20% moderate severity and 12% at high severity (Table 21). Fire suppression has resulted in much higher numbers of trees per area and the loss of most openings. And when fires occur, they often are of such intensity that the entire plant community is replaced (Kaufmann et al. 1992). Current fire severity is rated at 43.3%, higher than reference condition's 17.9% (Krausmann and Triepke 2015), giving it a moderate departure rating.

**Table 21. Gila NF local unit MCD 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 668 ac. | | | Black Range 3,180 ac. | | | Little Colorado-San Agustin Fringe 1,701 ac. | | | Lower Gila River 849 ac. | | | Mogollon Front 2,037 ac. | | | Upper Gila River 6,616 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 65 | 23 | 12 | 40 | 35 | 25 | 78 | 18 | 4 | 65 | 17 | 18 | 58 | 24 | 18 | 82 | 13 | 5 |

‡ 19 year period is 1996 through 2015

† Burn severity levels are: L =low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

| | | | | |
|---|---|---|---|---|
| Reference: | FRCC‡ I (III) | | | |
| Current: | FRCC I = 25.2% | FRCC II = 67.1% | FRCC III = 0.0% | No data = 7.6% |
| Departure: | High, trend is expected to continue away from reference conditions | | | |

‡ Krausmann and Triepke 2015

For the most part, the frequent fire mixed conifer type occupies warmer and drier sites of the mixed conifer life zone, and are characterized by an historic frequent fire regime (Baisan and Swetnam 1990; Grissino-Mayer et al. 1995; Heinlein et al. 2005), low severity surface fires, and infrequent mixed severity fires.

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 2,750 acres. The highest level occurred in 2001 at 13,435 acres. Overall, nearly 12% of this ERU has been affected by insect and disease activities since 1997.

The primary bark beetles in mixed conifer forests are the Douglas-fir beetle (*Dendroctonus pseudotsugae*) in Douglas-fir and the fir engraver (*Scolytus ventralis*) in white fir. Because the Douglas-fir beetle has often been considered the primary mortality agent in Douglas-fir, the role of many of the other bark beetles and woodborers has probably been underestimated (Ryerson 2015). The activity by Douglas-fir beetle specifically, increased Region-wide during the late 1950s to epidemic levels. The outbreak on the Gila NF peaked in 1958 affecting nearly 128,000 acres. Following the 1950s drought period, little bark beetle activity in Douglas-fir was recorded. As with the bark beetles in pines, attacks under endemic population levels are typically limited to injured or diseased trees. Stand density, species composition, and host tree diameter are all important factors in determining susceptibility of attack by these bark beetles (Ferrell et al. 1994; Schmitz and Gibson 1996). The limited length of records for bark beetle activity in the mixed conifer forests of the Gila NF exhibits no major changes in outbreak frequency or duration (Ryerson 2015). In southern New Mexico and on the Gila NF specifically, western spruce budworm defoliation has often been of less concern. However, an outbreak was reported in the mid-1960s with a peak in 1964 of over 40,000 acres on the Forest. Dwarf mistletoes, root diseases and broom rusts are common in the MCD ERU, but are not above endemic levels (Ryerson 2015). One interesting note: White pine blister rust, caused by the fungus *Cronartium ribicola*, is a recently introduced non-native invasive disease in the Southwestern Region and is one of the most damaging tree diseases in North America. The disease was introduced from Europe in the early 1900s. It was first detected on the Gila NF in 2005, in Johnson Canyon, south of Luna, NM. According to Ryerson (2015), eventually this disease is expected to impact white pine populations in many areas of the Southwest and may even eradicate white pine from the most susceptible sites.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the MCD ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein and bull thistle; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 22) leading to *potential risk due to legacy of past management or deviation from ongoing activities; therefore evaluate stressors and system reversibility* within the mixed conifer-frequent fire forest ERU.

**Table 22. Gila NF Mixed conifer-frequent fire forest ERU risk assessment matrix**

| Current MCD ERU Departure from RC (64%, moderate) | MCD ERU Trend after 100 Years (departure from RC 65%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34- 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Most mixed conifer-frequent fire forests were historically maintained by low intensity, high-frequency fire as open-canopied forests of diverse age structure. However, management practices, which included logging, fire suppression, road building, and livestock grazing, have changed mixed conifer forests across the region (Cooper 1960; Covington and Moore 1994; Lynch et al. 2000). Today many of these forests have been transformed into dense, even-aged thickets of young trees that are prone to high-intensity fire.

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *PONDEROSA PINE-EVERGREEN OAK (PPE) ERU*

### Spatial Niche

The PPE is not widespread within the context area at 622,820 acres (1.3%). However, within the Gila NF this ERU is 378,156 acres (11.6%) of the Forest. Within the context area landscape this ERU is represents the 9th largest ERU within the context area landscape, but represents the 4th largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 61% of the ERU within the ecoregion sections. In addition it has a greater proportional representation on the Forest (0.79) than in the context area. In fact, it has the highest proportional representation than any other ERU on the Forest. This ERU has a 58% departure rating (Table 24), however, within the PPE, across the Forest this varies from a low of 51% to a high of 72% within the Black Range and Lower Gila River local units, respectively. The influence of the Gila NF on the sustainability of this system is much greater than other areas on the landscape for 2 reasons: a) the greater amount of the ERU is located on the Forest, and b) the high nature of departure of this ERU within the context area, 71%. Seral state representation within the context area follows the same overall pattern as within the Gila, NF but to a much greater level. In general, this ERU has gone from a normally large size tree-open canopy nature to a medium sized tree-closed canopy condition throughout its range within the ecoregion.

Figure 20 and Figure 21 show the majority of this ERU occurs within the central portion of the context are and throughout the Forest. Table 23 displays the acreage and proportion of the PPF ERU within the local units and Forest.

**Table 23. PPE ERU acreage and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 87,665 | 23.2 | 54,123 | 14.3 | 56,971 | 15.1 | 70,161 | 18.6 | 36,037 | 9.5 | 73,199 | 19.4 | 378,156 | 12.1 |

This ERU ranges from a high 87,665 acres (23.2%) to a low of 36,037 acres (9.5%) in the Apache and Mogollon Front, respectively. Over half of the ERU, nearly 61% occurs within three local units, the Apache, Upper Gila River and Lower Gila River.

### General Description

The PPE ERU (Figure 19) occurs in the mild climate gradients of central and southern Arizona and in southern New Mexico, particularly below the Mogollon Rim, where warm summer seasons and bi-modal (winter-summer) precipitation regimes are characteristic. Generally, annual precipitation ranges from 13 to 25 inches, with 40-45% coming between October 1st and March 31st. This ecological type occurs at elevations ranging from 5,500 to 7,200 feet, on sites slightly cooler-moister than the Madrean Piñon-Oak ERU, and with a much greater plurality of ponderosa pine. This system is dominated by ponderosa pine and can

**Figure 19. Ponderosa pine-evergreen oak forest ERU (Photo by M.R. White 2002)**

be distinguished from the PPF ERU by well-represented evergreen oaks (e.g., Emory oak (*Quercus emoryi* Torr.), Arizona white oak, silverleaf oak, gray oak (*Quercus grisea* Liebm.)), alligator juniper, and piñon pine. Though not an indicator in the ponderosa pine life zone, border piñon (*Pinus discolor* D.K. Bailey & Hawksw.), along oneseed juniper (*Juniperus monosperma* (Engelm.) Sarg.) can occur as a dominant or codominant component of the PPE ERU. In terms of disturbance, the PPE averaged greater fire severity than the PPF above the Mogollon Rim, and greater patchiness with less horizontal uniformity and more even-aged conditions. Site potential, fire history, and the importance of perennial grasses versus shrubs in the understory vary on a gradient between two provisional subclasses (described below). Understory shrubs include manzanita (*Arctostaphylos* spp. Adans.), Sonoran scrub oak (*Quercus turbinella* Greene), skunkbush sumac (*Rhus trilobata* Nutt.), and mountain mahogany (*Cercocarpus montanus* Raf.).

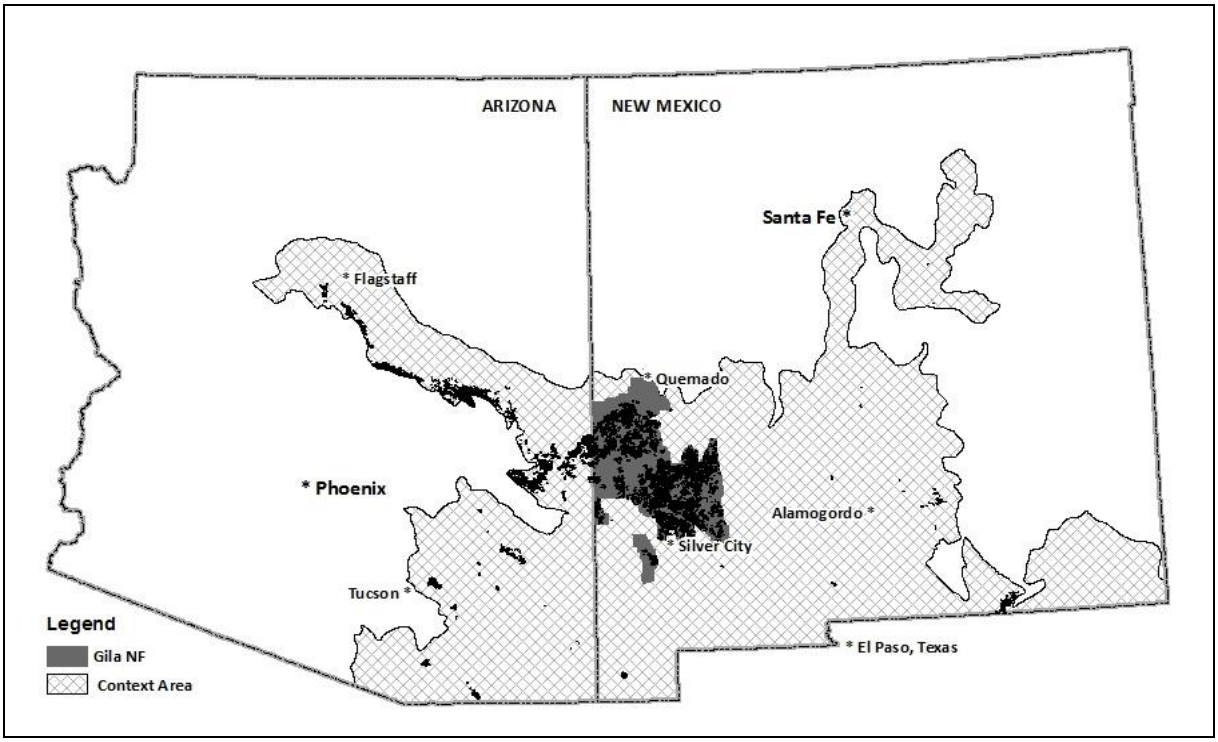


**Figure 20. General location (in black) of the ponderosa pine-evergreen oak forest (PPE) ERU within the context area**

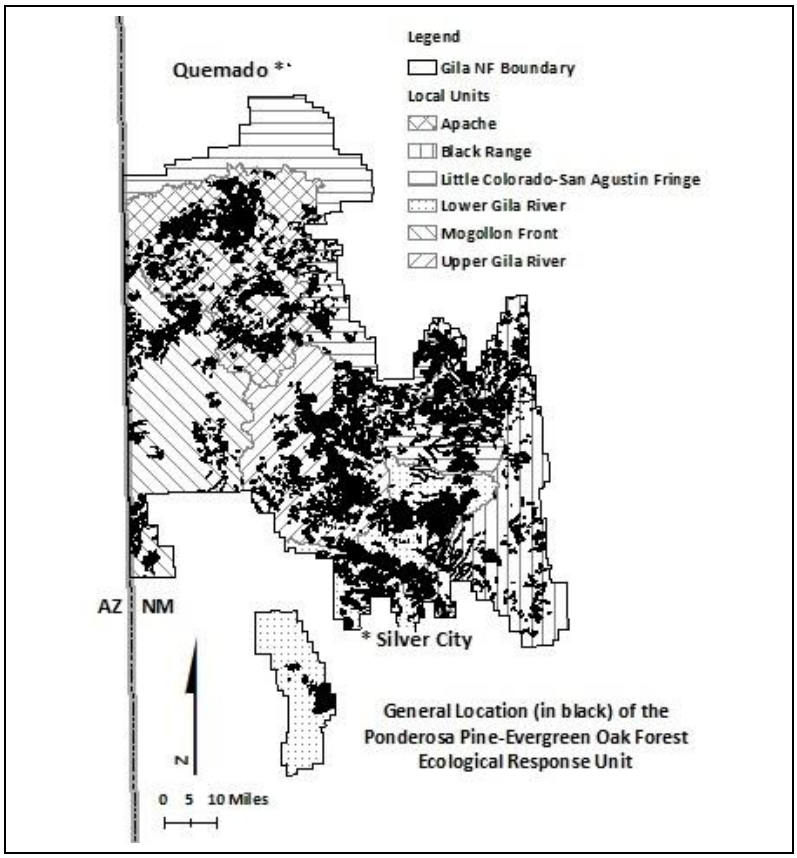


**Figure 21. General location (in black) of the ponderosa pine-evergreen oak forest (PPE) ERU within the Gila NF and the six local units**

The PPE ERU contains two subclasses, to date, these subclasses have not been distinguished geographically in regional efforts such as the *Climate Change Vulnerability Assessment* (Triepke et al. 2015), Forest Inventory and Analysis State Class Reporting, etc. The reference conditions and contemporary seral states presented later in this section reflect this ERU as a whole, without differentiation among provisional subclasses (Wahlberg et al. 2014). The two subclasses are:

*Ponderosa Pine-Evergreen Oak (Perennial Grass Subclass)*: This subclass is distinguished from the Ponderosa Pine–Evergreen Shrub subclass by a more continuous layer of perennial grasses in the understory and a relatively minor shrub component. These circumstances may be less evident in the current condition depending on the degree of shrub encroachment. Trees occur as individuals or in smaller groups and range from young to old, but were historically more uneven-aged in structure. The understory is dominated by low to moderate density shrubs, with herbaceous plants in the interspaces. Common grass species include sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), hairy grama (*B. hirsuta* Lag.) a variety of muhly's (e.g. *Muhlenbergia longiligula* Hitchc., *M. dubia* Fourn. ex Hemsl., and *M. torreyi* (Kunth) Hitchc. ex Bush). Fire frequency varied, but averaged higher with less severity. These disturbance patterns create and maintain the uneven-aged (grouped) low to moderately-closed canopy nature of this type. Site potential and disturbance history also maintained oak, juniper, and piñon as subdominant tree components, with herbaceous plants in the interspaces.

*Ponderosa Pine-Evergreen Oak (Evergreen Shrub Subclass)*: This subclass differ from the former subclass by site potential, typically favoring high shrub cover, and by higher fire severity, and more

even-aged conditions characteristic of mixed-severity fire regimes. This type is found on well-drained soils, frequently with coarse-textured or gravelly (stony) soil characteristics, that favor shrub layer development (particularly oaks). Trees occur as individuals or in small groups and patches and range from young to old, but typically groups or patches are even-aged in structure. The understory is dominated by moderate to high density shrubs, with limited grass cover.

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the PPE ERU was comprised of multistoried, medium to very large size trees with typically an open canopy nature (Table 24). Historically these forests were dominated by very shade intolerant and shade intolerant shrub and tree species that were adapted to the open canopy characteristics. Fire suppression has allowed the development of several younger age classes of trees and the accumulation of dead material on the forest floor (Covington and Moore 1992).

**Table 24. Seral state make-up of the PPE ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC[1] | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 4 | 3 | 3 | 3 | 3 |
| B | Mid-seral: Small size (≥ 5” & < 10” dbh/drc) trees with closed woody canopy cover | 3 | 12 | 18 | 3 | 3 |
| C | Mid-seral: Small size trees with open woody canopy cover | 24 | 8 | 6 | 8 | 6 |
| D | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees, single-storied or uneven-aged (multi-storied) with open woody canopy cover | 60 | 20 | 10 | 20 | 10 |
| E | Late-seral: Medium to very large size trees, single-storied or uneven-aged (multi-storied) with closed woody canopy cover | 4 | 53 | 60 | 4 | 4 |
| F | Early-seral: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover | 5 | 4 | 3 | 4 | 3 |
| Total | | 100 | 100 | 100 | 42 | 29 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 42) = 58 = MODERATE; and Context Area = (100 – 29) = 71 = HIGH

‡ Schussman and Gori 2006; USDA FS 2010b

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) –Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation of small and medium size trees, single or multi-storied with closed woody canopy cover (seral states B, E) and a significant under representation of medium to very large size trees, multi-storied with open woody canopy cover (seral states C, D). This is also the case within the context area landscape; however, with a much more highly significant departure rating (71%) than the Gila NF (Table 24). Due to the effects of long-term fire suppression in this type, in many locations the current condition is departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups; and reduced composition, density and vigor of the herbaceous understory plants. Other significant changes resulting from fire exclusion are increased homogeneity of the shrub structural stages on the landscape, facilitating larger patch sizes of high-severity fire effects. Currently, many of these sites are closed-canopy forests, capable of supporting crown fires.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 51% in the Black Range local unit to a high of 72% in the Lower Gila River local unit (Figure 22). Along with the Black Range, the other four local units have moderate departure. However, regardless of the differences between the local units, all of them have a significantly level of departure from reference condition.

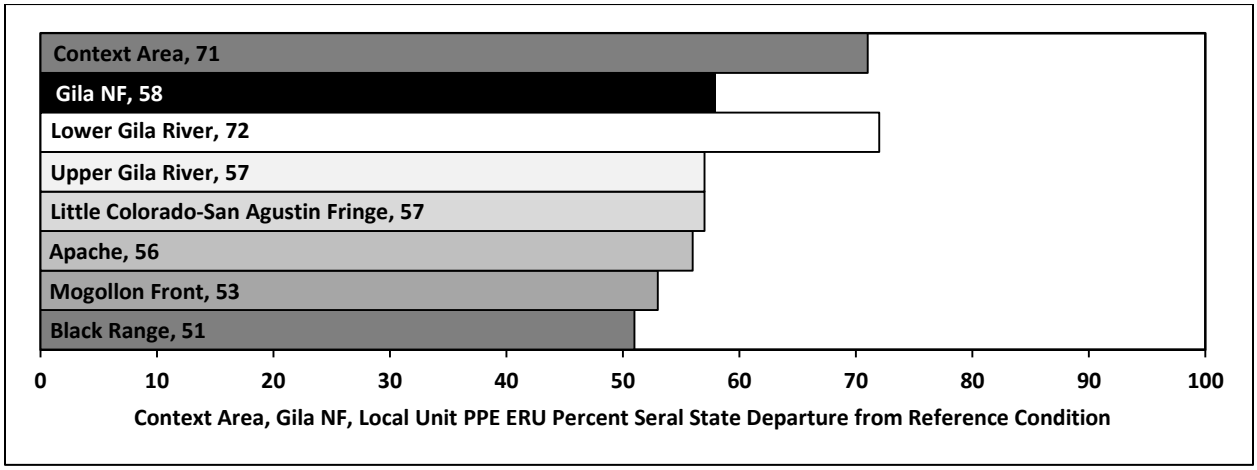


**Figure 22. Variations in seral state departure from reference condition for PPE ERU at the context area, Forest and local unit scales**

### Climate Change Vulnerability

Table 25 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the PPE ranges from moderate to high, with the greatest level of vulnerability occurring within the Black Range and Mogollon Front local units. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the greatest within the Apache and Lower Gila River local units.

**Table 25. Gila NF ponderosa pine-evergreen oak forest ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3]**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M | M-H | M-H | M | M | M | M | M-H | M-H | M | M | M | M | M |

[1] USDA FS 2013a, 2015a; Triepke et al. 2014; and Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

### Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 23 displays the state and transition modeling results for the PPE ERU at the plan scale.

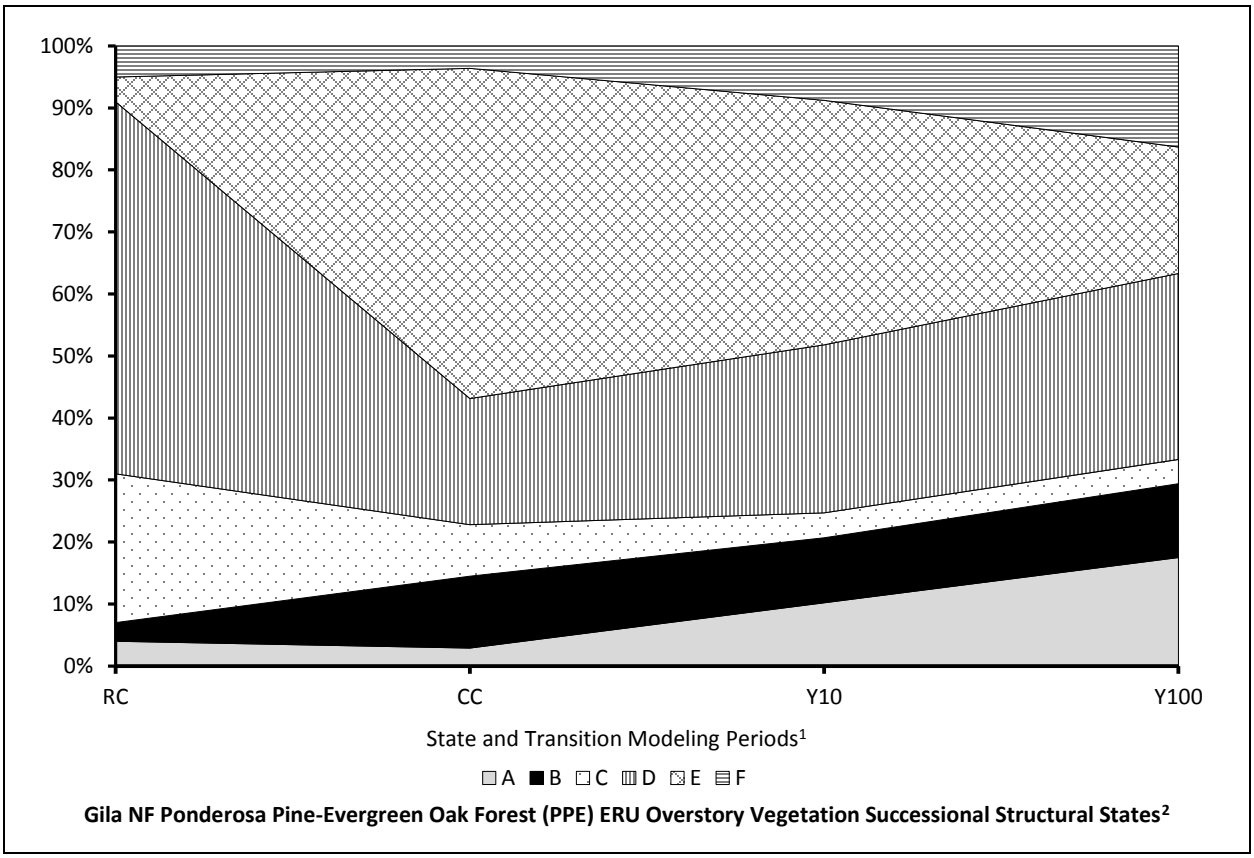


**Figure 23. Gila NF overstory vegetation successional structural states for ponderosa pine-evergreen oak forest (PPE) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 58% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 53% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 50% or moderate departure from RC
[2] See Table 24 for a description of the overstory vegetation successional structural states

The majority of the PPE ERU consists of medium size trees, single or multi-storied with closed woody canopy cover. There is almost no (≅ 0.02%) representation of very large size trees (20 in. +). In addition, this condition occupies most of the modern PPE ERU. Seral states C, D represented the major vegetation states within this ERU under reference conditions. The maintenance of the predominance of seral states A, B, C, E, and F carries on into the future under the continuation of current management with a static trend (± 5%) in relation to reference conditions out to 100 years.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 4.0 T/ac. | |
| Current: | 23.8 T/ac. | High |
| 100-years: | 23.8 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 6.0/ac. | | 1.0/ac. | |
| Current: | 6.4/ac. | Low | 1.5/ac. | Moderate |
| 100-years: | 6.4/ac. | Low/Static | 1.5/ac. | Moderate/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 0.02 to 50 ac.

Current: 34 ac

Departure: Low

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average rotation = 12.5 yrs., non-lethal rotation = 6.6 yrs., and mixed severity rotation = 110 yrs.

Current: FF = 36 yrs.

Departure: High

‡ Baisan and Swetnam 1990; Swetnam et al. 1992; Kaib et al. 1996; Kaib 2001; Schussman and Gori 2006, Abella and Fulé 2008; LANDFIRE 2007b, 2008a; Krausmann and Triepke 2015; Swetnam and Falk, 2015

Madrean piñon-oak woodland has been shown (Schussman and Gori 2006) to trend away from woodland with an open pine dominated overstory and oak understory to dense woodland with oaks and other sprouting tree species dominating the overstory (Barton 1999; Barton et al. 2001; Barton 2002; Fulé and Covington 1998). This change in density and species composition is the result of switching from centuries of predominantly low intensity frequent surface fires to decades without fire followed by stand replacing fires (Fulé and Covington 1998; Barton 2002). Frequent low intensity surface fires allow fire resistant pines to dominate a site and maintain an open stand structure. Additionally, short fire-free periods, between 20 and 30 years in length, are necessary to allow for periodic pine regeneration (Barton et al. 2001). The MPO ERU is characterized by historic fire regime group III (I), with an average fire return interval of 35-200+ years from mixed severity fire (Barrett et al. 2010; Wahlberg et al. 2014).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfires within the PPE ERU is 10,632 acres; roughly 85% at low severity, 12% at moderate severity and 2% at high severity (Table 26). Fire suppression has resulted in much higher numbers of trees per area and the loss of most openings. And when fires occur, they often are of such intensity that the entire plant community is replaced (Kaufmann et al. 1992). Current fire severity is rated at 19.0%, higher than reference condition's 16.6% (Krausmann and Triepke 2015), nevertheless, giving it a low departure rating.

**Table 26. Gila NF local unit PPE 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 528 ac. | | | Black Range 1,679 ac. | | | Little Colorado-San Agustin Fringe 1,629 ac. | | | Lower Gila River 804 ac. | | | Mogollon Front 549 ac. | | | Upper Gila River 5,444 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 94 | 6 | 0 | 79 | 17 | 4 | 89 | 10 | 1 | 86 | 11 | 3 | 69 | 25 | 5 | 86 | 12 | 2 |

‡ 19 year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

| | | | |
|---|---|---|---|
| Reference: | FRCC‡ I (III) | | |
| Current: | FRCC I = 0% | FRCC II = 100% | FRCC III = 0% |
| Departure: | High, trend is expected to continue away from reference conditions | | |

‡ Barrett et al. 2010; Wahlberg et al. 2014; Krausmann and Triepke 2015

Little is known, however, about the role of fire in the Madrean vegetation that covers portions of the mountains in southern New Mexico (Ffolliott et al. 1996). According to LANDFIRE (2007c), the fire regime of this ecological system is almost completely unknown. There are essentially no data about fire frequency, fire history or fire behavior (Baker and Shinneman 2004). It would seem that fire occurrence was determined primarily by fire occurrence in the surrounding matrix vegetation, and was ignited by lightning (Gottfried et al. 1995) during early summer (LANDFIRE 2007c). However, McPherson and Weltzin (2000) and Barton (2002), reported that this ecosystem was characterized by frequent, moderate-intensity fire during presettlement times. This system is likely predisposed to stand-replacement fires during the earliest stage of stand development. Replacement fires are assumed to have occurred every century or so, and mixed severity fires slightly less frequently (LANDFIRE 2007c).

### Gila NF Insects and Disease

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 2,145 acres. The highest level occurred in 2003 at 13,731 acres. Overall, nearly 10% of this ERU has been affected by insect and disease activities since 1997.

There is no specific information regarding insect and disease activities within the PPE ERU. However, due to many of the same tree and shrub species that occur within the PPF and the woodlands (JUG, MPO, PJC, PJG and PJO ERUs) also occur within the PPE ERU, it is likely that many of these pathogens affect the PPE ERU. Those of the PPF likely affect the higher elevations of the PPE and those from the woodlands affect the lower elevations.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the PPE ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, weeping lovegrass, cheatgrass (*Bromus tectorum* L.), and bull thistle occurring at low levels. Major roads and highways within this ERU have an abundance of the non-native white and yellow sweetclovers (*Melilotus* spp. Mill.).

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is toward reference condition (gray cells in Table 27) leadng to an assessment of *risk is addressed*; *therefore continue current management and identify restoration opportunities* within the ponderosa pine-evergreen oak forest ERU. Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change.

**Table 27. Gila NF Ponderosa pine-evergreen oak forest ERU risk assessment matrix**

| Current PPE ERU Departure from RC (58%, moderate) | PPE ERU Trend after 100 Years (departure from RC 50%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Most ponderosa pine-evergreen shrub forests were historically maintained by low intensity, high-frequency fire as open-canopied forests of diverse age structure. However, management practices, which included logging, fire suppression, road building, and livestock grazing, have changed these forests (Barton 1995, 1999, 2002; Swetnam and Baisan 1996; Arno 2000; Brown and Smith 2000; Baker and Shinneman 2004). Today many of these forests have been transformed into dense, even-aged thickets of young trees that are prone to high-intensity fire.

Restoration opportunities include vegetation treatments and silvicultural practices that restore and promote vegetative structure and composition that approximates natural range of variability (NRV) to promote stands of larger trees in more open canopy configuration and reduction in the small sized trees with closed canopies; manage fire as an integral component of ecosystem sustainability; restoration of natural processes and existing conditions that have been compromised by historical livestock management and fire suppression. Emerging and related concerns are the homogenization of the flora of this ERU. The diversity of native plants contributes to the maintenance and enhancement of above- and belowground biological interactions that keep ecological interactions intact (Printz et al. 2014). Disruptions in plant diversity by loss of species that are potentially important to the site and the threat to native species posed by nonnative species that spread in response to human activities create a host of issues related to ecosystem health. There is a need for ecological change within this ERU so that it is more resistant (withstand and maintain normal function) and resilient (recover from) to disturbances within its NRV. Resiliency requires forest characteristics such as fuel loading, species composition and stand structures be compatible with restoration of frequent surface fire functional processes. There is a need for ecological change because this ERU has experienced similar stand structural shifts as in the ponderosa pine and dry mixed conifer forest ERUs. More woody stems per acre have resulted in decreased herbaceous vegetation, increased bare ground with subsequent reductions in organic matter, soil fertility and concurrent increases in erosion and sedimentation.

Other restoration opportunities include improved travel management, road maintenance and design; and implementation of applicable best management practices (BMPs). In addition, invasive plant management is important because, according to Jordan et al. (2008), recent evidence suggests that positive feedbacks between invasive plants and soils could contribute significantly to plant invasions (Corbin and D'Antonio 2004; Ehrenfeld 2004; Scott et al. 2001; Wolfe and Klironomos 2005; Reinhart and Callaway 2006; Eppstein and Molofsky 2007), perhaps exemplifying 'ecological engineering' by biological invaders (Cuddington and Hastings 2004). Invasive species modify soils that they occupy in ways that increase their own fitness relative to that of native species (Jordan et al. 2008), and therefore, are more competitive in site occupation. For more information on stressors, see the System Drivers and Stressors Chapter.

## *MIXED CONIFER W/ ASPEN FOREST (MCW) ERU*

### Spatial Niche

The MCW is limited at 399,406 acres (0.9%) within the context area and 73,934 (2.3%) of the Gila NF, represents the 10th largest; tied with the PJC ERU within the context area, and 10th largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 19% of the ERU within the ecoregion sections. However it has a greater proportional representation on the Forest (0.45) than in the context area. This ERU has a 49% departure rating (Table 29), however, within the MCW, across the Forest this varies from a low of 49% in the AP, MF and UGR local units to a high of 62% in the BR local unit. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the moderate departure rating of this ERU within the context area, 49% (same as the Forest). Seral state representation within the context area follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally very large size tree-closed canopy nature to a more open herbaceous, smaller size-trees with a larger aspen component condition throughout its range within the ecoregion.

Figure 25 and Figure 26 show that the majority of this ERU occurs in the northern portion of the context area and south central portion of the Forest. Table 28 displays the acreage and proportion of the MCW ERU within the local units and Forest.

**Table 28. Mixed conifer w/ aspen forest ERU acreage and percent distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 5,098 | 6.9 | 17,936 | 24.3 | 2,719 | 3.7 | 3,089 | 4.2 | 19,073 | 25.8 | 26,019 | 35.2 | 73,934 | 2.3 |

This ERU ranges from a high 29,019 acres (35.2%) to a low of 2,719 acres (3.7%) in the Upper Gila River and Little Colorado-San Agustin Fringe, respectively. Over half of the ERU, nearly 61% occurs within two local units, the Upper Gila River and Mogollon Front.

### General Description

The MCW ERU (Figure 24) hosts a variety of dominant and co-dominant species spanning mesic environments in the Rocky Mountain and Madrean Provinces. Wet mixed conifer forests range in elevation from approximately 9,000 to 10,500 feet along a variety of gradients including gentle to very steep mountain slopes, situated between ponderosa pine and dry mixed conifer forests below and Spruce-Fir Forest ERU above. Generally, annual precipitation ranges from 23 to 32 inches, with 50% coming between October 1st and March 31st. Dominant and co-dominant vegetation varies in elevation and moisture availability. Ponderosa pine occurs incidentally or is absent, while Douglas-fir, southwestern white pine, white fir, and Colorado blue spruce occur as dominant and or codominant conifer species.

**Figure 24. Mixed conifer w/ aspen forest ERU (Wahlberg et al. 2014)**

Understory vegetation is comprised of a wide variety of shrubs, graminoids, and forbs depending on soil type, aspect, elevation, disturbance history, and other factors. Historically this ERU had over 10% tree canopy cover, with the exception of early, post-fire plant communities. Two subclasses exist for this ERU, with and without elk, differentiated by the presence of a quaking aspen (*Populus tremuloides* Michx.) state in the case of the latter ecosystem. The current situation on the Gila NF is with elk. Elk impacts are considered because according to (Bailey and Whitham 2002; Rolf 2001 (as cited in Smith 2006b), if elk are present, they may browse aspen until it does not produce ramets within 2-5 years. Furthermore, Bailey and Whitham (2002), also reported that after three growing seasons, elk had consumed 36 to 85 percent of aspen shoots in an unfenced burned area within a mixed conifer-ponderosa pine forest in northern Arizona. However, five years after this burn, not one of seventy regeneration plots outside of elk fences showed any living aspen sprouts, indicating heavy browsing by ungulates.

Originally aspen was conceptualized as having a unique system, however it has since been incorporated as a component of the mixed conifer w/ aspen forest ERU. This component is dominated by quaking aspen and may or may not have a significant conifer component, depending upon successional status. The understory structure may have shrubs and an herbaceous layer, or just an herbaceous layer. Common shrubs include oceanspray (*Holodiscus dumosus* (Nutt. ex Hook.) A. Heller), thimbleberry (*Rubus parviflorus* Nutt.), fivepetal cliffbush (*Jamesia americana* Torr. & A. Gray), and mountain ninebark (*Physocarpus monogynus* (Torr.) J.M. Coult.). The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Some of the species typically found associated with aspen include Nevada peavine (*Lathyrus lanszwertii* Kellogg var. *leucanthus* (Rydb.) Dorn), Fendler's meadow-rue (*Thalictrum fendleri* Engelm. ex A. Gray), elkweed (*Frasera speciose* Douglas ex Griseb.), common yarrow (*Achillea millefolium* L.), Canadian white violet (*Viola canadensis* L.), Indian paintbrush (*Castilleja* spp. Mutis ex L. f.), and several grasses and sedges (*Poa* spp. L. and sedges). Distribution of aspen within this ERU is limited by several factors including adequate soil moisture required to meet its high evapotranspiration demand, the length of the growing season or low temperatures, and major disturbances that clear areas of vegetation and stimulate root sprouting and colonization.

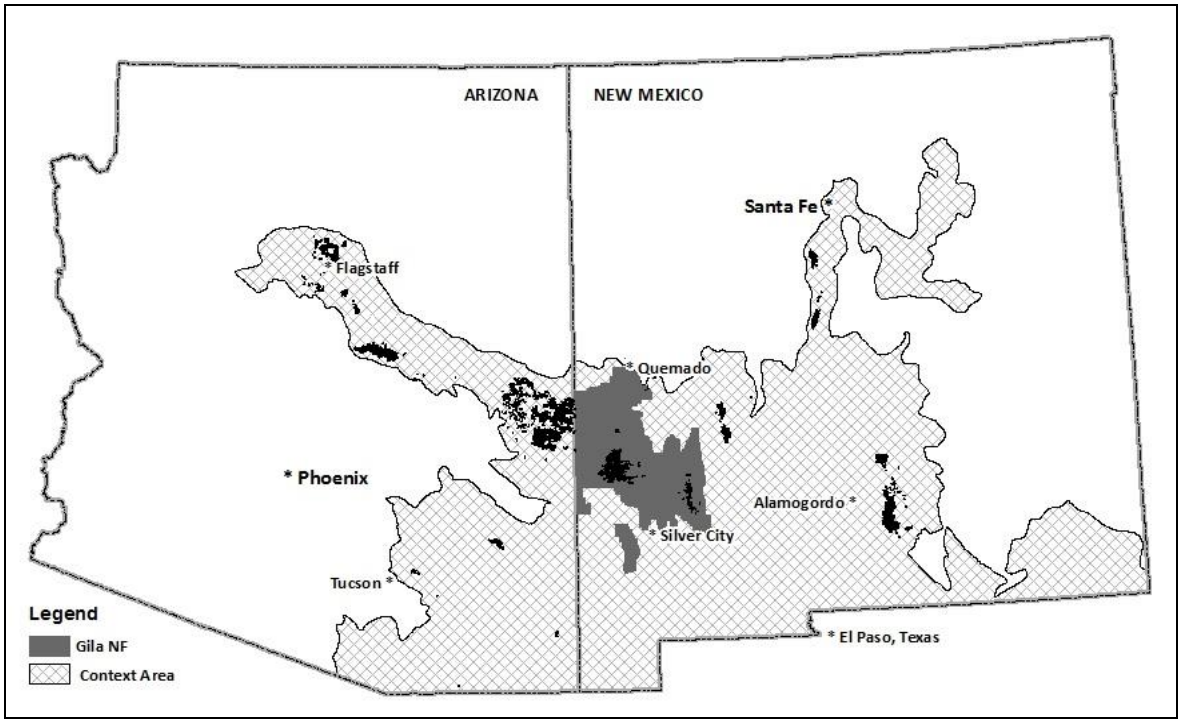


**Figure 25. General location (in black) of the mixed conifer w/ aspen forest (MCW) ERU within the context area**

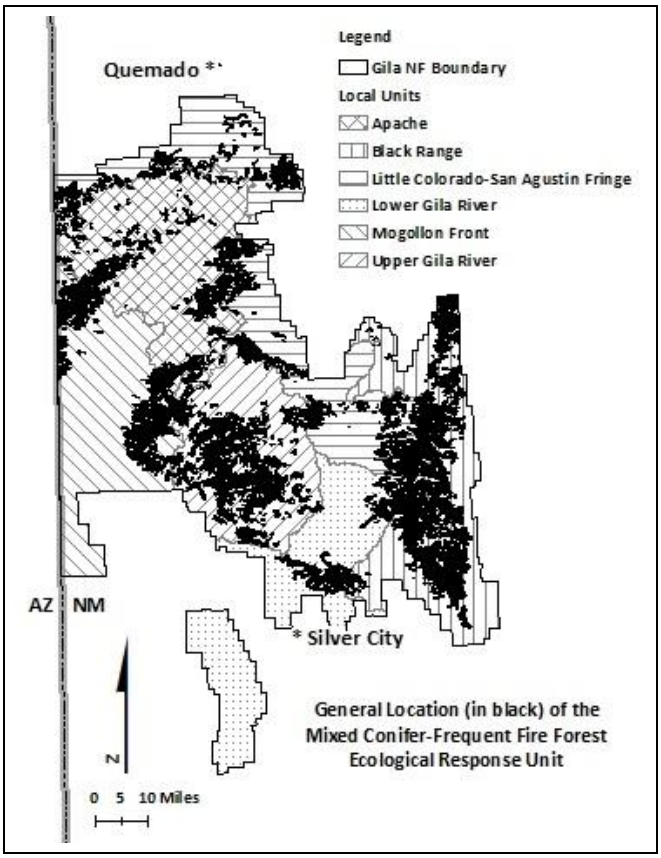


**Figure 26. General location (in black) of the mixed conifer w/ aspen forest (MCW) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the MCW ERU was comprised of single or multi-storied small to very large size-trees with typically closed canopy trees and a significant contingent of aspen (Table 29). Historically, these forests were dominated by even age stands of very shade tolerant and shade tolerant shrubs and trees that were adapted to closed canopy characteristics (Smith et al. 2008).

**Table 29. Seral state make-up of the MCW ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A, K | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 1 | 17 | 11 | 1 | 1 |
| B, T | Aspen/mixed deciduous trees of all sizes with open or closed woody canopy cover | 21 | 43 | 33 | 21 | 21 |
| C, D, G, H, L, M, P, Q | Early to mid-seral: Seedling/sapling (< 5” dbh/drc), small (≥ 5” & < 10” dbh/drc), medium (≥ 10” & < 20” dbh/drc) and large (≥ 20” & < 30” dbh/drc) tree sizes, all storiedness with open or closed woody canopy cover | 29 | 40 | 55 | 29 | 29 |
| E, F, N, O | Late-seral: Very large size (≥ 30” dbh/drc) trees, all storiedness with closed woody canopy cover | 49 | 0 | 0 | 0 | 0 |
| I, J, R, S | Late-seral: Very large size trees, all storiedness with open woody canopy cover *(occurs on contemporary landscapes only…)* | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 99 | 51 | 51 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 51) = 49 or MODERATE; and Context Area = (100 – 51) = 49 or MODERATE

‡ USDA FS 2015c; Smith 2006a, 2006c

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) –Current Departure

Departure: Moderate but still significant. Currently there is a sizeable over representation of aspen (seral states B, T) and seedling/sapling, small, medium and large size-trees, single or multi-storied with open or closed woody canopy cover characteristics (seral states C, D, G, H, L, M, P, Q); a significant under representation of very large size trees, trees, single or multi-storied with closed woody canopy cover (seral states E, F, N, O). There is almost no (≅ 0.03%) representation of very large size trees (20 in. +). This is also the case within the context area landscape, which has the same significant departure rating as the Forest. Natural succession in the presence of fire, human ground disturbance and vegetation manipulation, ungulate grazing/browsing, and the influence of a changing climate have been the primary system drivers and stressors.

### Gila NF Local Unit Variability in Seral State Departure from Reference Conditions

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 49% in the Apache, Mogollon Front and Upper Gila River local units to 62% in the Black Range local unit (Figure 27). All of the local units have moderate departure. However, regardless of the differences between the local units, all of them have a significant level of departure from reference condition.

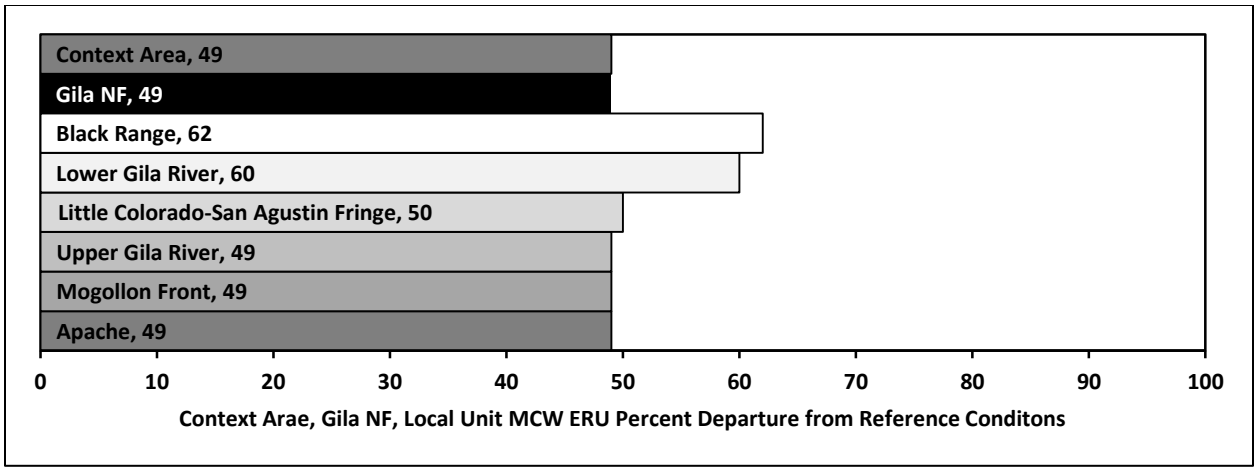


**Figure 27. Variations in seral state departure from reference condition for MCW ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 30 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the MCW ranges from moderate to high, with the greatest level of vulnerability occurring within the Black Range and Mogollon Front local units. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the greatest within the Apache and Lower Gila River local units.

**Table 30. Gila NF mixed conifer w/ aspen forest ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M-H | M-H | H-VH | L-M | ǂ | | | | M-H | M-H | M-H | M-H | M-VH | L-M |

[1] USDA FS 2013a, 2015a; Triepke et al. 2014; and Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂEmpty cells indicate no data is available for that variable

## Seral State (Successional Structural) Departure and Trend

Figure 28 displays the state and transition modeling results for the MCW ERU at the plan scale.

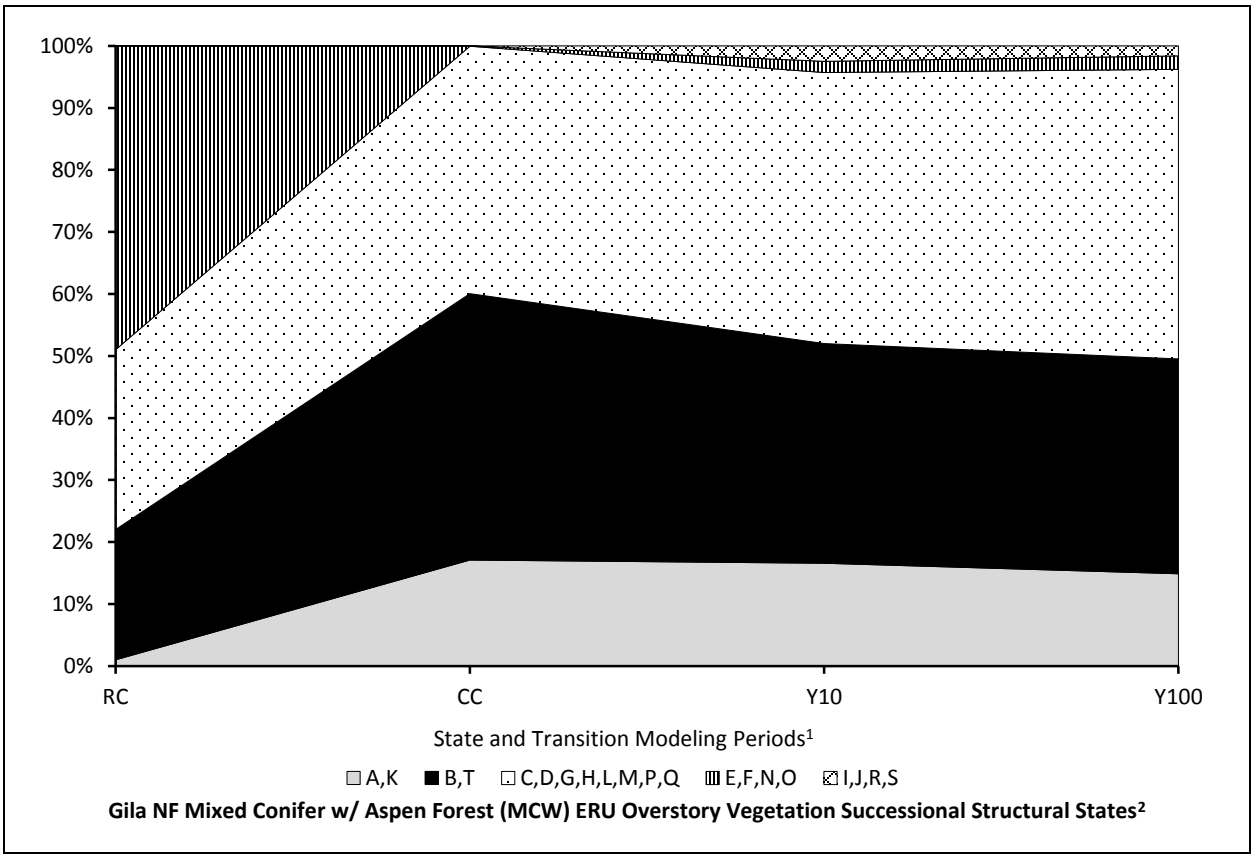


**Figure 28. Gila NF overstory vegetation successional structural states for mixed conifer with aspen forest (MCW) ERU under reference conditions (RC), current conditions, and following state and transition modeling results at 10 and 100 years, based on current management activities**

[1] RC = Reference conditions
CC = Current conditions = 49% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 47% or moderate departure form RC
Y100 = State and transition modeling results at 100 years = 47% or moderate departure from RC
[2] See Table 29 for a description of the overstory vegetation successional structural states

The majority of the MCW ERU consists of and seedling/sapling, small, medium and large size-trees, single or multi-storied with open or closed woody canopy cover characteristics, and aspen. In addition, this condition occupies most of the modern MCW ERU landscape. Seral States E, F, N, O represented the major vegetation state within this ERU under reference conditions. The maintenance of the preponderance of seral states C, D, G, H, L, M, P, and Q carries on into the future under the continuation of current management with a static trend (± 5%) in relation to reference conditions out to 100 and 1,000 years.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 30.0 T/ac. | |
| Current: | 81.7 T/ac. | High |
| 100-years: | 81.7 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 14.0/ac. | | 4.0/ac. | |
| Current: | 27.1/ac. | High | 10.2/ac. | Moderate |
| 100-years: | 27.1/ac. | High/Static | 10.2/ac. | Moderate/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 100 to 400 ac.

Current: 62 ac.

Departure: Moderate

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average 120 yrs., mixed severity rotation 100 yrs., and stand replacement rotation 150 yrs.

Current: FF = 15.6 yrs.

Departure: High

‡ Barrett 1988; Baisan and Swetnam 1990; Bradley et al. 1992a; Smith 2006a and 2006c; Romme et al. 2009a; Barrett et al. 2010; O'Connor et al. 2014; Wahlberg et al. 2014; Krausmann and Triepke 2015, Huffman et al. 2015; Swetnam and Falk 2015

MCW ERU was characterized by an average fire return interval of 50-100 years (Romme et al. 2009a; Roccaforte 2013) from both stand replacing and mixed severity fire. Small scale, stand replacing fire events play an important role in aspen regeneration, and upwards of 150 to 400 years for high intensity, stand replacing crown fires (Fulé et al. 2003; Swetnam et al. 2005; Vankat 2006; Vander Lee et al. 2006).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the MCW is 3,330 acres; roughly 47% at low severity, 22% at moderate severity and 31% at high severity (Table 31). Current fire severity is rated at 43.3%, lower than reference condition's 65.0% (Krausmann and Triepke 2015), nevertheless, giving it a low departure rating.

**Table 31. Gila NF local unit MCW 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 220 ac. | | | Black Range 209 ac. | | | Little Colorado-San Agustin Fringe 4 ac. | | | Lower Gila River 30 ac. | | | Mogollon Front 1,114 ac. | | | Upper Gila River 1,753 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 49 | 24 | 27 | 38 | 23 | 39 | 73 | 24 | 3 | 53 | 20 | 27 | 46 | 24 | 30 | 51 | 20 | 29 |

‡ 19 year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

Reference: FRCC‡ III, V

Current: FRCC I = 0.0% FRCC II = 85.2% FRCC III = 0.0% No data = 14.8%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 2,765 acres. The highest level occurred in 2013 at 28,278 acres. Overall, nearly 67% of this ERU has been affected by insect and disease activities since 1997.

The *Forest Insect and Disease History of the Gila National Forest* report (Ryerson 2015) does not differentiate between the MCD and MCW ERUs; see the MCD insect and disease section. Within the aspen component of the MCW ERU specific records of activity on the Gila NF extend only back to 1974 in available documents. However, primarily the western tent caterpillar (*Malacosoma californicum*) and the large aspen tortrix (*Choristoneura conflictana*) are the insects most often found defoliating aspen on the Gila NF. According to Ryerson (2015), this is probably due to the limited abundance of aspen on the Forest compared to other Forests in the Region and its presence in relatively remote and rugged locations such as on the Black Range. There was a widespread infection of aspen shoot blight (a fungal disease) in central and southern New Mexico in 1979. The soft bark of aspen is easily wounded by physical injury, various insects, and abiotic factors like winter injury. These wounds allow for the development of various canker diseases. Aspen is also subject to root rot. As landscape disturbances declined beginning in the early 1900s, aspen regeneration declined. The major disturbance agent missing from the landscape was fire, due to suppression efforts and the grazing related loss of fire-carrying fine fuels. Additionally, the aspen regeneration that did occur was subject to greater grazing pressure from both wildlife and domestic animals. Recently, aerial surveys have detected aspen mortality throughout NM. Aspen on southerly aspects are more susceptible to drought, particularly at the lower elevational limit of its range, and entire clones may be affected on such sites. On the Gila NF, aspen mortality has been observed throughout the Forest. A total of nearly 3,800 acres has been mapped with aspen mortality over this period.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the MCW ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein and bull thistle; occurring at low levels. Kentucky bluegrass likely occurs in this and all other mesic forest types.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 32) leading to *potential risk due to legacy of past management or deviation from ongoing activities; therefore evaluate stressors and system reversibility* within the mixed conifer w/ aspen forest ERU.

**Table 32. Gila NF Mixed conifer w/ aspen forest ERU risk assessment matrix**

| **Current MCW ERU Departure from RC (49%, moderate)** | **MCW ERU Trend after 100 Years (departure from RC 47%, moderate)** | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Disturbance regimes in contemporary wet mixed conifer forests have not been severely altered, thus, these ecosystems are generally in a condition similar to their evolutionary environment. In addition, management practices, which included logging, road building, and livestock grazing, have changed mixed conifer forests across the region (Cooper 1960; Covington and Moore 1994; Lynch et al. 2000; Romme et al. 2009a).

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant

species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease and parasites outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *SPRUCE-FIR FOREST (SFF) ERU*

### Spatial Niche

The SFF ERU is concentrated in isolated pockets at the very highest elevations within the context area. At 177,491 acres within the context area it contributes roughly 0.4% to the context landscape. At 23,779 acres the SFF ERU contributes roughly 0.7% to the Gila NF's land base. The SFF represents the 12th largest ERU within both the context area and Forest. The Gila NF's niche for this approximately 14% of the ERU within the ecoregion sections. However, it has a great proportional representation on the Forest (0.32%) than in the context area. This ERU has a 47% departure rating at the plan scale (Table 34), however, within the SFF, across the Forest this varies from a low of 46% in the MF local unit to a high of 67% in the Apache local unit. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the moderate departure rating of this ERU within the context area, 46%. Seral state representation within the context area follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally very large size tree-closed canopy nature to a more open herbaceous, smaller size-trees condition throughout its range within the ecoregion.

Figure 30 and Figure 31 show that the majority of this ERU occurs in the central portion of the context area and south central portion of the Forest. The SFF ERU does not occur in the Lower Gila River or Little Colorado-San Agustin Fringe local units. Table 33 displays the acreage and proportion of the MCW ERU within the local units and Forest.

**Table 33. Spruce-fir forest (SFF) ERU acreage distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 22 | 0.1 | 630 | 2.6 | 0 | 0.0 | 0 | 0.0 | 8,710 | 36.6 | 14,417 | 60.6 | 23,779 | 0.7 |

This ERU, where it occurs ranges from a high 14,417 acres (60.6%) to a low of 22 acres (0.1%) in the Apache, respectively. Over half of the ERU, nearly 61% occurs within one local unit, the Upper Gila River.

### General Description

Also known as sub-alpine conifer forests, the SFF ERU (Figure 29) ranges in elevation from 9,000 to 10,500 ft. along a variety of gradients including gentle to very steep mountain slopes. Generally, annual precipitation ranges from 27 to 36 inches, with 50% coming between October 1st and March 31st. The Spruce-fir forest is widespread in the Southwestern region, occurring on the Apache-Sitgreaves, Carson, Cibola, Coconino, Gila, Kaibab, Lincoln, and Santa Fe National Forests. This ERU is comprised almost entirely of Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) and/or corkbark fir (*A. lasiocarpa* (Hook.) Nutt. var. *arizonica* (Merriam) Lemmon) associations. Common understory species may include but are not limited to red baneberry

**Figure 29. Spruce-fir forest ERU (Photo by L.J. WhiteTrifaro 2009)**

(*Actaea rubra* Aiton) Willd.), sprucefir fleabane (*Erigeron eximius* Greene), strawberryleaf raspberry (*Rubus pedatus* Sm.), whortleberry (*Vaccinium myrtillus* L.), and twinflower (*Linnaea borealis* L.). Spruce-fir forests are disturbance forests, with climax seral states being less common than early seral communities (Peet 1988). Natural system drivers and stressors in this ERU include blow-down, insect outbreaks, climate change, and stand replacing fires.

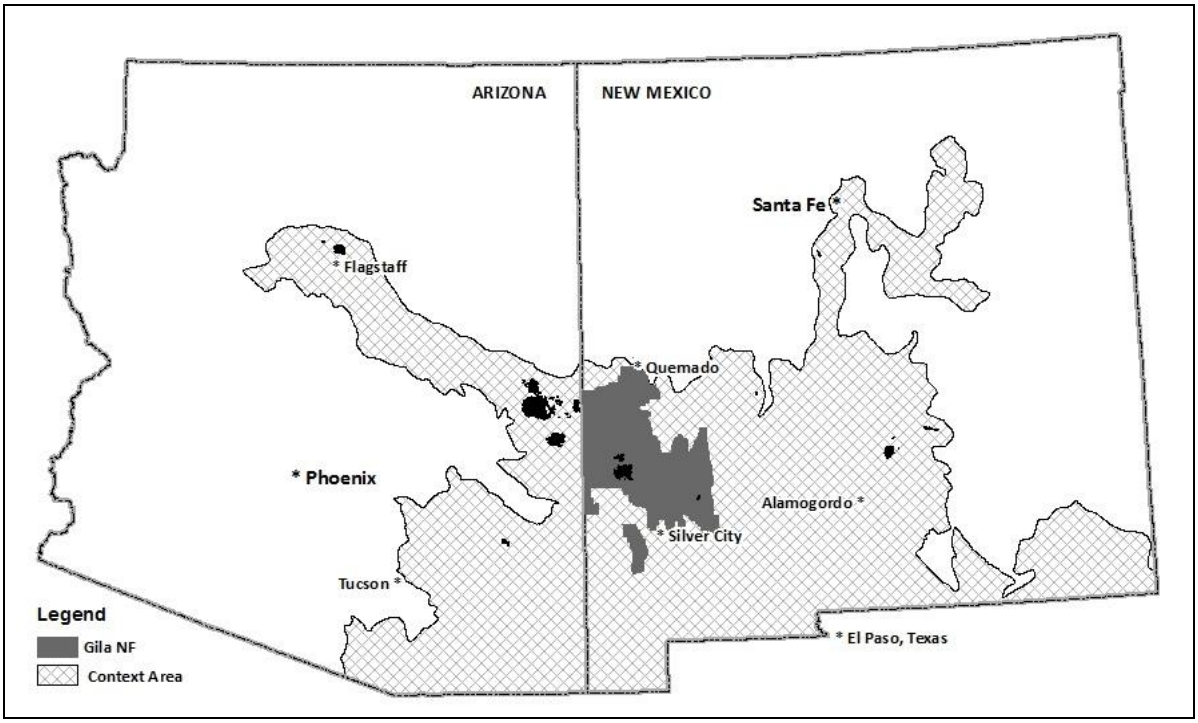


**Figure 30. General location (in black) of the spruce-fir forest (SFF) ERU within the context area**

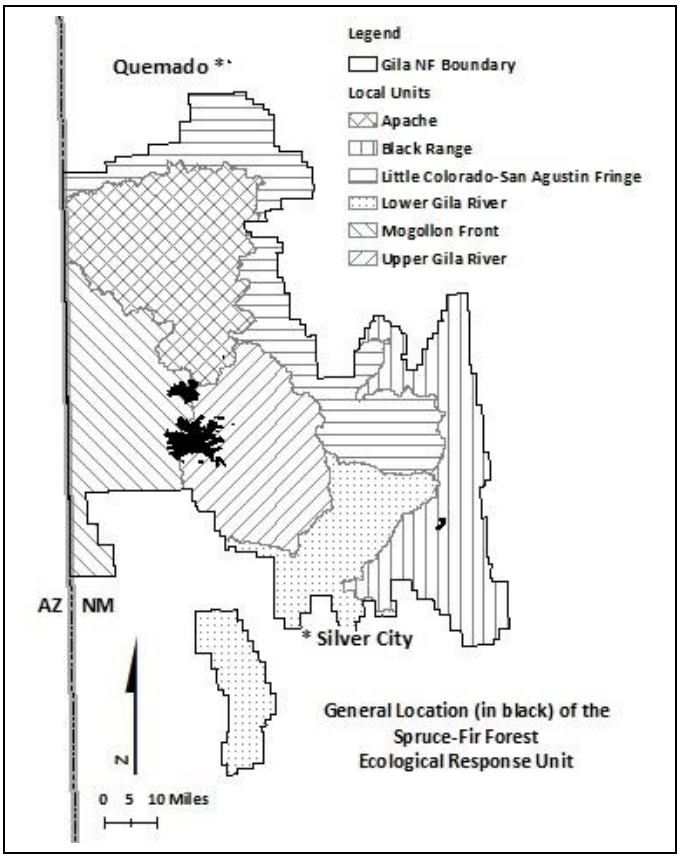


**Figure 31. General location (in black) of the spruce-fir forest (SFF) ERU within the Gila NF and the six local units**

The SFF ERU contains two Subclasses:

*Spruce-Fir Lower (AKA "Spruce-Fir Mix")*: This subclass typically occurs between 9,500 and 10,900 feet and includes a suite of mixed conifer species, especially Rocky Mountain Douglas-fir and white fir. Quaking aspen, occurs as a seral component that may be codominant or dominant (Muldavin et al. 1996). An assessment on the Kaibab NF (Higgins 2009) suggests that about 15% of the area occurs as an aspen cover type. This subclass often occurs in the transitional ecotone between the mixed conifer with aspen ERU and spruce-fir upper zone. It generally has similar process dynamics to the mixed conifer with aspen ERU but supports different tree species.

*Spruce-Fir Upper (AKA "Spruce-Fir Pure)*: Spruce and subalpine fir dominate the "Upper" subclass of this ERU which is typically found between 10,500 and 11,500 feet. It occurs adjacent to and below the Bristlecone Pine and Alpine and Tundra ERUs, above its "Lower" counterpart. This subclass does not occur on the Gila NF.

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the SFF ERU was comprised of single or multi-storied small to very large size-trees with typically closed canopy trees and a significant contingent of aspen (Table 34). Historically, these forests were dominated by even age stands of very shade tolerant and shade tolerant shrubs and trees that were adapted to closed canopy characteristics (Smith et al. 2006d).

**Table 34. Seral state make-up of the SFF ERU under reference (RC) and current conditions for both the Gila NF and context area (CA).**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A, B, C, G | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover, and seedling/sapling (< 5" dbh/drc), small (≥ 5" & < 10" dbh/drc) tree sizes with open (≥ 10% & < 30%) or closed woody canopy cover, all storiedness | 21 | 68 | 60 | 21 | 21 |
| D, H | Mid-seral: Medium to large size (≥ 10" & < 30" dbh/drc) trees, all storiedness with open or closed woody canopy cover | 33 | 32 | 39 | 32 | 33 |
| E, F | Late seral: Very large size (≥ 30" dbh/drc) trees, single or multi-storied with closed woody canopy cover | 46 | 0 | 0 | 0 | 0 |
| I, J | Late seral: Very large size trees, single or multi-storied with open woody canopy cover *(occurs on contemporary landscapes only…)* | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 100 | 53 | 54 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 53) = 47 or MODERATE; and Context Area = (100 – 54) = 46 or MODERATE

‡ USDA FS 2015d; Smith 2006d

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation the grass, forb, sparsely vegetated or recently burned and seedling/sapling, small, medium and large size-trees, single or multi-storied with open or closed woody canopy cover characteristics (seral states A, B, C, G); a significant under representation of very large size trees, trees, single or multi-storied with closed woody canopy cover (seral states E, F). There is almost no (≅ 0. 3%) representation of very large size trees (20 in. +). This is also the case within the context area landscape, which has the same significant departure rating as the Forest. Natural succession in the presence of fire, ungulate grazing/browsing, and the influence of a changing climate have been the primary system drivers and stressors.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 46% in the MF local unit to 67% in the AP local unit (Figure 32). All of the local units have moderate departure. However, regardless of the differences between the local units, all of them have a significant level of departure from reference condition.

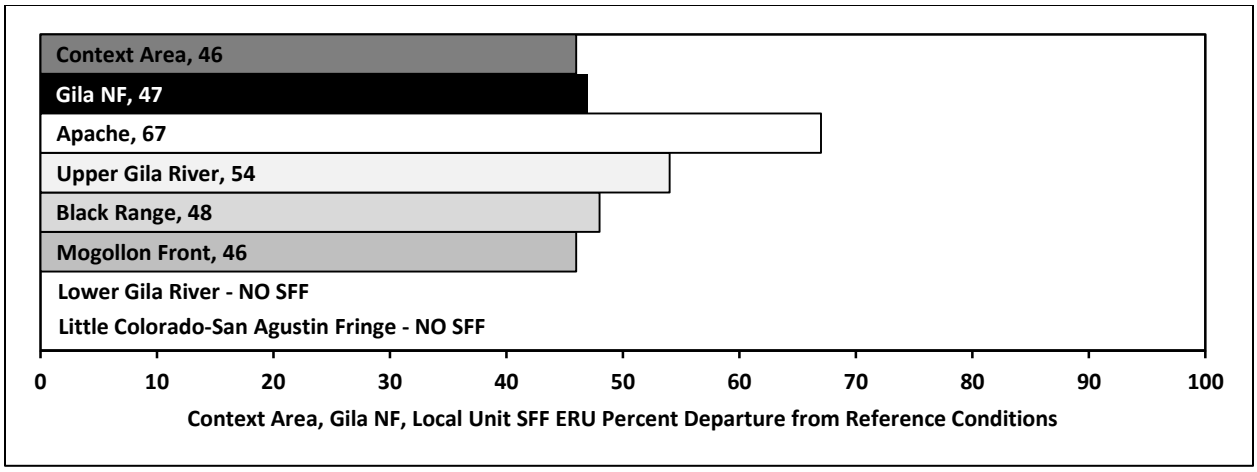


**Figure 32. Variations in seral state departure from reference condition for the SFF ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 35 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the SFF is consistently very high in all of the local units it been assessed in. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is also consistently low in all of the local units it been assessed in.

**Table 35. Gila NF spruce-fir forest ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| ǂ | | | | | | | | VH | L | VH | L | VH | L |

[1] Triepke et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

## Gila NF Seral State Proportion (Successional Structure) Departure and Trend

Figure 33 displays the state and transition modeling results for the SFF ERU at the plan scale.

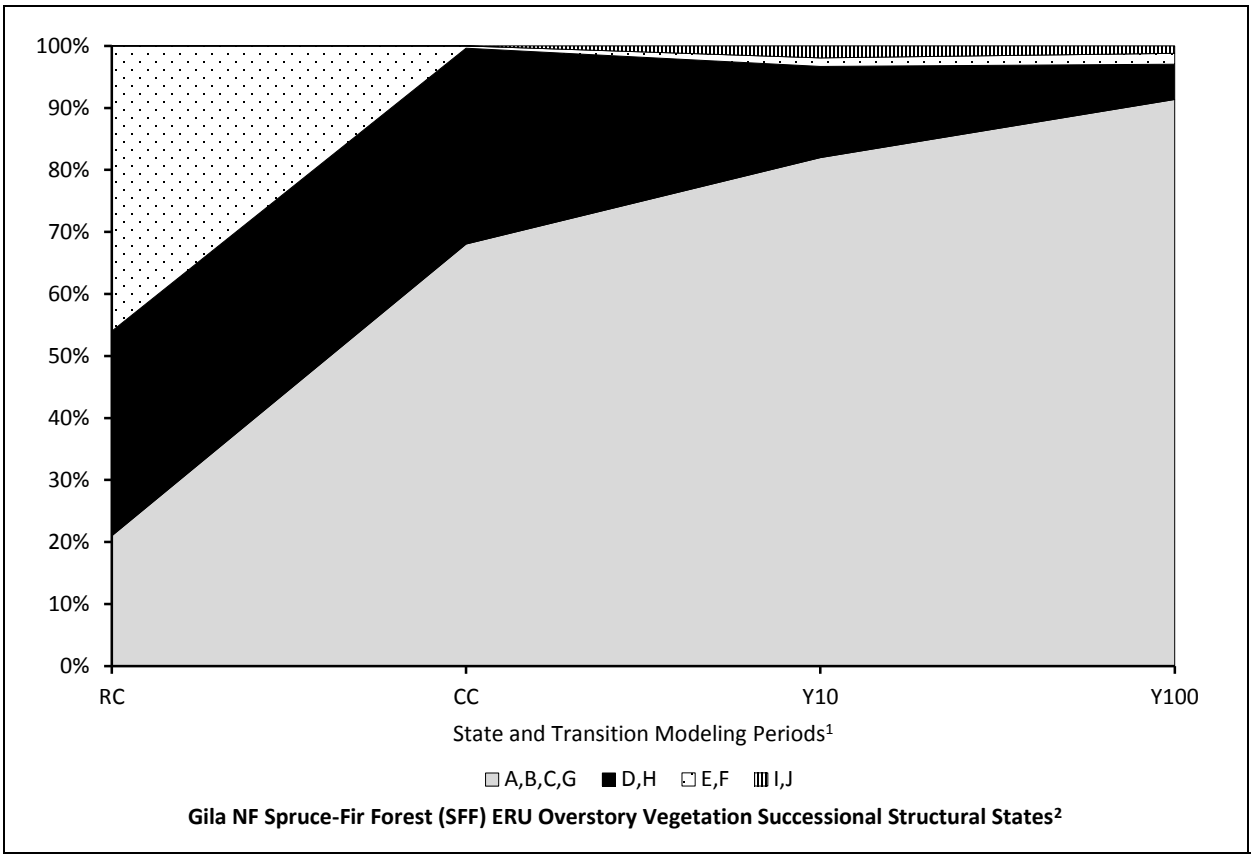


**Figure 33. Gila NF overstory vegetation successional structural states for spruce-fir forest (SFF) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 47% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 63% or moderate departure form RC
Y100 = State and transition modeling results at 100 years = 72% or high departure from RC
[2] See Table 34 for a description of the overstory vegetation successional structural states

The majority of the SFF ERU consists of grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, shrubs with open or closed canopy cover, and seedling/sapling, and small tree sizes with open or closed woody canopy cover characteristics (seral states A, B, C, G). The maintenance of the preponderance of these seral states carries on into the future under the continuation of current management with a significant trend away (+ 25 points) in relation to reference conditions out to 100 years.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 42.5 T/ac. | |
| Current: | 87.2 T/ac. | High |
| 100-years: | 81.7 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 25.0/ac. | | 9.0/ac. | |
| Current: | 19.0/ac. | Moderate | 11.2/ac. | Low |
| 100-years: | 19.0/ac. | Moderate/Static | 11.2/ac. | Low/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 200 to 1,000 ac.
Current: 79 ac.
Departure: Moderate

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average 155.6 yrs., mixed severity rotation 100 yrs., and stand replacement rotation 350 yrs.†
Current: FF = 17.1 yrs.
Departure: High

‡ Romme and Knight 1981; Grissino-Mayer et al. 1995; Schussman et al. 2006; Smith 2006d; Romme et al. 2009a; WDNR 2011; Krausmann and Triepke 2015
† According to Margolis et al. (2011) and Swetnam and Falk (2015), these forests burned historically on multi-century or longer intervals.

Fire is an infrequent but important stand initiating disturbance in these cool, mesic forests (Peet 1988). Mean fire-return intervals vary between 150 and 400 years but are probably not cyclical (Arno 1980; Romme and Knight 1981; Crane and Fischer 1986; Peet 1988; Turner and Romme 1994; Farris et al. 1998). Although small fires may occur more frequently than large fires; infrequent fires are considered to be most important in shaping the overall structure and composition of the landscape (Johnson and Wowchuk 1992; Agee 1993; Turner and Romme 1994; Bessie and Johnson 1995; Farris et al. 1998). Severe fires appear to decrease hazard of subsequent fires for decades or centuries because of fuel reduction (Romme 1982; Lotan et al. 1985; Bigler 2005).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the SFF ERU is 1,395 acres; roughly 25% at low severity, 20% at moderate severity and 56% at high severity (Table 36). Current fire severity is rated at 61.5%, higher than reference condition's 58.3% (Schussman et al. 2006), nevertheless, giving it a low departure rating.

**Table 36. Gila NF local unit SFF 19-year (1996-2015) average annual acres burned by wild fire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 1 ac. | | | Black Range 33 ac. | | | Little Colorado-San Agustin Fringe | | | Lower Gila River | | | Mogollon Front 481 ac. | | | Upper Gila River 879 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 93 | 7 | 0 | 17 | 30 | 53 | † | | | | | | 23 | 23 | 54 | 26 | 17 | 56 |

‡ 19-year period is 1996 through 2015
† Burn severity levels are: L = low; M = moderate; and H = high
† Empty cells indicate no data is available for that variable

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

| | | | | |
|---|---|---|---|---|
| Reference: | FRCC‡ V (III) | | | |
| Current: | FRCC I = 0.0% | FRCC II = 97.3% | FRCC III = 0.0% | No data = 2.7% |
| Departure: | High, trend is expected to continue away from reference conditions | | | |

‡ Romme and Knight 1981; Grissino-Mayer et al. 1995; Schussman et al. 2006; Romme et al. 2009a; WDNR 2011; Krausmann and Triepke 2015

Historic fire regime groups V and IV: Primarily long-interval (e.g., 150-300 years) stand replacement fires, with minor amount of terrain influenced by moderately long-interval (e.g., 50-100 years) mixed severity fires (LANDFIRE 2007d).

### Gila NF Insects and Disease – Reference and Currents

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 1,970 acres. The highest level occurred in 2014 at 18,837 acres. Overall, nearly 100% of this ERU has been affected by insect and disease activities since 1997.

There is a lack of documented observations and evaluation of historical insect and disease activity in the spruce-fir type on the Gila NF because of the limited distribution on the Forest (0.7% of the Gila NF based on ERU analysis) and its relative remoteness. Many of the common agents would be expected to be present, but have not necessarily been specifically documented. Common agents include bark beetles, defoliating agents, broom rust, and root diseases (Ryerson 2015).

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the SFF ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein and bull thistle; occurring at low levels.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is away from reference conditions (gray cells in Table 37) leading to a *potential for high risk; therefore evaluate stressors and system reversibility* within the spruce-fir forest ERU.

**Table 37. Gila NF Spruce-fir forest ERU risk assessment matrix**

| **Current SFF ERU Departure from RC (47%, moderate)** | **SFF ERU Trend after 100 Years (departure from RC 72%, high)** | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

According to Vankat (2013), most research on spruce-fir forest dynamics is from the central and northern Rocky Mountains, and evidence from the Southwest indicates both similarities and differences. Important stressors and drivers of vegetation dynamics are a diverse disturbance regime that is dominated by fire, wind, insects (Veblen 2000; Bebi et al. 2003), climate variation, and anthropogenic disturbances that include livestock grazing, fire management, and nearby land use (Vankat 2013), singularly and/or in combination. Historical fire regimes were crown-fire in upper elevations and mixed-severity in at least some lower-elevation sites. Key processes of vegetation dynamics are succession and gap dynamics.

Historical descriptions indicate spruce-fir forest was dense before Euro-American influence. SFF forests have the greatest risk of running out of habitable area as new trees only germinate up-slope at higher elevation seeking more favorable climatic conditions. They are also at greater risk of high severity fire when they do burn, leaving their former habitat space to be recolonized by other species such as aspen or pine (Swetnam and Falk 2015).

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression and human-caused fires can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

# Woodland ERUs

## *PIÑON-JUNIPER WOODLAND (PJO) ERU*

### Spatial Niche

The PJO is widespread and at 2,585,904 acres (5.5%) within the context area and 848,440 acres (25.9%) of the Gila NF, represents the 5th largest ERU within the context area and the largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 33% of the ERU within the ecoregion sections. However, it has a greater proportional representation on the Forest (0.65) than in the context area. This ERU has a 36% departure rating (Table 39), however, within the PJO, across the Forest this varies from a low of 30% to a high of 45% within the Little Colorado-San Agustin Fringe and Mogollon Front local units, respectively. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the higher departure rating of this ERU within the context area, 41%. Seral state representation within the context area follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally medium to large size tree-closed canopy nature to a smaller tree size with open or closed canopy and medium to large size trees with open canopy characteristics throughout its range within the ecoregion.

Figure 35 and Figure 36 show that the majority of this ERU occurs in the northern and eastern portions of the context area and the northwestern and southeastern portions of the Forest. Table 38 displays the acreage and proportion of the PJO ERU within the local units and Forest.

**Table 38. Piñon-juniper woodland (PJO) ERU acreage and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 97,007 | 11.4 | 260,351 | 30.7 | 111,055 | 13.1 | 191,213 | 22.5 | 146,107 | 17.2 | 42,707 | 5.0 | 848,440 | 26.4 |

This ERU ranges from a high 260,351 acres (30.7%) to a low of 42,707 acres (5.0%) in the Black Range and Upper Gila River, respectively. Over half of the ERU, nearly 53% occurs within the Black Range and Lower Gila River local units.

### General Description

Also called the "piñon-juniper persistent woodland," the PJO ERU (Figure 34) serves as a broad grouping of different plant associations for descriptive purposes. Trees may occur as individuals or in smaller groups and range from young to old, but more typically as large even-aged structured patches. The site is characteristically dominated by moderate to high density tree canopy, and understory herbaceous plants/shrubs are limited or scarce. It is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. Generally, annual

**Figure 34. Piñon-juniper woodland ERU (Photo by M.R. White 2002)**

precipitation ranges from 11 to 22 inches, with 40-45% coming between October 1st and March 31st. Typical stressors and drivers (fire, insects, disease, etc.) are high severity and occur infrequently. These disturbance patterns create and maintain the even-aged nature of this vegetation type. Woodland development occurs in distinctive phases; ranging from open grass-forbs, to mid-aged open canopy to mature closed canopy woodland. Where fire is very infrequent, the fire regime is usually attributed to local edaphically[18]-influenced fire affects such as rocky scarps, etc. On these sites, factors such as insect and disease may be the only disturbance agents that affect woodland development. Tree and shrub species composition varies throughout the Southwest and common trees include twoneedle piñon (*Pinus edulis*), singleleaf piñon (*Pinus monophylla* Torr. & Frém.), Utah juniper (*Juniperus osteosperma* (Torr.) Little), oneseed juniper, and alligator juniper. Typically, sparse native understory grasses are perennial species, such as several species of grama (*Bouteloua* spp. Lag.), common wolftail (*Lycurus phleoides* Kunth), and threeawns (*Aristida* spp. L), while forbs consist of both annuals and perennials. Shrubs are characteristically sparse to moderately distributed. This type is typically found on sites with rocky soil characteristics. Fire suppression has not exhibited the far-reaching effects on this ERU, as has been the case in other woodland types, since the fire frequency may or may not have been altered during the period since Euro-American settlement. Vegetation maturation, decadence and overall readiness for ignition are some of the key characteristics that influence fire disturbances in this type.

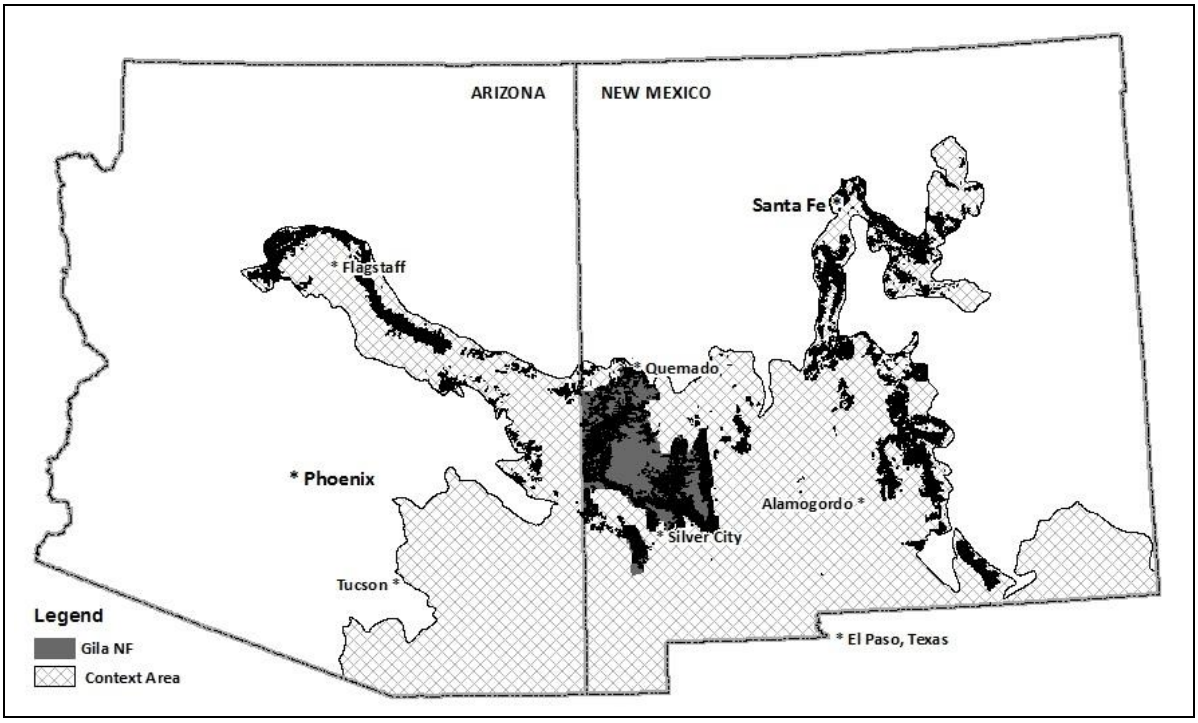


**Figure 35. General location (in black) of the piñon-juniper woodland (PJO) ERU within the context area**

[18] Resulting from or influenced by the soil rather than the climate.

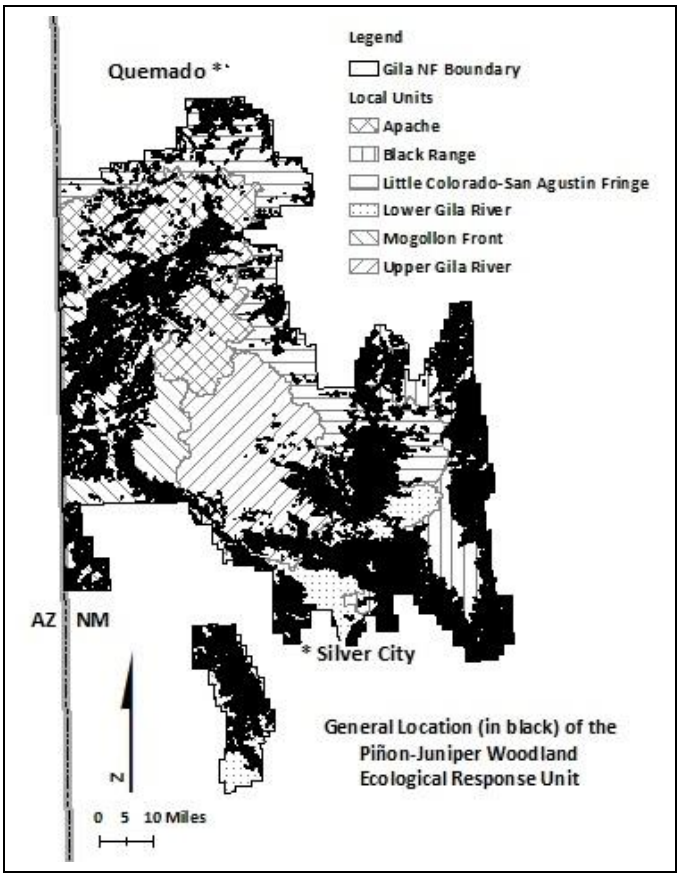


**Figure 36. General location (in black) of the piñon-juniper woodland (PJO) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the PJO ERU was comprised of medium to very large size trees with a closed canopy nature (Table 39). Historically, these woodlands were characterized by multi-aged stand structure with a range of tree densities and canopy cover, depending on site conditions (USDI NPS 2016).

**Table 39. Seral state make-up of the PJO ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 10 | 5 | 14 | 5 | 10 |
| B, C, E | Mid seral: Seedling/sapling size (< 5” dbh/drc) trees with open (≥ 10% & < 30%) or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover | 5 | 23 | 28 | 5 | 5 |
| D | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover | 10 | 28 | 25 | 10 | 10 |
| F | Mid-seral: Small size trees with closed woody canopy cover | 15 | 11 | 12 | 11 | 12 |
| G | Late-seral: Medium to very large size trees with closed woody canopy cover | 60 | 33 | 22 | 33 | 22 |
| Total | | 100 | 100 | 100 | 64 | 59 |
| Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 64) = 36 or MODERATE; and Context Area = (100 – 59) = 41 or MODERATE | | | | | | |

‡ USDA FS 2010c; LANDFIRE 2005a

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation seedling/sapling size trees with open or closed woody canopy cover, small size trees with open woody canopy cover (seral states B, C, E), and medium to very large size trees with open woody canopy cover (seral state D). There is a significant under representation of medium to very large size trees with closed woody canopy cover (seral state G). There is no quantifiable representation of very large size trees (20 in. +) within this ERU primarily due to past chaining and cabling activities, as well as high-grading the larger trees for fire wood.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 30% in the Little Colorado-San Agustin Fringe local unit to a high of 45% in the Mogollon Front local unit (Figure 37). Little Colorado-San Agustin Fringe and Lower Gila River local units have a low or no-significant departure from reference conditions; the other four local units have a moderate but significant departure from reference conditions.

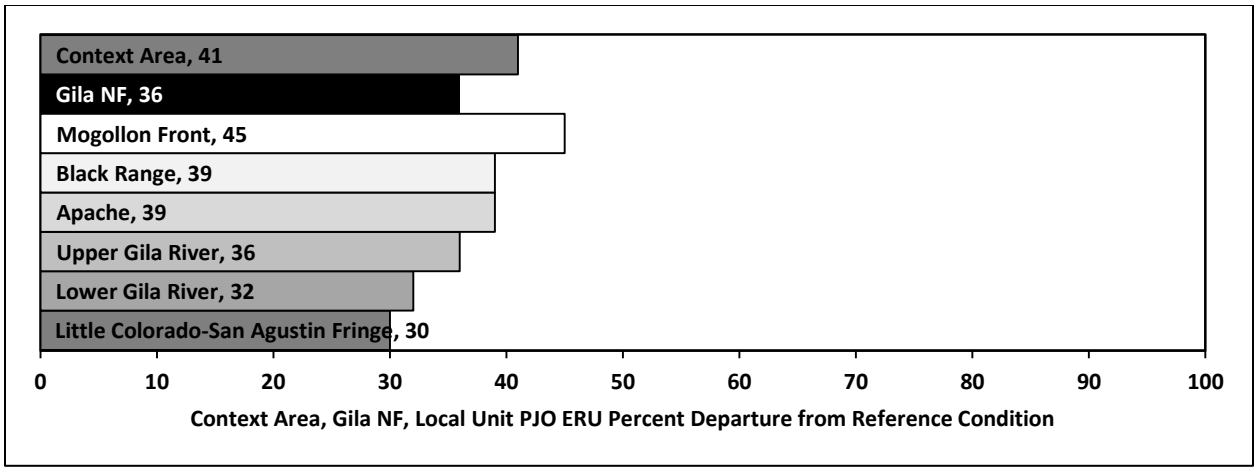


**Figure 37. Variations in seral state departure from reference condition for PJO ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 40 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the PJO ranges from low to high, with the greatest level of vulnerability occurring within the Lower Gila River local unit. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the same across all analyzed local units.

**Table 40. Piñon-juniper woodland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| L-M | M | ǂ | | L | M | H | M | M | M | L | M | L-M | M |

[1] Triepke et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 38 displays the state and transition modeling results for the PJO ERU at the plan scale.

The majority of the PJO ERU consist of seedling/sapling size trees with open or closed woody canopy cover and small to very large size trees with open woody canopy cover. Seral state G represented the major vegetation state within this ERU under reference conditions. The continual increase in seral state A and the maintenance of seral state D carries on into the future under continuation of current management with a significant increase in departure (36% to 50%) from current to 100 years.

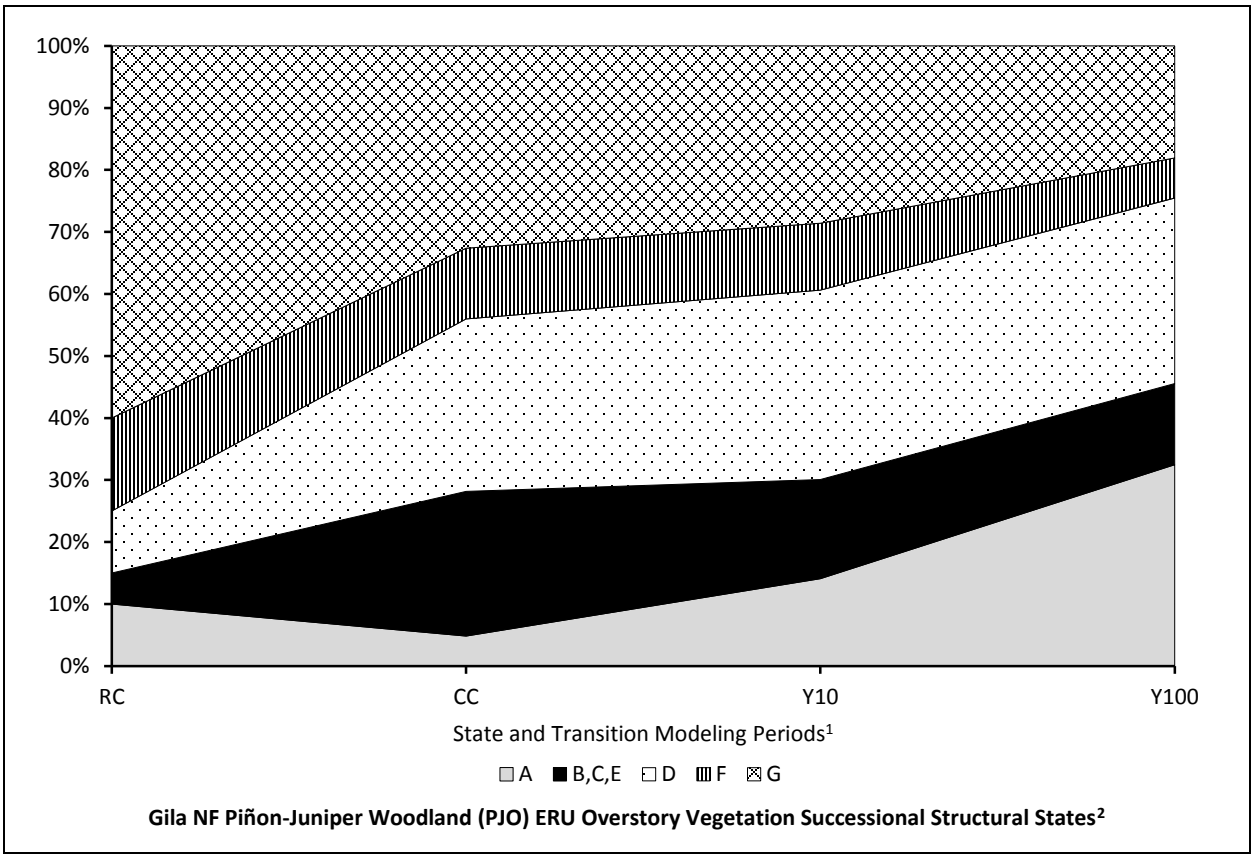


**Figure 38. Gila NF overstory vegetation successional structural states for piñon-juniper woodland (PJO) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 36% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 36% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 50% or moderate departure from RC
[2] See Table 39 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 2.9 T/ac. | |
| Current: | 15.4 T/ac. | High |
| 100-years: | 15.4 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 2.0/ac. | | 1.0/ac. | |
| Current: | 6.3/ac. | Moderate | 1.6/ac. | Moderate |
| 100-years: | 6.3/ac. | Moderate/Static | 1.6/ac. | Moderate/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 50 to 400 ac.

Current: 20 ac.

Departure: Moderate

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average rotation = 254.5 yrs., mixed severity rotation = 200 yrs., and stand replacement rotation = 350 yrs.

Current: FF = 143.9 yrs.

Departure: Low

‡ Gottfried et al. 1995; Floyd et al. 2000; Muldavin et al. 2003; Floyd et al. 2004; Vander Lee et al. 2006; Brown et al. 2008; Floyd et al. 2008; Romme et al. 2009b; Barrett et al. 2010; Swetnam and Brown 2010; Wahlberg et al. 2014; Krausmann and Triepke 2015; Swetnam and Falk 2015

Fire regimes for piñon-juniper woodlands are difficult to reconstruct owing to scant fire scar evidence (Baker and Shinneman 2004). However, the general consensus is that piñon-juniper woodland developed after infrequent stand-replacing fire and was most likely maintained by patchy mixed-severity fires that occurred with moderate to low frequency (Arnold et al. 1964; Tausch et al. 1981; Tress and Klopatek 1987; Despain and Mosley 1990; Miller 1999; Floyd et al. 2000 and 2004; Muldavin et al. 2003; Romme et al. 2003; Huffman et al. 2006).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the PJO ERU is 5,894 acres; roughly 86% at low severity, 11% at moderate severity and 2% at high severity (Table 41). Current fire severity is rated at 18.5%, lower than reference condition's 63.6% (Krausmann and Triepke 2015), giving it a high departure rating.

**Table 41. Gila NF local unit PJO 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 155 ac. | | | Black Range 2,013 ac. | | | Little Colorado-San Agustin Fringe 1,125 ac. | | | Lower Gila River 1,049 ac. | | | Mogollon Front 448 ac. | | | Upper Gila River 1,104 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 93 | 6 | 1 | 83 | 13 | 4 | 93 | 7 | 0 | 93 | 7 | 0 | 78 | 19 | 3 | 82 | 15 | 3 |

‡ 19 year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

Reference: FRCC‡ V (III)

Current: FRCC I = 0.0% FRCC II = 95.0% FRCC III = 0.0% No data = 5.0%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 4,700 acres. The highest level occurred in 2003 at 60,449 acres. Overall, nearly 10% of this ERU has been affected by insect and disease activities since 1997.

A long-term perspective on the extent of past insect and disease activity in the piñon-juniper woodlands is often lacking because it has not often been recorded in historical reports. The PJO woodland is

susceptible to attacks by several species of bark beetles. Localized mortality of piñon trees caused by the native piñon ips bark beetle (*Ips confusus*) is not uncommon throughout New Mexico and on the Gila NF. During periods when piñon ips populations are at endemic levels, individual or small groups of stressed, damaged, or diseased trees are attacked. Defoliating agents are present in the PJO, however, they typically do not cause substantial or long-term damage (Ryerson 2015). There are also several species of mistletoes present in the woodland.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the PJO ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, cheatgrass, and weeping lovegrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is away from reference conditions (gray cells in Table 42) resulting in an assessment of *potential for high risk; therefore evaluate stressors and system reversibility* within the PJO ERU.

**Table 42. Gila NF Piñon-juniper woodland ERU risk assessment matrix**

| Current PJO ERU Departure from RC (36%, moderate) | PJO ERU Trend after 100 Years (departure from RC 50%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

According to Gori and Bate (2007), based on published literature, climate variation, insect outbreaks, fire and seed dispersal by birds and small mammals appear to be the most important drivers and stressors that determined the historical structure of piñon-juniper woodlands and the distribution and abundance of this ecotype across the landscape. According to Miller and Tausch (2001), woodlands expansion began during the late 1800s throughout most of its range (Cottam and Stewart 1940; Miller and Rose 1999). Causes for PJO expansion are frequently attributed to important stressors and drivers such as the reduced role of fire, introduction of domestic livestock, climate change, and increased atmospheric $CO_2$ (Miller and Rose 1999), singularly and/or in combination. According to Miller and Tausch (2001), many woodlands are in a transitional state where tree densities and cover are continuing to increase, causing declines in understory composition, cover, production and diversity (Pieper 1995); which has led to increased soil erosion bringing about changes in wildlife habitat (Baker et al. 1995; Wilcox and Breshears 1995). With the introduction of cheatgrass, any type of fire has the potential to create the perfect situation for its expansion, which has negative consequences to ecosystem function and process.

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological

composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *PIÑON-JUNIPER GRASS WOODLAND (PJG) ERU*

### Spatial Niche

The PJG is widespread and at 1,411,018 acres (3.0%) within the context area and 291,649 acres (8.9%) of the Gila NF, represents the 6th largest ERU within the context area and the 5th largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 21% of the ERU within the ecoregion sections. However, it has a greater proportional representation on the Forest (0.50) than in the context area. This ERU has a 39% departure rating at the plan scale (Table 44), however, within the PJG, across the Forest this varies from a low of 37% to a high of 49% within the Black Range and Mogollon Front, and Upper Gila River local units, respectively. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the moderate departure rating of this ERU within the context area, 37%. Seral state representation within the context area does not follow the same overall pattern as within the Gila NF. In general this ERU has gone from a normally seedling/sapling size trees with open or closed woody canopy cover, and small to very large size trees with open woody canopy cover to a medium to very large size trees with closed woody canopy cover nature (Table 44).

Figure 40 and Figure 41 show that the majority of this ERU occurs in the northern and eastern portions of the context area and the northwestern and central portions of the Forest. Table 43 displays the acreage and proportion of the PJG ERU within the local units and Forest.

**Table 43. Piñon-juniper grass (PJG) ERU acreage distribution and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 65,676 | 22.5 | 13,225 | 4.5 | 93,597 | 32.1 | 33,158 | 11.4 | 54,838 | 18.8 | 31,155 | 10.7 | 291,649 | 9.1 |

This ERU ranges from a high 93,579 acres (32.1%) to a low of 13,225 acres (4.5%) in the Little Colorado-San Agustin Fringe and Black Range, respectively. Over half of the ERU, nearly 55% occurs within the Little Colorado-San Agustin Fringe and Apache local units.

### General Description

The PJG ERU (Figure 39) occurs across the states of Arizona and New Mexico, in what were historically more open woodlands with grassy understories. It is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. Tree species include one seed juniper, Utah juniper Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), and alligator juniper. Piñon trees include twoneedle piñon. Native understories were made up of perennial grasses, with both annual and perennial forbs, and shrubs that were absent or scattered. Contemporary understories often include invasive grasses and uncharacteristically high shrub cover. The PJG ERU including its various vegetation states, occurs on deep, fine-textured soils (usually mollisol) in valley bottoms and on gentle

**Figure 39. Piñon-juniper grass woodland ERU (Photo by T. Palmer 2006)**

plains with few barriers to fire spread; within areas of warm summer seasons and a bi-modal precipitation regime. Generally, annual precipitation ranges from 11 to 22 inches, with 40-45% coming between October 1st and March 31st. According to Wahlberg et al. (2014), empirical information on the historic condition of this type is lacking; however, site productivity provides inference for the development of a grass/fine fuels layer, in turn, providing inference of frequent fire and open, uneven-aged forest dynamics. At least one study, substantiating multiple tree cohorts in similar plant communities, corroborates these assumptions (Gottfried 2003). As such, trees would have occurred as individuals or in smaller clumps and range from young to old. Scattered shrubs and a dense herbaceous understory of native grasses and forbs characterize this type. Typical drivers and stressors (fire, insects, disease, etc.) are low severity and high frequency. These disturbance patterns would have created and maintained uneven-aged and open-canopied conditions. The tree and grass species composition varies throughout the Region, consisting a mix of one species of piñon (ranges are typically distinct) and one or more juniper species. Typically, native understory grasses are perennial species, while forbs consist of both annuals and perennials. Shrubs are characteristically absent or scattered. Due to the effects of long-term fire suppression and grazing in this type, in many locations the current condition is severely departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups; and reduced composition, density and vigor of the herbaceous understory plants. Many of these sites currently are closed-canopy woodlands, with insufficient understory vegetation to support surface fires.

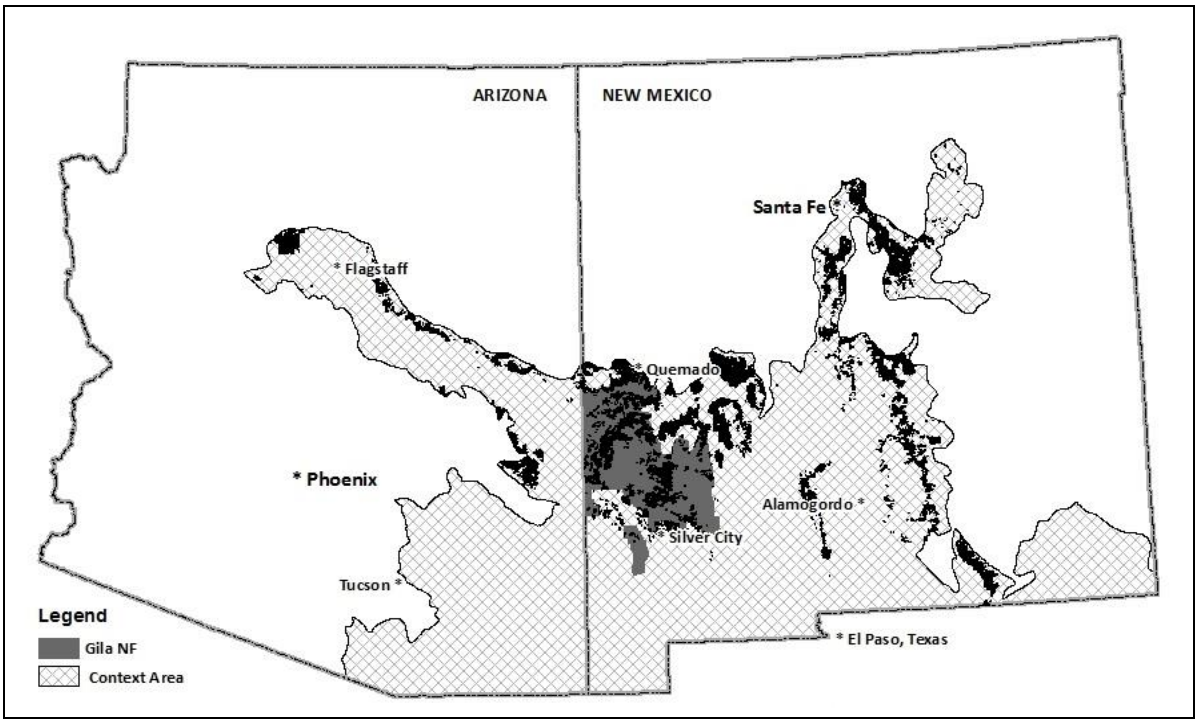


**Figure 40. General location (in black) of the piñon-juniper grass woodland (PJG) ERU within the context area**

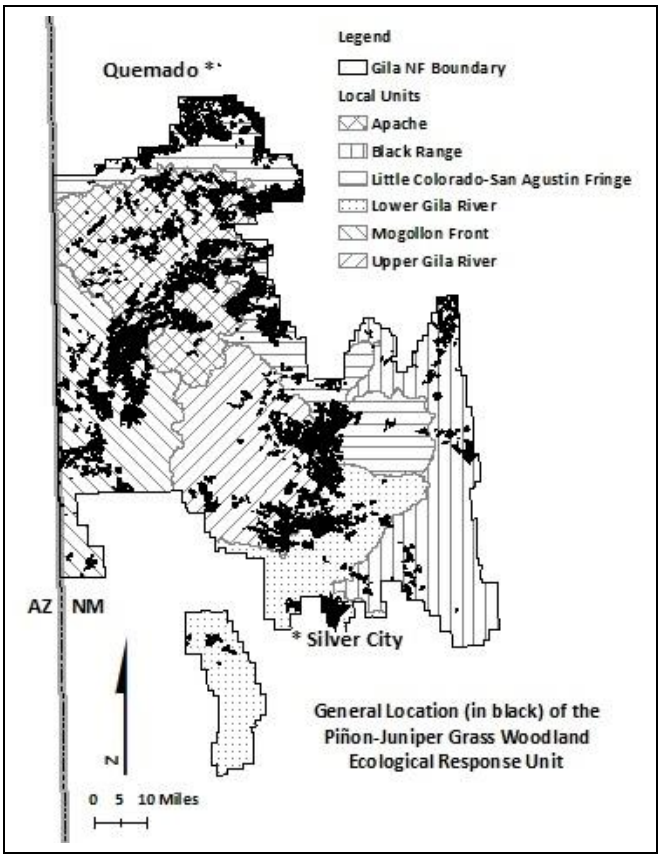


**Figure 41. General location (in black) of the piñon-juniper grass woodland (PJG) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

In general this ERU has gone from a normally seedling/sapling size trees with open or closed woody canopy cover, and small to very large size trees with open woody canopy cover to a medium to very large size trees with closed woody canopy cover nature (Table 44). Historically, this ecotype supported stands of uneven-aged trees and open-canopied conditions.

**Table 44. Seral state make-up of the PJG ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 5 | 5 | 22 | 5 | 5 |
| B, C, E | Mid-seral: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover | 25 | 11 | 20 | 11 | 20 |
| D | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover | 50 | 25 | 18 | 25 | 18 |
| F | Mid-seral: Small size trees with closed woody canopy cover | 10 | 12 | 16 | 10 | 10 |
| G | Late-seral: Medium to very large size trees with closed woody canopy cover | 10 | 47 | 24 | 10 | 10 |
| Total | | 100 | 100 | 100 | 61 | 63 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 61) = 39 or MODERATE; and Context Area = (100 – 63) = 37 or MODERATE

‡ USDA FS 2010d; LANDFIRE 2005b

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation medium to very large size trees with closed woody canopy cover (seral state G). Historically, canopy coverage of greater than 70% and sparse understory vegetation as a result is uncharacteristic for the ERU (LANDFIRE 2008b). There is a significant under representation of seedling/sapling size trees with open or closed woody canopy cover, and small to very large size trees with open woody canopy cover. There is no quantifiable representation of very large size trees (20 in. +) within this ERU primarily due to past chaining and cabling activities, as well as high-grading the larger trees for fire and novelty wood.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 37% in the Black Range and Mollogon local units to a high of 49% in the Upper Gila River local unit (Figure 42). Regardless of the differences between the local units, all of them have a significant departure from reference conditions.

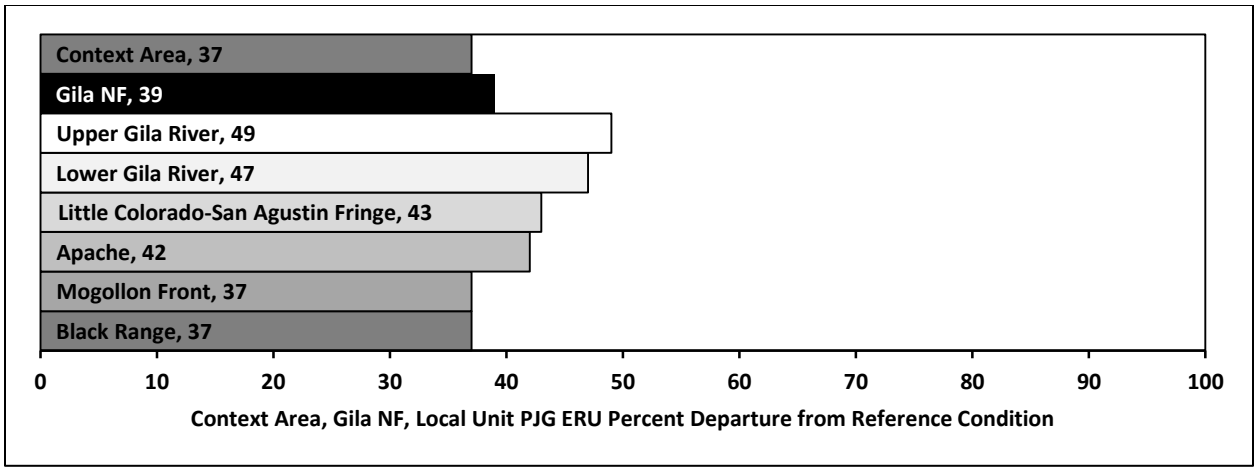


**Figure 42. Variations in seral state departure from reference condition for PJG ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 45 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the PJG ranges from low to very high, with the greatest level of vulnerability occurring within the Lower Gila River local unit. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is the close to the same across all analyzed local units.

**Table 45. Gila NF piñon-juniper grass woodland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3]**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M-H | M | M | M | L | M | H-VH | L-M | M-H | M | M-H | M | M | M |

[1] Triepke et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 43 displays the state and transition modeling results for the PJG ERU at the plan scale.

The majority of the PJG ERU consists of medium to very large size trees with closed woody canopy cover (seral state G). Seral state D represented the major vegetation state within this ERU under reference conditions. The continual increase in seral state A off-sets the decline of seral state G into the future under continuation of current management with static trend in departure (± 5%) from current to 100 years.

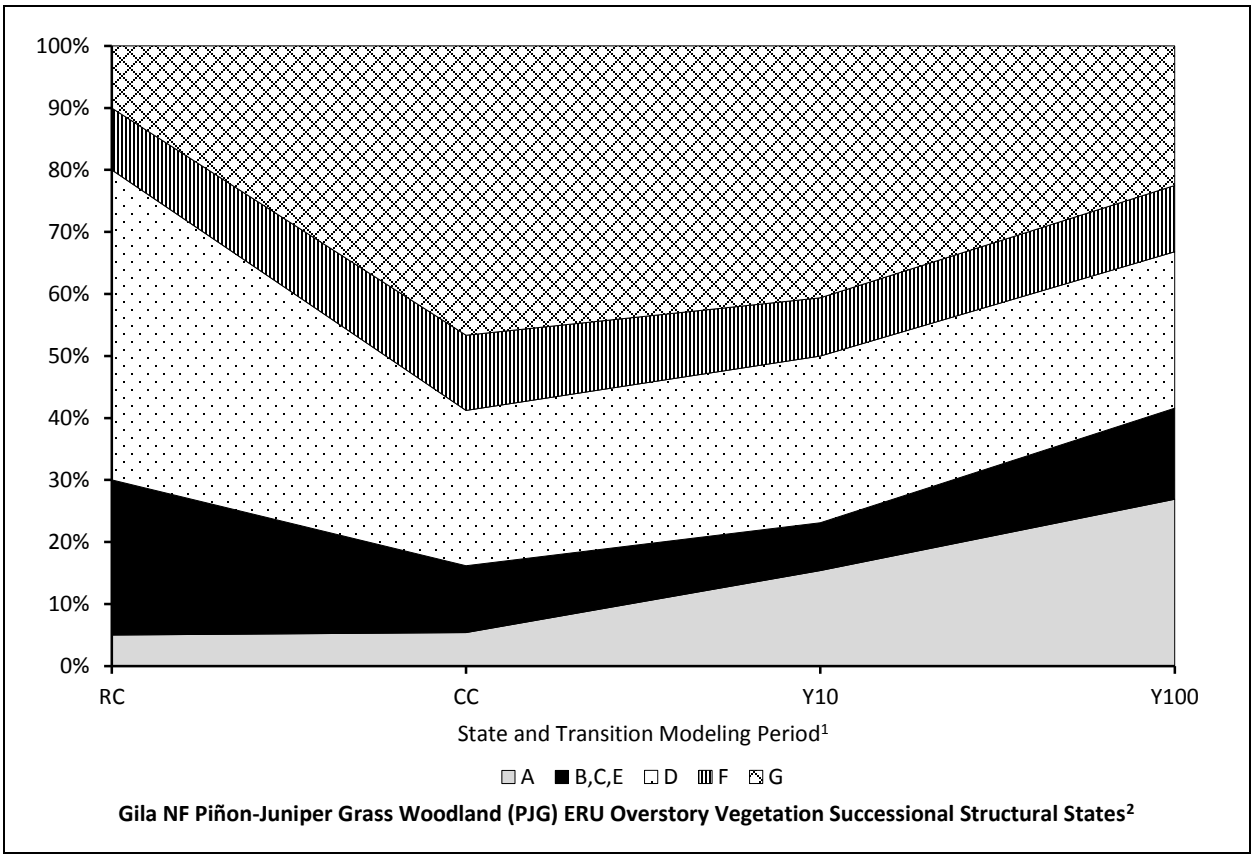


**Figure 43. Gila NF overstory vegetation successional structural states for piñon-juniper grass woodland (PJG) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 39% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 41% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 35% or moderate departure from RC
[2] See Table 44 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 2.4 T/ac. | |
| Current: | 13.4 T/ac. | High |
| 100-years: | 13.4 T/ac. | High/Static |

| | Snag Density (8” dbh) | Departure/Trend | Snag Density (18” dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 5.0/ac. | | 1.0/ac. | |
| Current: | 4.4/ac. | Moderate | 0.7/ac. | Moderate |
| 100-years: | 4.4/ac. | Moderate/Static | 0.7/ac. | Moderate/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

| | |
|---|---|
| Reference: | 0.07 to 1 ac. |
| Current: | 28 ac. |
| Departure: | High |

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average fire rotation = 20.1 yrs. and non-lethal fire rotation = 20.1 yrs.

Current: FF = 154 yrs.

Departure: High

‡ Allen 1989; Despain and Mosley 1990; Baisan and Swetnam 1995; Grissino-Mayer et al. 1995; Gottfried et al. 1995; Romme et al. 2003; Baker and Shinneman 2004; Vander Lee et al. 2006; LANDFIRE 2008b; Poulos et al. 2009; Barrett et al. 2010; Margolis 2014; Wahlberg et al. 2014; Krausmann and Triepke 2015; Swetnam and Falk 2015

**Gila Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the PJG ERU is 1,894 acres; roughly 89% low severity, 10% moderate severity and 1% at high severity (Table 46). Current fire severity is rated at 18.2% under reference conditions it was 12.5% (Krausmann and Triepke 2015) giving it a low departure. Current fire severity is rated at 17.2%, higher than the reference condition's 12.5% (Krausmann and Triepke 2015), nevertheless, giving it a low departure rating.

**Table 46. Gila NF local unit PJG 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 255 ac. | | | Black Range 18 ac. | | | Little Colorado-San Agustin Fringe 335 ac. | | | Lower Gila River 38 ac. | | | Mogollon Front 200 ac. | | | Upper Gila River 1,048 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 92 | 7 | 1 | 84 | 10 | 6 | 95 | 5 | 0 | 97 | 3 | 0 | 87 | 12 | 1 | 86 | 13 | 2 |

‡ 19-year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

Reference: FRCC‡ I

Current: FRCC I = 0.0% FRCC II = 95.5% FRCC III = 0.0% No data = 4.5%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 850 acres. The highest level occurred in 2003 at 7,034 acres. Overall, nearly 5% of this ERU has been affected by insect and disease activities since 1997.

As mentioned in the PJO ERU write-up, a long-term perspective on the extent of past insect and disease activity in the piñon-juniper woodlands is often lacking because it has not often been recorded in historical reports. The PJG woodland is susceptible to attacks by several species of bark beetles. Localized mortality of piñon trees caused by the native piñon ips bark beetle (*Ips confusus*) is not uncommon throughout New Mexico and on the Gila NF. During periods when piñon ips populations are at endemic levels, individual or small groups of stressed, damaged, or diseased trees are attacked. Defoliating agents are present in the PJG, however, they typically do not cause substantial or long-term damage (Ryerson 2015). There are also several species of mistletoes present in the woodland.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the PJG ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein,

cheatgrass, and weeping lovegrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 47) leading to *potential risk due to legacy of past management or deviation from ongoing activities; therefore requires evaluation of stressors and system reversibility* within the PJG ERU.

**Table 47. Gila NF Piñon-juniper grass woodland ERU risk assessment matrix**

| Current PJG ERU Departure from RC (39%, moderate) | PJG ERU Trend after 100 Years (departure from RC 35%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

According to Gori and Bate (2007), based on published literature, climate variation, insect outbreaks, fire and seed dispersal by birds and small mammals appear to be the most important drivers and stressors that determined the historical structure of piñon-juniper woodlands and the distribution and abundance of this ecotype across the landscape. Causes for PJG expansion are frequently attributed to important stressors and drivers such as the reduced role of fire, introduction of domestic livestock, climate change, and increased atmospheric $CO_2$ (Miller and Rose 1999), singularly and/or in combination. According to Miller and Tausch (2001), many woodlands are in a transitional state where tree densities and cover are continuing to increase, causing declines in understory composition, cover, production and diversity (Pieper 1995); which has led to increased soil erosion bringing about changes in wildlife habitat (Baker et al. 1995; Wilcox and Breshears 1995). With the introduction of cheatgrass, any type of fire has the potential to create the perfect situation for its expansion, which has negative consequences to ecosystem function and process. Piñons were especially hard hit by the 1996 to early 2000s drought in Arizona and New Mexico. In a few cases, stands of piñon pine exceeded 97% mortality, while juniper in the same stands experienced less than 1% mortality (McDowell et al. 2008). Drying and increased temperatures may lead to even larger and more widespread mortality events in these woodland where even the junipers experience greater mortality (Swetnam and Falk 2015).

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *JUNIPER-GRASS WOODLAND (JUG) ERU*

### Spatial Niche

The JUG is widespread and at 3,703,181 acres (7.9%) within the context area and 114,396 acres (3.6%) of the Gila NF, represents the 3rd largest ERU within the context area and the 7th largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 3.1% of the ERU within the ecoregion sections. In addition, it has a lower proportional representation on the Forest (-0.39) than in the context area. This ERU has a 29% departure rating at the plan scale (Table 49), however, within the JUG, across the Forest this varies from a low of 24% to a high of 41% within the Black Range and Mogollon Front, and Upper Gila River local units, respectively. The influence of the Gila NF on the sustainability of this system is limited not because of the departure level but because of the large proportional representation of this ERU off the Forest, however, the departure of this ERU within the context area is higher (38%) than on Forest. Seral state representation within the context area and the Forest are different (Table 49).

Figure 45 and Figure 46 show that the majority of this ERU occurs in the southwestern and northeastern portions of the context area and the southwestern portion of the Forest and in the Burro Mountains. Table 48 displays the acreage and proportion of the JUG ERU within the local units and Forest.

**Table 48. Juniper-grass woodland (JUG) ERU acreage distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 442 | 0.4 | 0 | 0.0 | 0 | 0.0 | 39,759 | 34.8 | 65,898 | 57.6 | 8,317 | 7.3 | 114,396 | 3.6 |

This ERU, where it occurs, ranges from a high 65,898 acres (57.6%) to a low of 0442 acres (0.4%) in the Mogollon Front, and Apache local units, respectively. Over half of the ERU, nearly 57% occurs within one local unit, the Mogollon Front.

### General Description

The JUG ERU (Figure 44) is typically found on warmer and drier settings beyond the environmental limits of piñon, and just below and often intergrading with the piñon-juniper zone. The juniper-grass ecosystem is generally uneven-aged and very open in appearance (savanna-like), primarily on mollisol soils. Trees occur as individuals or in smaller groups and range from young to old. A dense herbaceous matrix of native grasses and forbs characterize this type. Typical drivers and stressors (i.e., fire, insects, disease) are low severity and high frequency. These disturbance patterns create and maintain the uneven-aged, open-canopy nature of this type. The tree and grass species composition varies throughout the Region, consisting of a mix of one or more juniper species. Typically, native understory grasses are perennial species, while forbs consist of both annuals and perennials. Shrubs are characteristically absent or scattered. This type is typically found on sites with well-developed, loamy soil characteristics, generally at the drier edge of the woodland

**Figure 44. Juniper-grass woodland ERU (Photo by M.R. White 2007)**

climatic zone. Generally these types are most extensive in geographic areas dominated by warm (summer) season or bi-modal precipitation regimes. Generally, annual precipitation ranges from 11 to 22 inches, with 55-60% coming between April 1st and September 31st. It is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. Common grass species found in JUG include blue grama and other species of grama grass (sideoats, hairy, black *(Bouteloua eriopoda* (Torr.) Torr.*),* New Mexico muhly (*Muhlenbergia pauciflora* Buckley), curlyleaf muhly (*Muhlenbergia setifolia* Vasey), western wheatgrass (*Pascopyrum smithii* (Rydb.) Á. Löve), and needle and thread grasses (*Hesperostipa* spp. (Elias) Barkworth). It is hypothesized that a regime of frequent, low-intensity surface fires is responsible for maintaining the open stand structure and dense herbaceous growth of piñon-juniper savanna (USDI NPS 2016). Overall these sites are less productive for tree growth than the piñon-juniper woodland type.

Due to the effects of long-term fire suppression and grazing in this type, in many locations the current condition is severely departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups, and reduced composition, density and vigor of the herbaceous understory plants. Many of these sites currently are closed-canopy woodlands, with insufficient understory vegetation to support surface fires.

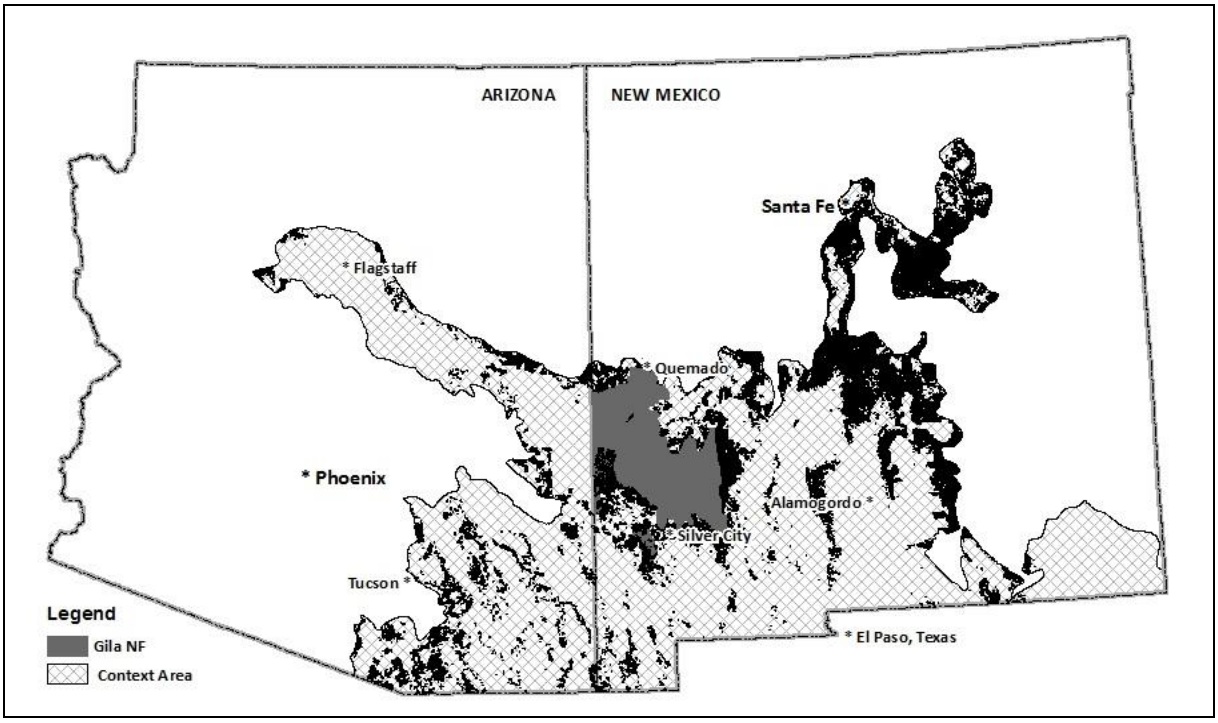


**Figure 45. General location (in black) of the juniper grass woodland (JUG) ERU within the context area**

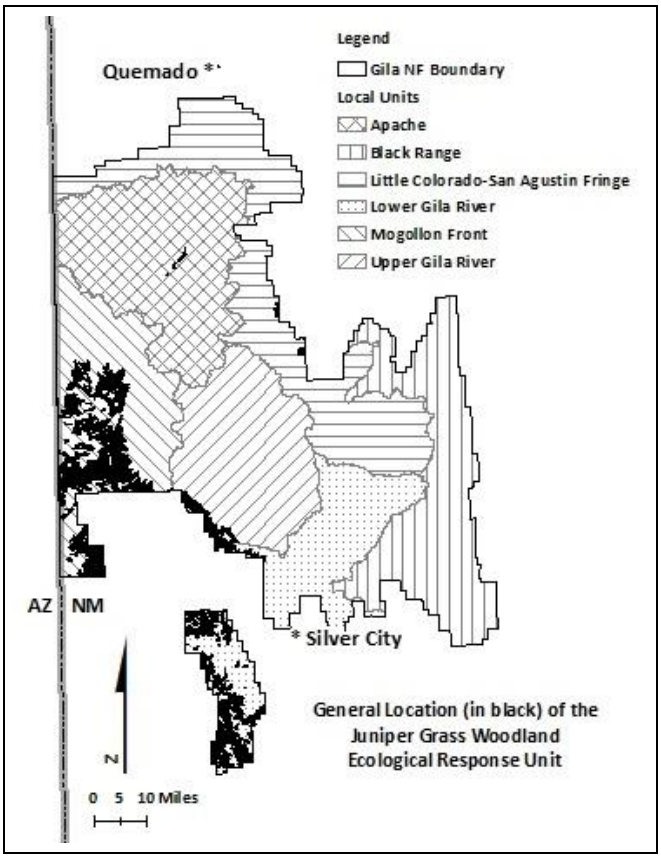


**Figure 46. General location (in black) of the juniper grass woodland (JUG) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the JUG ERU was comprised of small and medium to very large size trees with open woody canopy cover, and seedling/sapling size trees with open or closed woody canopy cover. Currently it is a mix of grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover, small and medium to very large size trees with open woody canopy cover, and seedling/sapling size trees with open or closed woody canopy cover (Table 49). Historically, this ecotype supported an open savanna-like stand structure, low densities of trees and shrubs, and dense herbaceous growth: grasses, forbs, and annuals (UDSI NPS 2016).

**Table 49. Seral state make-up of the JUG woodland ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 5 | 28 | 35 | 5 | 5 |
| B, C, E | Mid-seral: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover | 25 | 31 | 13 | 25 | 13 |
| D | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover | 50 | 30 | 27 | 30 | 27 |
| F | Mid-seral: Small size trees with closed woody canopy cover | 10 | 3 | 7 | 3 | 7 |
| G | Late-seral: Medium to very large size trees with closed woody canopy cover | 10 | 8 | 18 | 8 | 10 |
| Total | | 100 | 100 | 100 | 71 | 62 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 71) = 29 or LOW; and Context Area = (100 – 62) = 38 or MODERATE

‡ USDA FS 2010e; LANDFIRE 2005b

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Low. Currently there is an over representation of grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover (seral state A), with a concurrent under representation of medium to very large size trees with open woody canopy cover (seral state D). There is almost no (≅ 0. 002%) representation of very large size trees (20 in. +) within this ERU, primarily due to high-grading the larger trees for fire wood and ornamental wood.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 24% in the Mogollon Front local unit to a high of 41% in the Upper Gila River local unit (Figure 47). Two local units have low, but non-significant departure from reference conditions (Mogollon Front and Apache); while two have moderate, but significant departure from reference conditions (Upper Gila River and Lower Gila River).

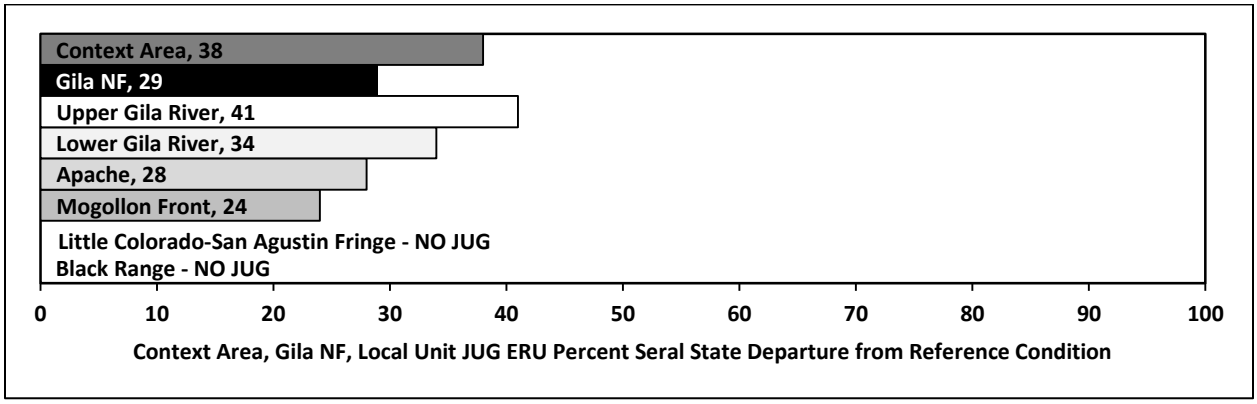


**Figure 47. Variations in seral state departure from reference condition for JUG ERU at the context area, Forest and local unit scale**

### Climate Change Vulnerability

Table 50 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the JUG ranges from moderate to high, with the greatest level of vulnerability occurring within the Lower Gila River local unit. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) ranges from moderate to high, with the greatest level of uncertainty occurring in the Upper Gila River local unit.

**Table 50. Gila NF juniper-grass woodland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UC)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| ǂ | | | | | | H | M | M | M | M | M-H | M-H | M |

[1] Triepke et al. 2014; Triepke 2015

[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)

[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

ǂ Empty cells indicate no data is available for that variable

### Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 48 displays the state and transition modeling results for the JUG ERU at the plan scale.

Currently the JUG ERU is fairly evenly distributed between seral state A (grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover), seral states B, C, E (seedling/sapling size trees with open or closed woody canopy cover, and small size trees with open woody canopy cover), and seral state D (medium to very large size trees with open woody canopy cover). Seral states D, and B, C, E represented the major vegetation states within this ERU under reference conditions. The continual increase in seral state A into the future under continuation of current management produces a trend in departure away from reference conditions (+ 7%) for current and continues to increase (+ 30%) out to 100 years.

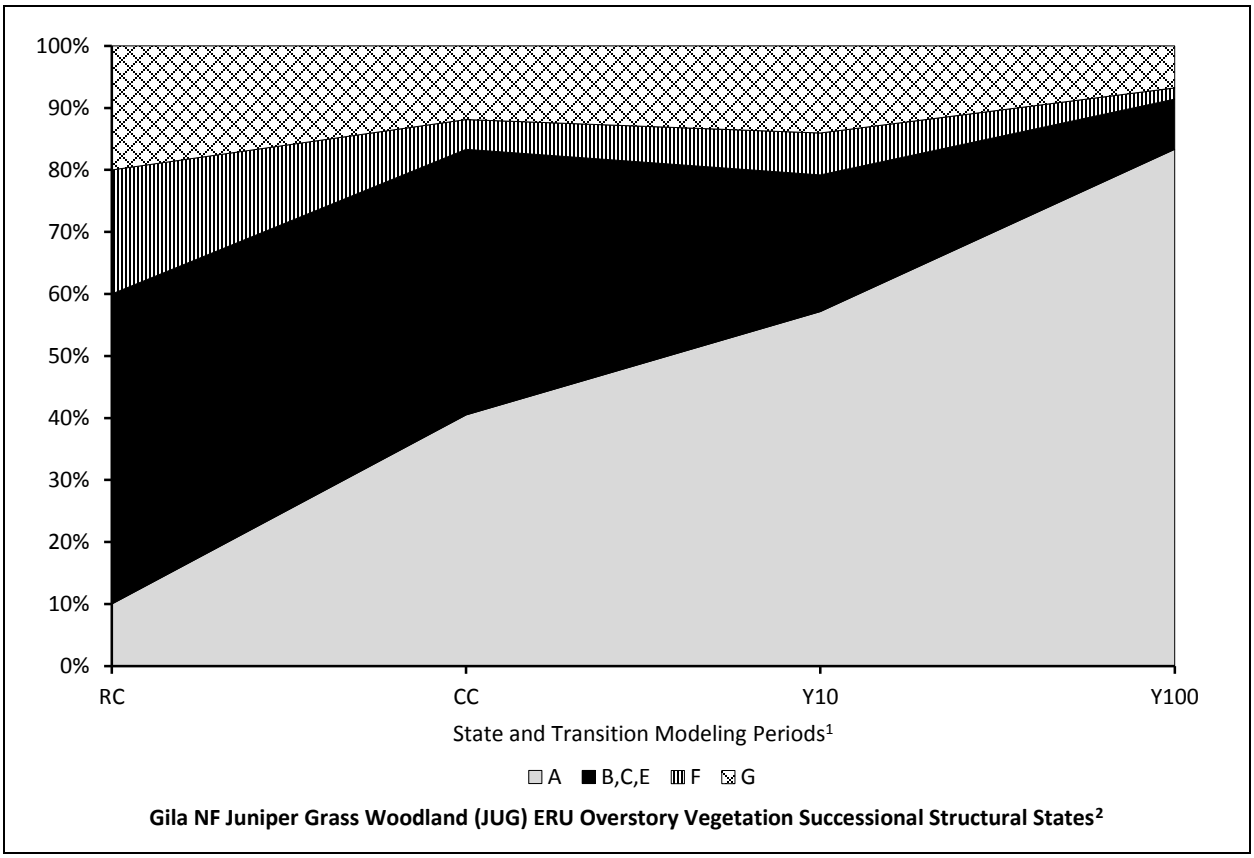


**Figure 48. Gila NF overstory vegetation successional structural states for juniper grass woodland (JUG) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities.**

[1] RC = Reference conditions
CC = Current conditions = 29% or low departure from RC
Y10 = State and transition modeling results at 10 years = 36% or low departure from RC
Y100 = State and transition modeling results at 100 years = 59% or moderate departure from RC
[2] See Table 49 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 3.0 T/ac. | |
| Current: | 13.8 T/ac. | High |
| 100-years: | 13.8 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 3.0/ac. | | 1.0/ac. | |
| Current: | 3.4/ac. | Low | 0.6/ac. | Low |
| 100-years: | 3.4/ac. | Low/Static | 0.6/ac. | Low/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

| | |
|---|---|
| Reference: | 0.07 to 1 ac. |
| Current: | 5 ac. |
| Departure: | High |

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average fire rotation = 13 yrs. and non-lethal fire rotation = 13 yrs.

Current: FF = 1,308 yrs.

Departure: High

‡ Johnsen 1962; Wright and Bailey 1982; Gottfried et al. 1995; Paysen et al. 2000; Baker and Shinneman 2004; Schussman et al. 2006; Hauser 2007; Margolis 2014; Krausmann and Triepke 2015

As mentioned in the PJO ERU write-up, fire regimes for piñon-juniper woodlands are difficult to reconstruct owing to scant fire scar evidence (Baker and Shinneman 2004). However, the general consensus is that JUG developed with frequent low severity fires (Schussman et al. 2006; USDI NPS 2016) every 15 to 50 years and stand replacement every 150 to 250 years. Some typically less common old growth stands are thought to have fire return intervals of 400 years or longer. Post Euro-American settlement brought about reduced fire frequency and a significant change in fire severity (Romme et al. 2003).

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the JUG is 88 acres; roughly 97% at low severity, 3% at moderate severity and 0% at high severity (Table 51). Current fire severity is rated at 13.6%, higher than the reference condition's 12.5% (Krausmann and Triepke 2015), nevertheless, giving it a low departure rating.

**Table 51. Gila NF local unit JUG acres burned by wildfires and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | | Black Range | | | Little Colorado-San Agustin Fringe | | | Lower Gila River 28 ac. | | | Mollogon 59 ac. | | | Upper Gila River | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| † | | | | | | | | | 100 | 0 | 0 | 96 | 4 | 0 | | | |

‡ 19 year period is 1996 through 2015

† Burn severity levels are: L =low; M = moderate; and H = high

† Empty cells indicate no data is available for that variable.

### Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure

Reference: FRCC‡ I

Current: FRCC I = 0.0% FRCC II = 92.4% FRCC III = 0.0% No data = 7.6%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 205 acres. The highest level occurred in 2003 at 1,991 acres. Overall, nearly 3% of this ERU has been affected by insect and disease activities since 1997.

As mentioned in the PJO ERU write-up, a long-term perspective on the extent of past insect and disease activity in the piñon-juniper woodlands is often lacking because it has not often been recorded in historical reports. The JUG woodland is susceptible to attacks by several species of bark beetles. Localized mortality of piñon trees caused by the native piñon ips bark beetle (*Ips confusus*) is not uncommon throughout New Mexico and on the Gila NF. During periods when piñon ips populations are at endemic levels, individual or small groups of stressed, damaged, or diseased trees are attacked. Defoliating agents are present in the JUG, however, they typically do not cause substantial or long-term damage (Ryerson 2015). There are also several species of mistletoes present in the woodland.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the JUG ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, bullthistle, cheatgrass, and weeping lovegrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is non-significant; however, the current trend is away from reference conditions (gray cells in Table 52) resulting in an assessment of *potential risk; therefore evaluate magnitude of future deviations, threats and system reversibility* within the juniper grass woodland ERU.

**Table 52. Gila NF Juniper grass woodland ERU risk assessment matrix**

| Current JUG ERU Departure from RC (29%, low) | JUG ERU Trend after 100 Years (departure from RC 59%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

According to Gori and Bate (2007), based on published literature, climate variation, insect outbreaks, fire and seed dispersal by birds and small mammals appear to be the most important drivers and stressors that determined the historical structure of piñon-juniper woodlands and the distribution and abundance of this ecotype across the landscape (USDI NPS 2016). Causes for JUG expansion are frequently attributed to important stressors and drivers such as the reduced role of fire, introduction of domestic livestock, climate change, and increased atmospheric $CO_2$ (Miller and Rose 1999), singularly and/or in combination. According to Miller and Tausch (2001), many woodlands are in a transitional state where tree densities and cover are continuing to increase, causing declines in understory composition, cover, production and diversity (Pieper 1995); which has led to increased soil erosion bringing about changes in wildlife habitat (Baker et al. 1995; Wilcox and Breshears 1995). With the introduction of cheatgrass, any type of fire has the potential to create the perfect situation for its expansion, which has negative consequences to ecosystem function and process.

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes,

change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *MADREAN PIÑON-OAK WOODLAND (MPO) ERU*

### Spatial Niche

The MPO is generally limited to the southwestern portion (Sky Islands) of the context area at 902,219 acres or 1.9%. On the Gila NF its 17,361 acres or 0.5% is scattered about the Forest, found primarily within the southwestern portion of the Forest (Figure 50 and Figure 51). The MPO represents the 8th largest ERU in the context area and the 2nd smallest upland ERU on the Forest. The Gila NF's niche for this ERU is approximately 1.9% of the ERU within the ecoregion sections. In addition, it has a lower proportional representation on the Forest (-0.57) than in the context area. This ERU has a 19% departure rating (Table 54), however, within the MPO, across the Forest this varies from a low of 19% to a high of 49% within the Mogollon Front and Little Colorado-San Agustin Fringe local units, respectively. The influence of the Gila NF on the sustainability of this system is limited not because of the departure level but because of the large proportional representation of this ERU off the Forest, however, the departure of this ERU within the context area is nearly three times higher (60%) as on Forest. Seral state representation within the context area and the Forest are different (Table 54).

Figure 50 and Figure 51 show that the show the distribution of this ERU within the context area and Forest. Table 53 displays the acreage and proportion of the MPO ERU within the local units and Forest.

**Table 53. Madrean piñon-oak ERU acreage distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 855 | 4.9 | 252 | 1.5 | 869 | 5.0 | 0 | 0.0 | 13,794 | 79.5 | 1,591 | 9.2 | 17,361 | 0.5 |

This ERU, where it occurs, ranges from a high 13,794 acres (79.5%) to a low of 252 acres (1.5%) in the Mogollon Front, and Black Range local units, respectively. Over half of the ERU, nearly 80% occurs within one local unit, the Mogollon Front.

### General Description

The Madrean piñon-oak woodland ERU (Figure 49) is concentrated in the Madrean province and is dominated by an open to closed canopy of evergreen oaks such as Arizona white oak, alligator juniper, Mexican piñon (*Pinus cembroides* Zucc.), Chihuahua pine, and other various pines with a grassy understory. On the Gila NF, oneseed juniper is often present to dominant (LANDFIRE 2008c). Understories may be variable and may be dominated by shrubs such as manzanita, Mexican cliffrose (*Purshia mexicana* (D. Don) Henrickson), Apache plume (*Fallugia paradoxa* (D. Don) Endl. ex Torr.), or barberry (*Berberis* spp. L.). Common herbaceous species include sideoats grama, cane bluestem (*Bothriochloa barbinodis* (Lag.) Herter), and several species of muhlys. Graminoids decrease in cover and biomass with increasing cover of woody plants (LANDFIRE 2008c) Elsewhere in the region, as far east as

**Figure 49. Madrean piñon-oak woodland ERU (Wahlberg et al. 2014)**

the southern Rocky Mountains, plant communities dominated by tree-form evergreen oaks with or without piñon and juniper codominants have been placed in the Madrean piñon-oak as a provisional resort, pending revision of the ERU framework. In these cases, the composition differs from communities of the Madrean province, though the form and dynamics of the system are consistent with the ERU concept. Vegetation structural development is apparently determined by soil type and depth (Gottfried et al. 1995). Stands commonly are located in a variety of sites including along drainages, on rocky slopes, and on alluvial basin fill and fans (USDA FS 1997). This ERU is transitional with the ponderosa pine-evergreen oak ERU but lacks dominance of large pine species (i.e. Arizona pine, Apache pine, and Chihuahuan pine). Madrean piñon-oak woodlands usually occupy foothills and mountains ranging from approximately 4,000 to 7,000 ft. in elevation. Climate generally consists of mild winters and wet summers with mean annual precipitation ranging from about 10 to 25 inches with 55-60% coming between April 1st and September 31st. Historically this ERU had over 10% tree canopy cover, with the exception of early, post-fire plant communities. This ERU was previously named "Madrean Pine-Oak Woodland" but was changed to better reflect the woodland nature of the unit, and avoid confusion with other classification approaches with regards to "Madrean Pine" (Wahlberg et al. 2014).

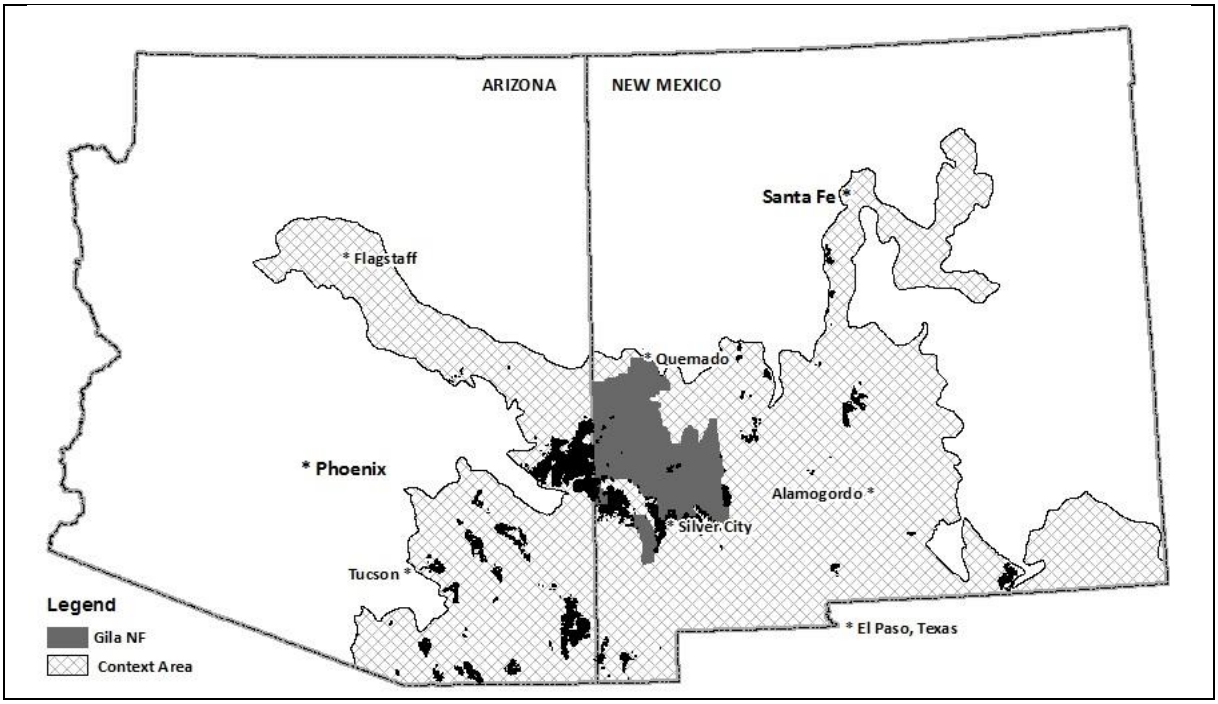


**Figure 50. General location (in black) of the Madrean piñon-oak woodland (MPO) ERU in the context area**

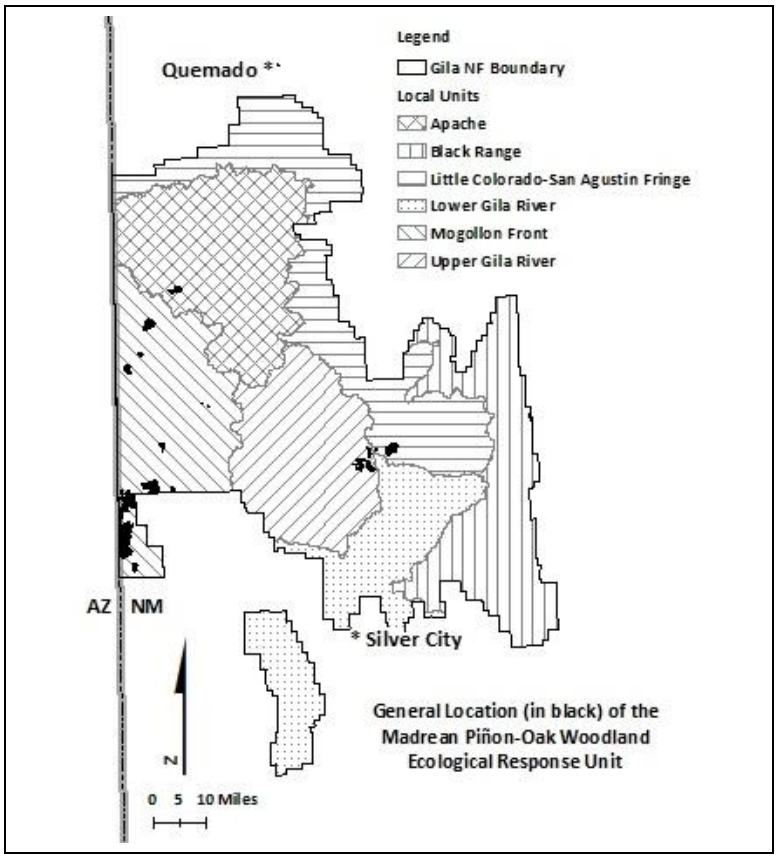


**Figure 51. General location (in black) of the Madrean piñon-oak woodland (MPO) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the MPO ERU was comprised of small and medium to very large size trees with open woody canopy cover. Currently it is a mix of grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover, and seedling/sapling size trees with open or closed woody canopy cover. Historically, this ecotype supported open savanna-like stand structure, supported low densities of trees and shrubs, and dense herbaceous growth.

**Table 54. Seral state make-up of the MPO ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 4 | 8 | 12 | 4 | 4 |
| B, E | Early-seral: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover | 5 | 8 | 2 | 5 | 2 |
| C | Mid-seral: Small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover | 24 | 26 | 10 | 24 | 10 |
| D | Late seral: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover | 60 | 41 | 17 | 41 | 17 |
| F | Mid-seral: Small size trees with closed woody canopy cover | 3 | 5 | 23 | 3 | 3 |
| G | Late-seral: Medium to very large size trees with closed woody canopy cover | 4 | 13 | 36 | 4 | 4 |
| Total | | 100 | 100 | 100 | 81 | 40 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 81) = 19 or LOW; and Context Area = (100 – 40) = 60 or MODERATE

‡ USDA FS 2010f; Schussman and Gori 2006; LANDFIRE 2007d and 2007h

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Low. Currently there is a small over representation of grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover (seral state A), seedling/sapling size trees with open or closed woody canopy cover (seral state B, E), medium to very large size trees with closed woody canopy cover (seral state G); with a concurrent under representation of medium to very large size trees with open woody canopy cover (seral state D). There is no quantifiable representation of very large size trees (20 in. +) within this ERU on the Forest, primarily due to high-grading the larger trees for fire wood and ornamental wood.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 19% in the Mogollon Front local unit to a high of 49% in the Upper Gila River local unit (Figure 52). Three local units have low, but non-significant departure from reference conditions (Mogollon Front, Apache and Upper Gila River); while two have moderate, but significant departure from reference conditions (Black Range and Little Colorado-San Agustin Fringe).

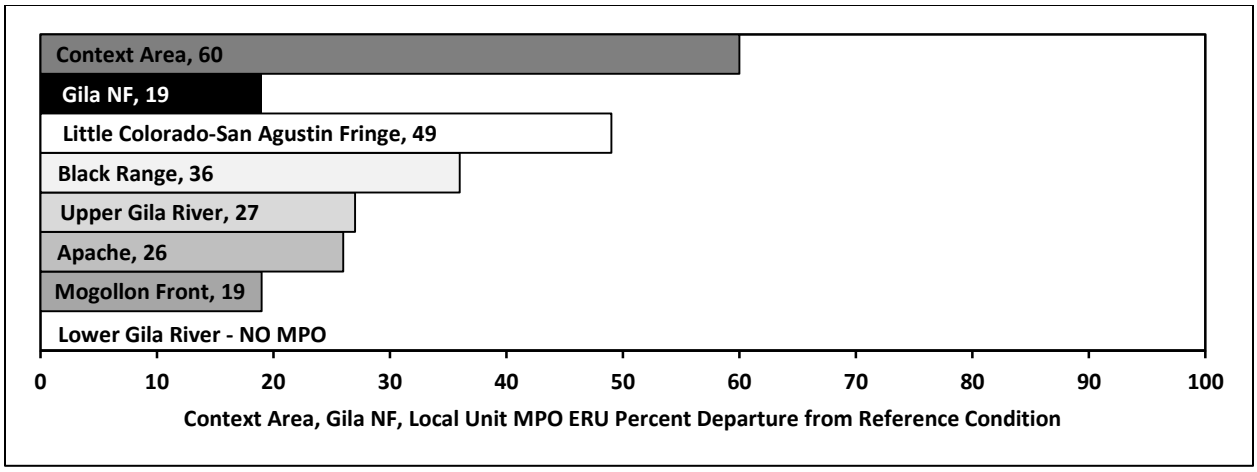


**Figure 52. Variations in seral state departure from reference condition for MPO ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 55 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the MPO is rated as low. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) is moderate.

**Table 55. Gila NF Madrean piñon-oak woodland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| ǂ | | | | | | | | L | M | | | L-M | M |

[1] Triepke, et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 53 displays the state and transition modeling results for the MPO ERU at the plan scale.

Under reference conditions, MPO was dominated by seral state D (medium to very large size trees with open woody canopy cover). Currently, the MPO is similar to reference conditions. However, under continuation of current management seral state G (medium to very large size trees with closed woody canopy cover) becomes dominant quite quickly and reaches a highly significant departure level through all modeling periods.

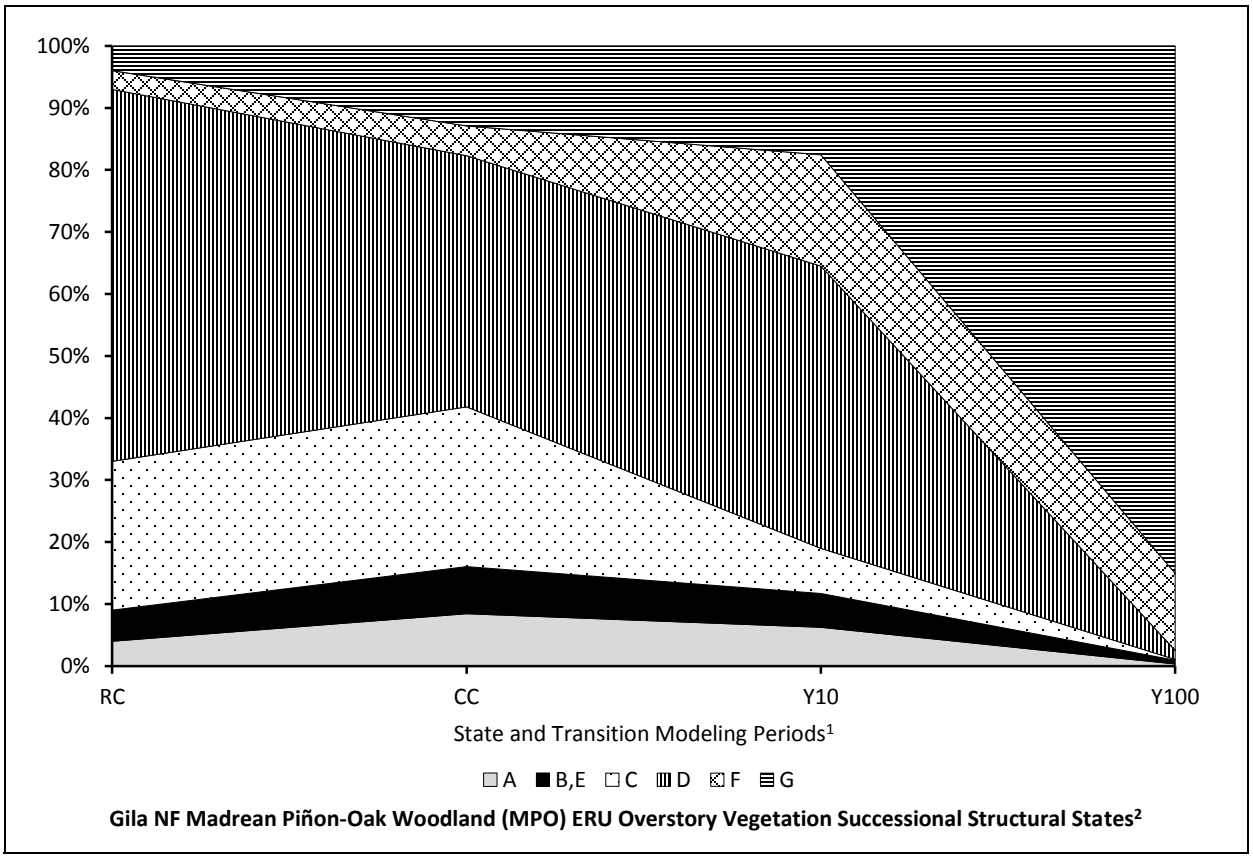


**Figure 53. Gila NF overstory vegetation successional structural states for Madrean piñon-oak woodland (MPO) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 19% or low departure from RC
Y10 = State and transition modeling results at 10 years = 31% or low departure from RC
Y100 = State and transition modeling results at 100 years = 90% or high departure from RC
[2] See Table 54 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 3.3 T/ac. | |
| Current: | 18.3 T/ac. | High |
| 100-years: | 18.3 T/ac. | High/Static |

| | Snag Density (8" dbh) | Departure/Trend | Snag Density (18" dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 4.0/ac. | | 1.0/ac. | |
| Current: | 4.3/ac. | Low | 0.7/ac. | Low |
| 100-years: | 4.3/ac. | Low/Static | 0.7/ac. | Low/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

There is no patch size assessment data for this ERU.

### Gila NF Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average fire rotation = 13 yrs. and non-lethal fire rotation = 13 yrs. Surface fire and mixed severity, 6 to 12 yrs.; Stand replacement fire, 500 yrs.

Current: FF = 632.6 yrs.

Departure: High

‡ Fulé and Covington 1996, 1997, 1998 and 1999; Kaib et al. 1996; Swetnam and Baisan 1996; Barton 1999 and 2002; Fulé et al. 2000 and 2005; Swetnam et al. 1992 and 2001; Schussman and Gori 2006; Schussman et al. 2006; LANDFIRE 2007d and 2008c; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual area burned by wildfire within the MPO ERU is 27 acres; roughly 97% at low severity, 3% at moderate severity and 0% at high severity (Table 56). Current fire severity is rated at 13.7%, higher than reference condition's 12.5% (Schussman et al. 2006), never the less, giving it a low departure rating.

**Table 56. Gila NF local unit MPO 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | | Black Range | | | Little Colorado-San Agustin Fringe | | | Lower Gila River | | | Mogollon Front 1 ac. | | | Upper Gila River 26 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| ϯ | | | | | | | | | | | | 100 | 0 | 0 | 97 | 3 | 0 |

‡ 19-year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

ϯ Empty cells indicate no data is available for that variable

### Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

Reference: FRCC‡ I (III)

Current: FRCC I = 0.0% FRCC II = 79.5% FRCC III = 0.0% No data = 20.5%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 655 acres. The highest level occurred in 2003 at 8,170 acres. Overall, nearly 68% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases active in the MPO ERU, but it is likely that the same drivers and stressors as in the other woodlands are active within this ERU.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the MPO ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, bullthistle, cheatgrass, and weeping lovegrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is non-significant; however, the current trend is away from reference conditions (gray cells in Table 57) resulting in an assessment of *potential risk; therefore evaluate magnitude of future deviations, threats and system reversibility* within the Madrean piñon-oak woodland ERU.

**Table 57. Gila NF Madrean piñon-oak woodland ERU risk assessment matrix**

| Current MPO ERU Departure from RC (19%, low) | MPO ERU Trend after 100 Years (departure from RC 90%, high) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static, neither toward nor away (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Madrean pine-oak ecosystems have been observed to convert to oak-scrub (interior chaparral type) woodlands after modern wildfires (Barton 2002; Iñiguez 2006; Iñiguez et al. 2009). Movement of pine-oak ecosystems to higher elevations is likely to occur as global warming alters their typical precipitation and temperature regimes (Allen and Breshears 1998).

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *PIÑON-JUNIPER EVERGREEN SHRUB WOODLAND (PJC) ERU*

### Spatial Niche

The PJC is generally limited to scattered location within the context area, however, the greatest concentration is in the southeastern portion of the context area at 401,552 acres or 0.9% it is the context area's 12th largest ERU. On the Gila NF its 10,678 acres or 0.3% is scattered, but primarily found within the southwestern portion of the Forest (Figure 55 and Figure 56). The PJC represents the smallest upland ERU on the Forest. The Gila NF's niche for this ERU is approximately 2.7% of the ERU within the ecoregion sections. In addition, it has a lower proportional representation on the Forest (-0.45) than in the context area. This ERU has a 50% departure rating (Table 59), however, within the PJC, across the Forest this varies from a low of 46% to a high of 99% within the Mogollon Front and Lower Gila River local units, respectively. The influence of the Gila NF on the sustainability of this system is limited not because of the departure level but because of the large proportional representation of this ERU off the Forest, however, the departure of this ERU within the context area is also lower (42%) than on Forest. Seral state representation within the context area and the Forest are different (Table 59).

Figure 55 and Figure 56 show that the show the distribution of this ERU within the context area and Forest. Table 58 displays the acreage and proportion of the PJC ERU within the local units and Forest.

**Table 58. Piñon-juniper evergreen oak ERU acreage distribution and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 909 | 8.5 | 2,100 | 19.7 | 1,449 | 13.3 | 17 | 0.2 | 6,203 | 58.1 | 0 | 0.0 | 10,678 | 0.3 |

This ERU, where it occurs, ranges from a high 6,203 acres (58.1%) to a low of 17 acres (0.2%) in the Mogollon Front, and Lower Gila River local units, respectively. Over half of the ERU, nearly 58% occurs within one local unit, the Mogollon Front.

### General Description

The piñon -juniper/evergreen shrub woodland ERU (Figure 54) is typically found on lower slopes in transition zones, often between interior chaparral and montane forests, and is most extensive in geographic areas dominated by mild climate gradients and bi-modal precipitation regimes. The PJC ERU is a broad grouping of different plant associations for descriptive purposes, with tree and shrub species composition varying throughout the Region. Historically this ERU had greater than 10% tree canopy cover in later successional stages, expressed by twoneedle piñon, single leaf piñon, Utah juniper, oneseed juniper, or alligator juniper. Piñon is occasionally absent, but one or more juniper species are always present. Oak trees (i.e., Arizona white oak, gray oak, Emory oak) are subordinate, but have high constancy in mild climate zones between central Arizona and southwestern New Mexico. Trees occur as individuals or in smaller groups and range from young to old, but typically small stands or clumps are even-aged in structure as a consequence of mixed severity fire (at least historically). The understory is dominated by low to

**Figure 54. Piñon-juniper evergreen shrub woodland ERU (Photo by L.J. WhiteTrifaro 2008)**

moderate density shrubs, with herbaceous plants in the interspaces. Shrub species include species of manzanita, mountain mahogany, antelope bitterbrush (*Purshia tridentata* (Pursh) DC.), silktassles *(Garrya* spp. Douglas ex Lindl.), Stansbury cliffrose (*Purshia stansburiana* (Torr.) Henrickson), Sonoran scrub oak, and sumacs (*Rhus* spp. L.).

Typical drivers and stressors (fire, insects, disease) are mixed severity and moderate, although some evergreen shrub woodland types exhibit infrequent fire/high severity effects (FR IV, 35-200 years, replacement severity; e.g., piñon-juniper/manzanita). These disturbance patterns create and maintain tree-age diversity and low to moderately-closed canopy typical of this type. Understory plants consisting of perennial native grasses and both annuals and perennial forbs comprise the remainder of the inter-canopy interspaces. Climate generally consists of mild winters and wet summers with mean annual precipitation ranging from about 10 to 25 inches with 55-60% coming between April 1st and September 31st. The PJC ERU is found on well-drained soils, frequently with coarse-textured or gravelly (stony) soil characteristics. Aside from disparities in structure and composition, PJC can also be differentiated from interior chaparral by longer fire intervals and less severe fire events. Due to the effects of long-term fire suppression, in many locations the current condition is severely departed from historic conditions. Typically these changes include in-filling of the canopy gaps, increased density of tree groups, and reduced composition, density and vigor of the herbaceous understory plants. Many of these sites currently are closed-canopy woodlands, with insufficient understory vegetation to support surface fires.

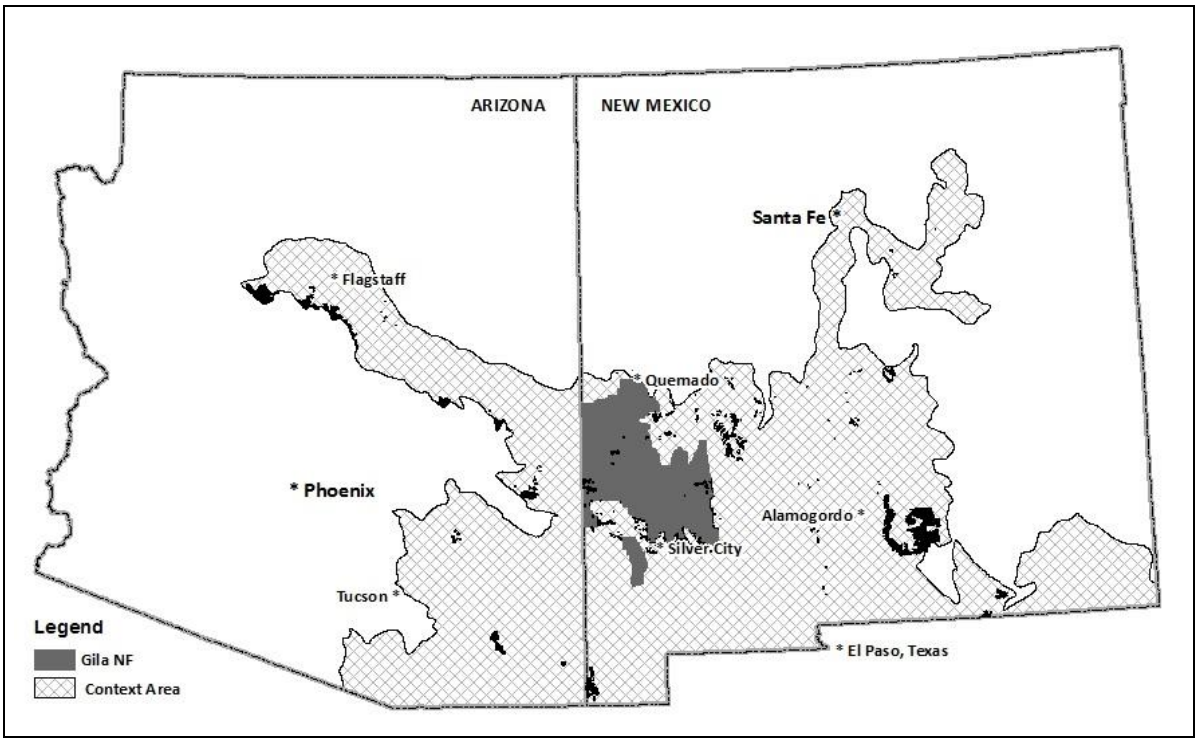


**Figure 55. General location (in black) of the piñon-juniper evergreen shrub woodland (PJC) ERU within the context area**

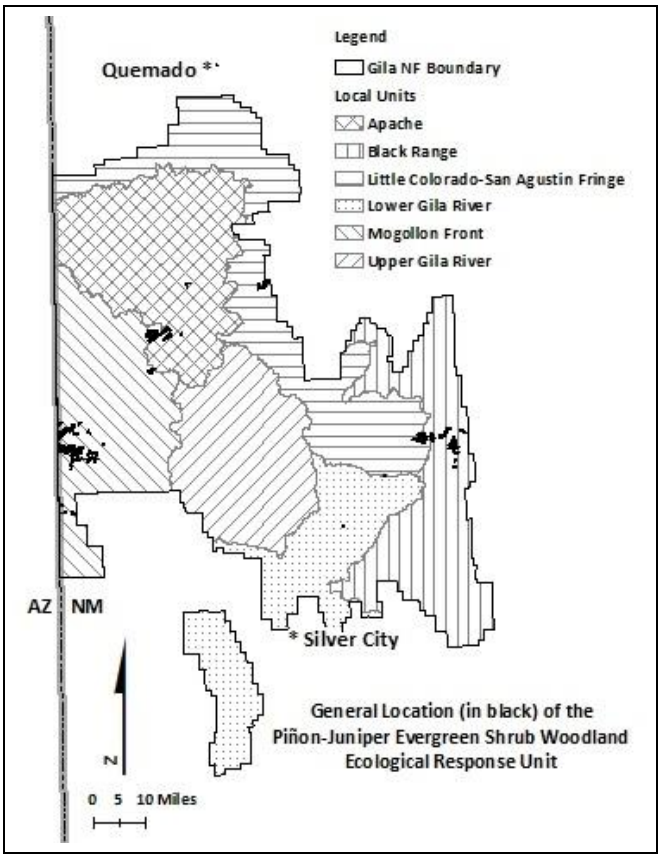


**Figure 56. General location (in black) of the piñon-juniper evergreen shrub woodland (PJC) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) Reference and Current Conditions

Under reference conditions the majority of the PJC ERU was comprised of seedling/sapling size trees with open or closed woody canopy cover, and small size trees with open woody canopy cover and medium to very large size trees with open woody canopy cover (Table 59). Historically, the disturbance patterns caused by the drivers and stressors, mentioned above, created and maintained tree-age diversity and low to moderately-closed canopy typical of this type. Understory plants consisting of perennial native grasses and both annuals and perennial forbs comprise the remainder of the inter-canopy interspaces (Wahlberg et al. 2014).

**Table 59. Seral state make-up of the PJC ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover, and shrubs with open (≥ 10% & < 30%) or closed (≥ 30%) woody canopy cover | 5 | 1 | 12 | 1 | 5 |
| B, C, E | Mid-seral: Seedling/sapling size (< 5” dbh/drc) trees with open or closed woody canopy cover, and small size (≥ 5” & < 10” dbh/drc) trees with open woody canopy cover | 55 | 15 | 13 | 15 | 13 |
| D | Late-seral: Medium to very large size (≥ 10” dbh/drc) trees with open woody canopy cover | 40 | 34 | 40 | 34 | 40 |
| F | Mid-seral: Small size trees with closed woody canopy cover | 0 | 12 | 11 | 0 | 0 |
| G | Late-seral: Medium to very large size trees with closed woody canopy cover | 0 | 38 | 21 | 0 | 0 |
| Total | | 100 | 100 | 100 | 50 | 58 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 50) = 50 or MODERATE; and Context Area = (100 – 58) = 42 or MODERATE

‡ USDA FS 2010g; LANDFIRE 2007d, 2007i, 2008c

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High)

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is an over representation of small size trees with closed woody canopy cover (seral state F), and medium to very large size trees with closed woody canopy cover (seral state G); with a concurrent under representation of seedling/sapling size trees with open or closed woody canopy cover, and small size trees with open woody canopy cover (seral state B, C, E), and medium to very large size trees with open woody canopy cover (seral state D). There is no quantifiable representation of very large size trees (20 in. +) within this ERU primarily due to past chaining and cabling activities, as well as high-grading the larger trees for fire wood.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 46% in the Mogollon Front local unit to a high of 99% in the Lower Gila River local unit (Figure 57). Two local units have moderate, but significant departure from reference conditions (Mogollon Front and Little Colorado-San Agustin Fringe); while two have significantly high departure from reference conditions (Apache and Lower Gila River).

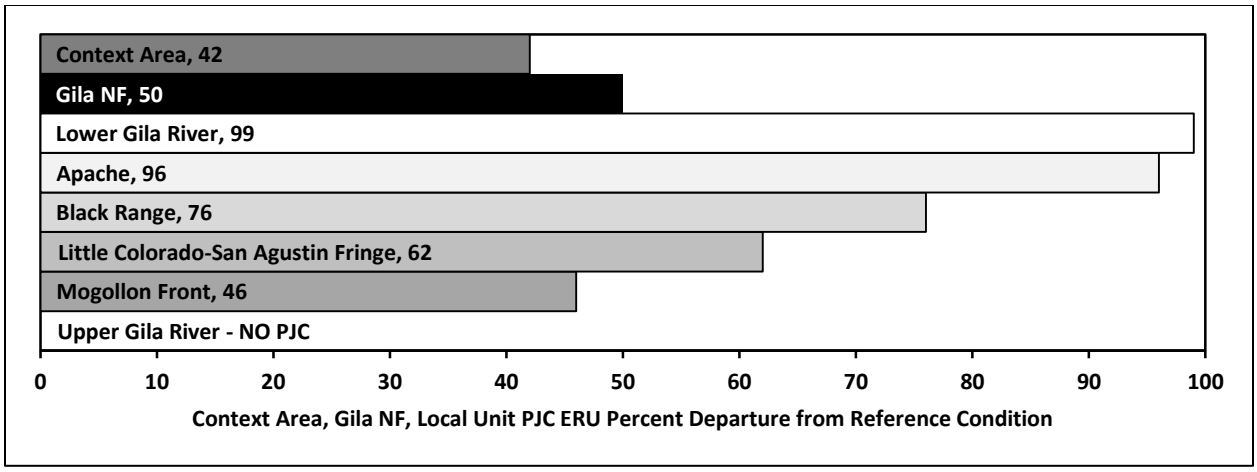


**Figure 57. Variations in seral state departure from reference condition for PJC ERU at the context area, Forest and local unit scales**

### Climate Change Vulnerability:

There is no climate change vulnerability and uncertainty assessment data for this ERU.

### Gila NF Seral State Proportion (Succession Structural States) Departure and Trend

Figure 58 displays the state and transition modeling results for the PJC ERU at the plan scale.

Under reference conditions, PJC was dominated by seral state B, C, E (seedling/sapling size trees with open or closed woody canopy cover, and small size trees with open woody canopy cover) and seral state D (medium to very large size trees with open woody canopy cover). Currently, the PJC is dominated by seral states G (medium to very large size trees with closed woody canopy cover), and seral state D. However, under continuation of current management seral state G declines and seral state A (grass, forb, sparsely vegetated or recently burned with very open woody canopy cover, and shrubs with open or closed woody canopy cover) becomes dominant quite quickly however, departure from reference conditions remains moderate, but significant through all modeling periods.

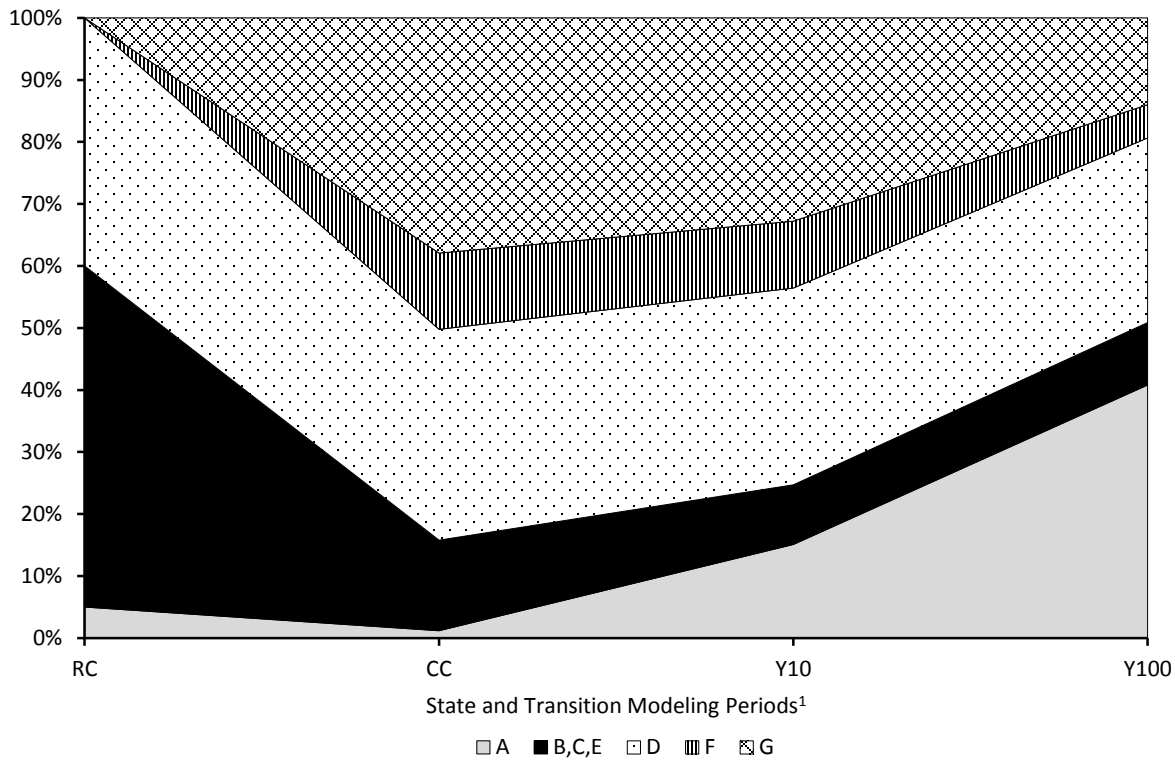


**Figure 58. Gila NF overstory vegetation successional structural states for piñon-juniper evergreen shrub woodland (PJC) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 50% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 54% or high departure from RC
Y100 = State and transition modeling results at 100 years = 55% or moderate departure from RC
[2] See Table 59 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

| | Coarse Woody Debris | Departure/Trend |
|---|---|---|
| Reference: | 3.1 T/ac. | |
| Current: | 13.3 T/ac. | High |
| 100-years: | 13.3 T/ac. | High/Static |

| | Snag Density (8” dbh) | Departure/Trend | Snag Density (18” dbh) | Departure/Trend |
|---|---|---|---|---|
| Reference: | 3.0/ac. | | 1.0/ac. | |
| Current: | 4.7/ac. | Moderate | 1.5/ac. | Low |
| 100-years: | 4.7/ac. | Moderate/Static | 1.5/ac. | Low/Static |

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

There is no patch size assessment data for this ERU.

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average rotation = 206.3 yrs., mixed severity rotation = 213 yrs., and stand replacement rotation = 200 yrs.

Current: FF = 429.4 yrs.

Departure: Moderate

‡ LANDFIRE, 2007d and 2007i, and 2008c; Wahlberg et al. 2014; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within this ERU is 25 acres; roughly 95% at low severity, 5% at moderate severity and 0% at high severity (Table 60). Current fire severity is rated at 14.6%, lower than reference condition's 69.3% (Schussman et al. 2006), giving it a high departure rating.

**Table 60. Gila NF local unit PJC 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | | Black Range 3 ac. | | | Little Colorado-San Agustin Fringe 8 ac. | | | Lower Gila River | | | Mogollon Front 14 ac. | | | Upper Gila River 27 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| ϯ | | | 92 | 7 | 1 | 91 | 9 | 0 | | | | 97 | 2 | 1 | | | |

‡ 19-year period is 1996 through 2015

† Burn severity levels are: L = low; M = moderate; and H = high

ϯ Empty cells indicate no data is available for that variable

### Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

Reference: FRCC‡ III, IV

Current: FRCC I = 0.0% FRCC II = 71.7% FRCC III = 19.7% No data = 8.6%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 811 acres. The highest level occurred in 2003 when the entire ERU was affected. Overall, nearly 100% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases active in the PJC ERU, but it is likely that the same drivers and stressors as in the other woodlands are also active within this ERU.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the PJC ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, bullthistle, cheatgrass, and weeping lovegrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 61) leading to *potential risk due to legacy of past management or deviation from ongoing activities*; therefore, *evaluate stressors and system reversibility* within the piñon-juniper/evergreen shrub woodland ERU.

**Table 61. Gila NF Piñon-juniper/evergreen shrub woodland risk assessment matrix**

| Current PJC ERU Departure from RC (50%, moderate) | PJC ERU Trend after 100 Years (departure from RC 55%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static (± 5% change) | away from RC (> 5% change) |
| Significant Departure (34-100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| Non-significant Departure (0-33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

# Shrubland ERU

## *MOUNTAIN MAHOGANY MIXED SHRUBLAND (MMS) ERU*

### Spatial Niche

The MMS is generally located within the New Mexico portion of the context area; at 356,451 acres (or 0.8% of the context area) it is tied with MSG as the 11th largest ERU. On the Gila NF its 166,488 acres (or 5.1% of the Forest) is scattered about the Forest, found primarily within the southern portion of the Forest (Figure 60 and Figure 61). The MMS represents the 6th largest upland ERU on the Forest. The Gila NF's niche for this ERU is approximately 46.7percent of the ERU within the ecoregion sections. In addition it has a greater proportional representation on the Forest (0.74) than in the context area. In fact, it has the 2nd highest proportional representation of any ERU on the Forest. This ERU has a 64% departure rating (Table 63), however, within the MMS, across the Forest this varies from a low of 58% to a high of 68% within the Lower Gila River and Little Colorado-San Agustin Fringe local units, respectively. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the moderate departure rating of this ERU within the context area, 42%. However, due to the high proportional representation on the Gila NF, the Forest has a higher level of responsibility for maintenance of this ERU. Seral state representation within the context area does not follow the same overall pattern as within the Gila NF (Table 63).

Figure 60 and Figure 61 show that the show the distribution of this ERU within the context area and Forest. Table 62 displays the acreage and proportion of the MMS ERU within the local units and Forest.

**Table 62. Mountain mahogany mixed shrubland ERU acreage percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 1,946 | 1.2 | 20,577 | 12.4 | 151 | 0.1 | 45,624 | 27.4 | 32,225 | 19.4 | 65,965 | 39.6 | 166,488 | 5.2 |

This ERU ranges from a high of 65,965 acres (39.6%) to a low of 151 acres (0.1%) in the Upper Gila River and Little Colorado-San Agustin Fringe, respectively. Over half of the ERU, nearly 67% occurs within two local units, the Upper Gila River and Lower Gila River.

## General Description

The mountain mahogany mixed shrubland ERU (Figure 59) occurs in the foothills, canyon slopes, and lower slopes of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Colorado. These shrublands are often associated with exposed sites, rocky substrates, dry conditions, and recurrent historic fire that limited tree growth. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs including mountain mahogany and skunkbush sumac. Historically this ERU had less than 30% tree canopy cover. The mountain mahogany mixed shrubland ERU is characterized by historic fire regime group IV, with an average fire return interval of 35-200 years from stand replacing fire.

**Figure 59. Mountain mahogany mixed shrubland ERU (Wahlberg et al., 2014)**

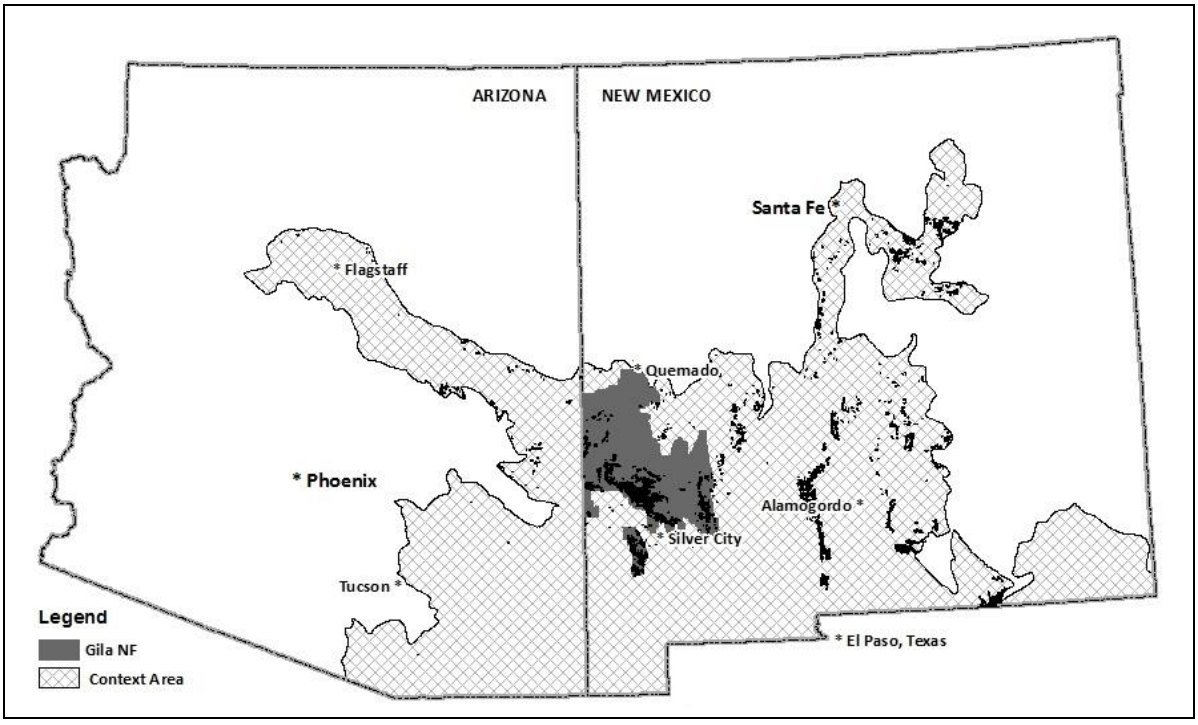


**Figure 60. General location (in black) of the mountain mahogany mixed shrubland (MMS) ERU within the context area**

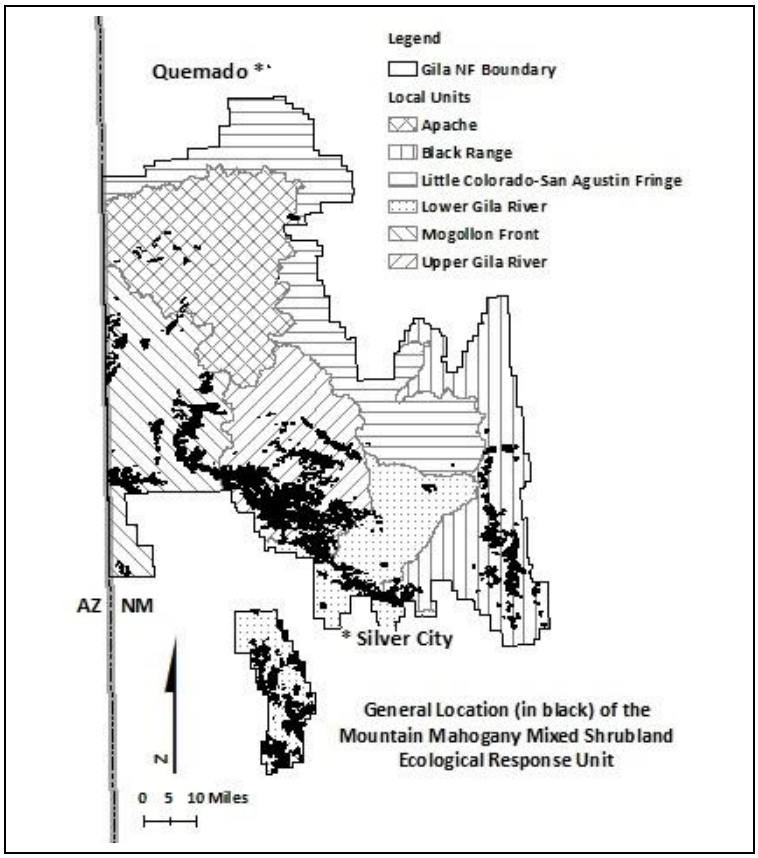


**Figure 61. General location (in black) of the mountain mahogany mixed shrubland (MMS) ERU within the Gila NF and the six local units**

## Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the MMS ERU was dominated by all size shrubs with open or closed canopy cover (Table 63). Currently, this ERU is dominated by all size trees with open or closed canopy cover.

**Table 63. Seral state make-up of the MMS ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Early seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover | 5 | 2 | 9 | 2 | 5 |
| B | Mid-seral: All size shrubs with open (≥ 10% & < 30%) canopy cover | 50 | 3 | 17 | 3 | 17 |
| C | Late-seral: All size shrubs with closed (≥30%) canopy cover | 15 | 1 | 6 | 1 | 6 |
| D | Late-seral: All size trees with open or closed canopy cover | 30 | 94 | 68 | 30 | 30 |
| Total | | 100 | 100 | 100 | 36 | 58 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 36) = 64 or MODERATE; and Context Area = (100 – 58) = 42 or MODERATE

‡ USDA FS 2015e; LANDFIRE 2007e

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker, 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High)

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: Moderate but significant. Currently there is an over representation of all size trees with open or closed canopy cover (seral state D) and concurrent under representation of all size shrubs with open or closed canopy cover (seral states B and C). Historically, this ERU had no more than 30% tree canopy cover.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 59% in the Lower Gila River local unit to a high of 68% in the Little Colorado-San Agustin Fringe local unit (Figure 62). All of the local units have significant departure from reference conditions.

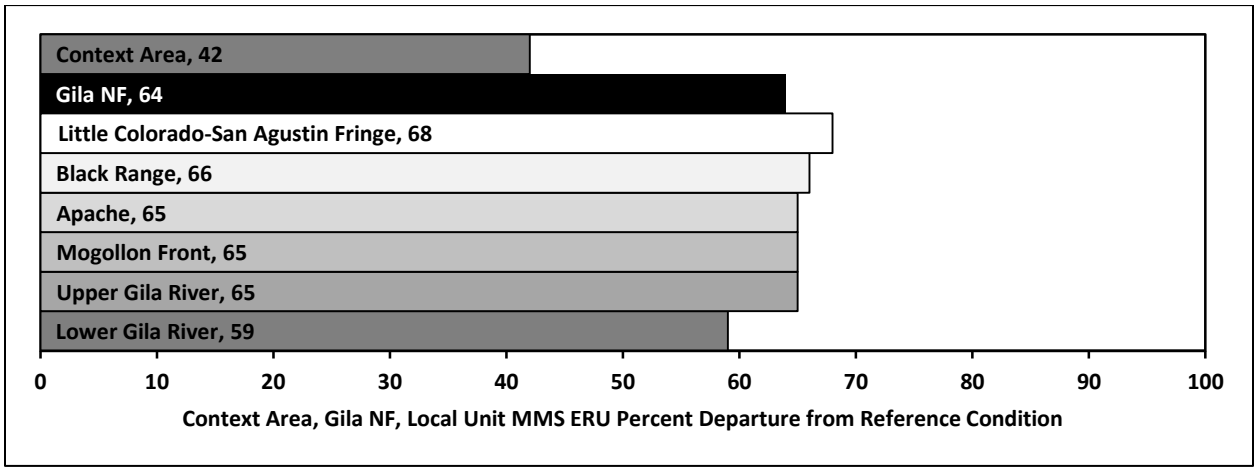


**Figure 62. Variations in seral state departure from reference condition for MMS ERU at the context area, Forest and local unit scales**

### Climate Change Vulnerability

Table 64 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the MMS ranges from low to high, with the greatest level of vulnerability occurring within the Lower Gila River local unit. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) are moderate for all local units considered.

**Table 64. Gila NF mountain mahogany mixed shrubland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| ǂ | | L | M | | | M-H | M | L | M | L-M | M | L-M | M |

[1] USDA FS 2013a and 2015a; Triepke, et al. 2014; and Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UC) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

### Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 63 displays the state and transition modeling results for the MMS ERU at the plan scale.

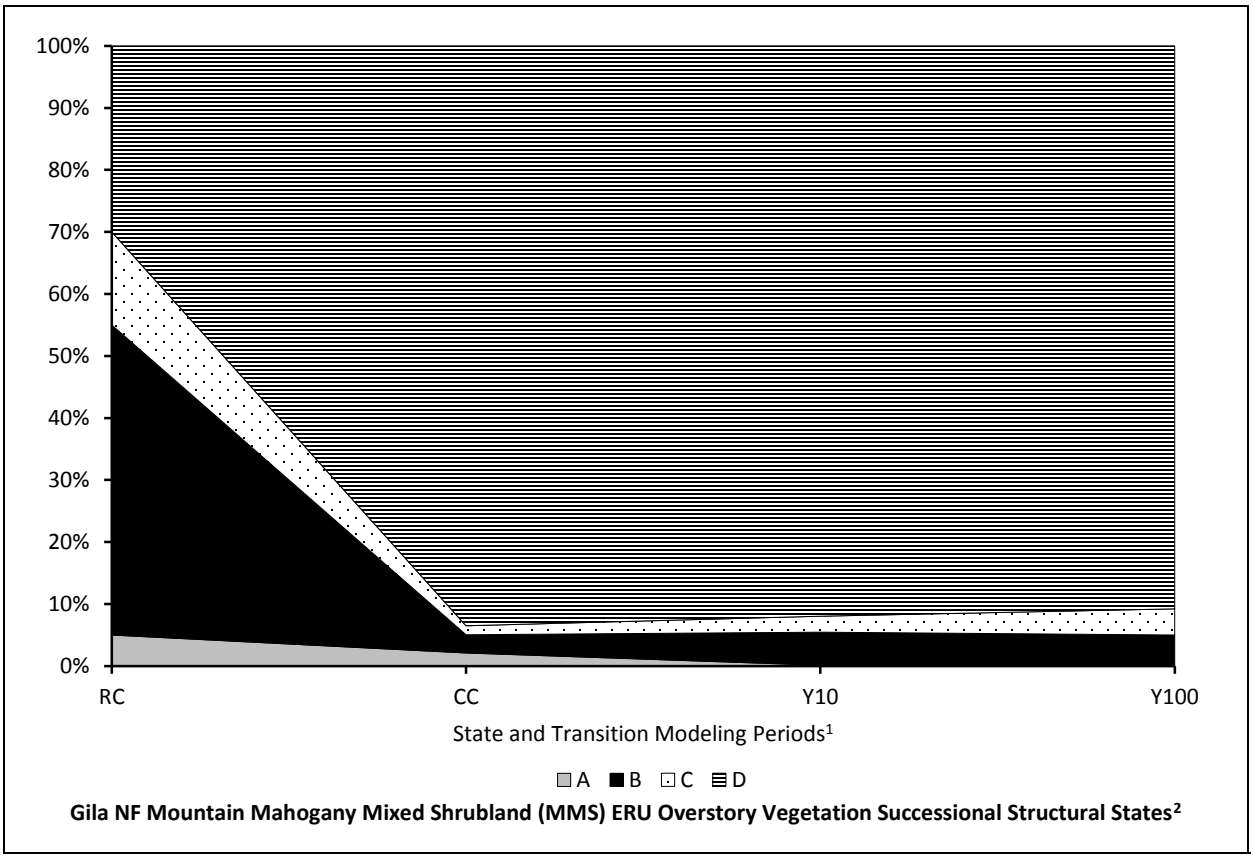


**Figure 63. Gila NF overstory vegetation successional structural states for mountain mahogany mixed shrubland (MMS) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities.**

[1] RC = Reference conditions
CC = Current conditions = 64% or low departure from RC
Y10 = State and transition modeling results at 10 years = 62% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 61% or moderate departure from RC
[2] See Table 63 for a description of the overstory vegetation successional structural states

The majority of this ERU is dominated by trees. In addition, this condition occupies most of the modern MMS landscape. Seral states B and C represented the major vegetation state under reference conditions. The dominance of seral state D remains constant through all modeling periods and trend is static in relation to reference condition.

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend

There is no coarse woody debris and snag density assessment data for this ERU.

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 174 to 206 ac.
Current: 34 ac.
Departure: High

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = historic fire interval = 0 to 35 yrs.

Current: FF = 32.2 yrs.

Departure: Low

‡ Wahlberg et al. 2014; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the MMS ERU is 5,166 acres; roughly 74% low severity, 21% moderate severity and 5% at high severity (Table 65). Current fire severity is rated at 23.9%, lower than reference condition's 73% (Fryer and Luensmann 2012), giving it a high departure rating.

**Table 65. Gila NF local unit MMS 19-year average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19 Year‡ Average Acres Burned and at What Percent Severity Level | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AP 3 ac. | | | BR 712 ac. | | | LCSAF 2 ac. | | | LGR 36 ac. | | | MF 806 ac. | | | UGR 3,607 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 85 | 14 | 1 | 69 | 27 | 4 | 42 | 42 | 16 | 98 | 2 | 0 | 72 | 24 | 4 | 76 | 19 | 5 |

‡ 19-year period is 1996 through 2015

Burn severity levels are: L = low; M = moderate; and H = high

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

Reference: FRCC‡ II, IV

Current: FRCC I = 0.0% FRCC II = 31.7% FRCC III = 67.0% No data = 1.3%

Departure: High, trend is expected to continue away from reference conditions

‡ Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 94 acres. The highest level occurred in 2013 at 633 acres. Overall, nearly 1% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases active in the MMS ERU, but it is likely that the same drivers and stressors as in the woodlands are active within this ERU.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the MMS ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, bullthistle, cheatgrass, and weeping lovegrass; occurring at low levels.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 66) leading to *potential risk due to legacy of past management or deviation from ongoing activities; which requires evaluation of stressors and system reversibility* within the mountain mahogany mixed shrubland ERU.

**Table 66. Gila NF mountain mahogany mixed shrubland ERU risk assessment matrix**

| Current MMS ERU Departure from RC (64%, moderate) | MMS ERU Trend after 100 Years (departure from RC 61%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static (± 5% change) | away from RC (> 5% change) |
| significant departure (34 - 100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant departure (0 - 33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

# Grassland ERUs

## *MONTANE/SUBALPINE GRASSLANDS (MSG) ERU*

### Spatial Niche

The MSG is limited at 379,720 acres (0.8%) within the context area and it is tied with MMS as the 11th largest ERU. MSG contributes 113,785 (3.5%) to the Gila NF, and represents the 8th largest ERU on the Forest. The Gila NF's niche for this ERU is approximately 30% of the ERU within the ecoregion sections. In addition, it has a greater proportional representation on the Forest (0.62) than in the context area. This ERU has a 45% departure rating (Table 68), however, within the MSG, across the Forest this varies from a low of 38% in the Upper Gila River local unit to a high of 91% in the Mogollon Front local unit. The influence of the Gila NF on this particular ERU has to do with both its higher proportional representation on the Forest and the low departure rating of this ERU within the context area, 32%. However, due to the high proportional representation on the Gila NF, the Forest has a higher level of responsibility for maintenance of this ERU. Seral state representation within the context area does not follows the same overall pattern as within the Gila NF (Table 68). In general, this ERU has gone from a normally open grassland to a tree encroached grassland that in some locations looks like forest or woodland.

Figure 65 and Figure 66 show that the show the distribution of this ERU within the context area (primarily located in the northern and eastern portions of the context area) and northern and central portions of the Forest. Table 67 displays the acreage and proportion of the MSG ERU within the local units and Forest.

**Table 67. Montane/subalpine grasslands ERU acreage and percent within the local units**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 20,028 | 17.6 | 6,835 | 6.0 | 37,045 | 32.6 | 0 | 0.0 | 137 | 0.1 | 49,740 | 43.7 | 113,785 | 3.5 |

This ERU, in which it occurs: ranges from a high 49,740 acres (43.7%) to a low of 137 acres (0.1%) in the Upper Gila River and Mogollon Front, respectively. Over half of the ERU, nearly 76% occurs within two local units, the Upper Gila River and Little Colorado-San Agustin Fringe.

### General Description

Also referred to as montane grasslands, the MSG ERU (Figure 64) occurs at elevations ranging from 8,000 to 10,900 feet. Size of montane/subalpine grasslands range from small park-like openings to extensive landscapes covering several thousand acres. This ERU contains a mix of dominant and co-dominant species in both dry and moister environments and often harbors several plant associations with varying prominent grasses and herbaceous species. Such dominant species may include Parry's oatgrass

**Figure 64. Montane/subalpine grasslands ERU (Photo by M.R. White 1998)**

(*Danthonia parryi* Scribn.), Arizona fescue, Thurber's fescue (*Festuca thurberi* Vasey), pine dropseed, non-native bluegrasses (*Poa pratensis* L. and *P. compressa* L.), mountain muhly, various sedges, shooting star (*Dodecatheon jeffreyi* Van Houtte), fowl mannagrass (*Glyceria striata* (Lam.) Hitchc.), Sierra rush (*Juncus nevadensis* S. Watson), Rocky Mountain iris (*Iris missouriensis* Nutt.), Parry's bellflower (*Campanula parryi* A. Gray), California false hellebore (*Veratrum californicum* Durand), and species of bulrush (*Scirpus* spp. L. and/or *Schoenoplectus* spp. (Rchb.) Palla). Historically this ERU had less than 10% tree canopy cover and less than 10% shrub cover. However, tree encroachment may occur along the periphery of the grasslands, trees may include Engelmann and blue spruce, Rocky Mountain Douglas-fir, white and subalpine fir, ponderosa and limber pine, depending on elevation and adjacent forest ERUs. Some shrubs may also be present. Some portions of the MSG are seasonally wet, which is closely tied to snowmelt, though they typically do not experience flooding events. The montane/subalpine grasslands are often interspersed with the herbaceous riparian (RU190) ERU. Soils in swales and on riparian benches are usually moist throughout the year, and often harbor several plant associations with varying dominant grasses and herbaceous species. Upland and swale vegetation composition are characterized by different dominant species. Generally, annual precipitation ranges from 20 to 31 inches, with 50-55% coming between October 1st and March 31st. Because of the broad nature of this ERU, future work may develop subclasses splitting out montane grassland from the subalpine grassland.

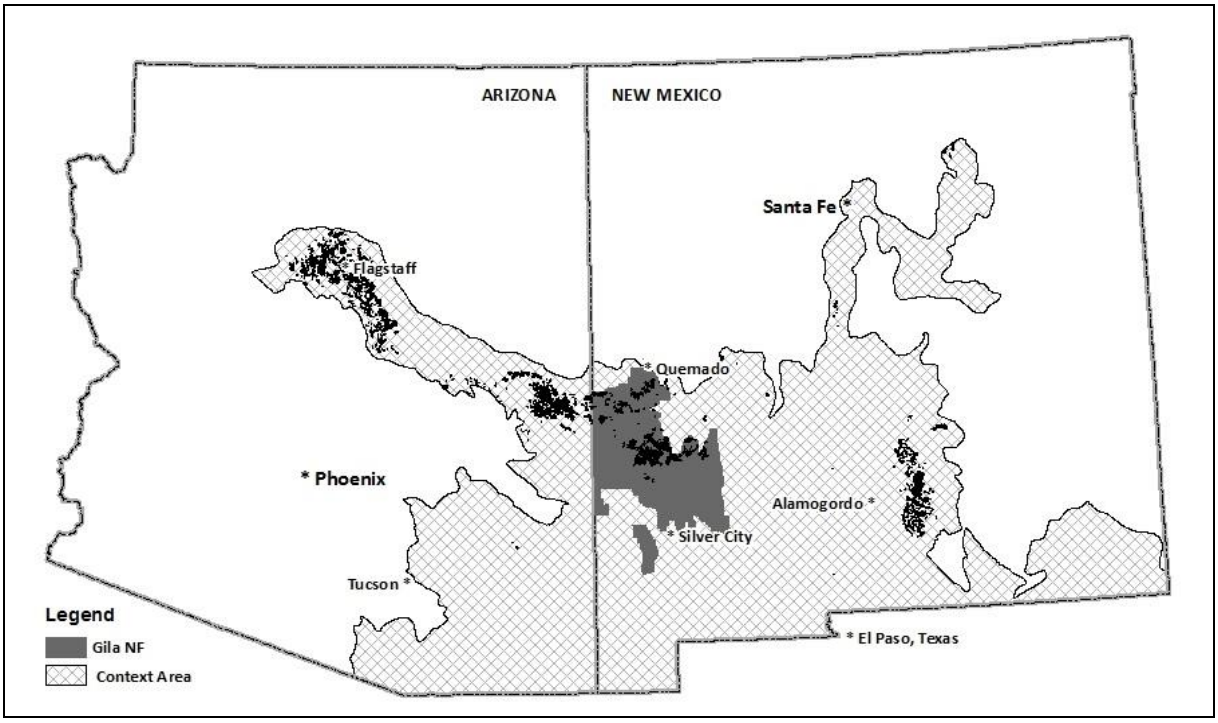


**Figure 65. General location (in black) of the montane/subalpine grasslands (MSG) ERU within the context area**

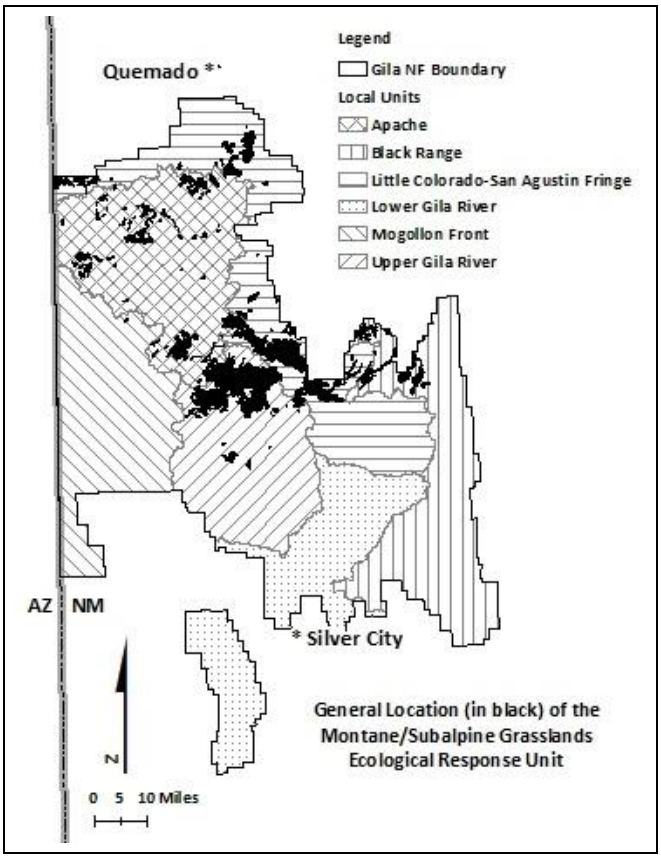


**Figure 66. General location (in black) of the montane/subalpine grasslands (MSG) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions this ERU was dominated by herbaceous vegetation (Table 68). Grasses provided the largest amount of biomass, however, forbs provided the greatest number of individual plant species (White 2002). At present, these grasslands have a significant amount of woody species encroachment. Encroachment by woody plants into grasslands across all elevations should be expected to continue in the absence of active fire management programs (Bond and Keeley 2005).

**Table 68. Seral state make-up of the MSG ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A,C | High-seral: Short-term recently burned, sparsely vegetated (associated with high condition (high ecological status, primarily edaphic types)), and < 10% tree cover & < 10% shrub cover; and Low- to mod-seral: Short-term recently burned, sparsely vegetated (associated with low-moderate condition (low-moderate ecological status, disclimax types)), and < 10% tree cover & < 10% shrub cover | 20 | 0 | 20 | 0 | 20 |
| B | High-seral: All herb dominance types of high condition (high ecological status, primarily edaphic types), and < 10% tree cover & < 10% shrub cover | 45 | 55 | 18 | 45 | 18 |
| D | Low- to mod-seral: All herb dominance types of low-moderate condition (low-moderate ecological status, disclimax types), and < 10% tree cover & < 10% shrub cover | 35 | 10 | 30 | 10 | 30 |
| E, F, G | Low- to mod seral, woody encroachment: All shrub dominance types of low-moderate seral condition, non-ruderal (low-moderate ecological status, disclimax types), and ≥ 10% shrub cover and < 10% tree cover; and all tree dominance types of low-moderate seral condition, non-ruderal (low-moderate ecological status, disclimax types), and < 10% shrub cover and ≥ 10% tree cover *(occurs on contemporary landscapes only…)* | 0 | 35 | 33 | 0 | 0 |
| Total | | 100 | 100 | 100 | 55 | 68 |

Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 55) = 45 or MODERATE; and Context Area = (100 – 68) = 32 or LOW

‡ USDA FS 2016a; LANDFIRE 2007f

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High)

### Gila NF Seral State Proportion (Vegetation Structure) –Current Departure

Departure: Moderate but significant. Currently there is a sizeable over representation of shrub and tree encroachment (seral states E, F, G) and a concurrent under representation of short-term recently burned, sparsely vegetated (associated with high condition (high ecological status, primarily edaphic types)) (seral state A, C) and high ecological status herbaceous vegetation (seral state B). A very similar situation occurs within the context area, except for a well-represented seral state A, C.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 38% in the Upper Gila River local unit to a high of 91% in the Mogollon Front local unit (Figure 67). All of the local units, except the Mogollon Front have moderate, but significant departure from reference conditions. The Mogollon Front has a significantly high departure from reference conditions.

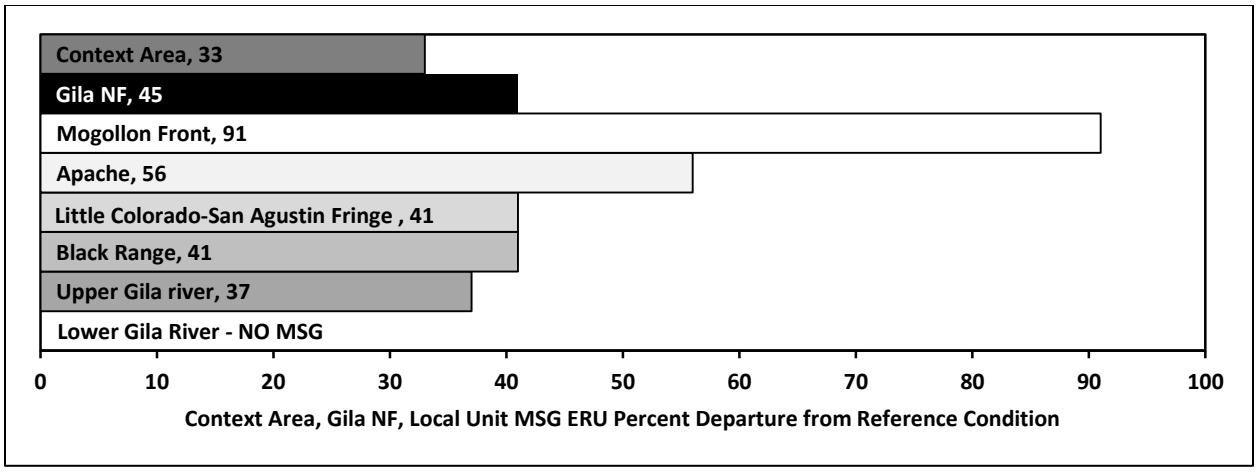


**Figure 67. Variations in seral state departure from reference condition for MSG ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 69 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the MSG ranges from moderate to high, with the greatest level of vulnerability occurring within the Apache and Upper Gila River local units. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) are moderate to high for all local units considered.

**Table 69. Gila NF montane/subalpine grasslands ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M | M-H | M-H | M | M | M-H | ǂ | | | | M-H | M | M | M-H |

[1] Triepke et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 68 displays the state and transition modeling results for the MSG ERU at the plan scale. The large segment of these grasslands are dominated by shrubs and trees (seral states E, F, G), and that carries on into the future under current management. There is also a concurrent decline in high seral condition herbaceous vegetation (seral state B) within this ERU in the future. Departure is trending away from reference conditions.

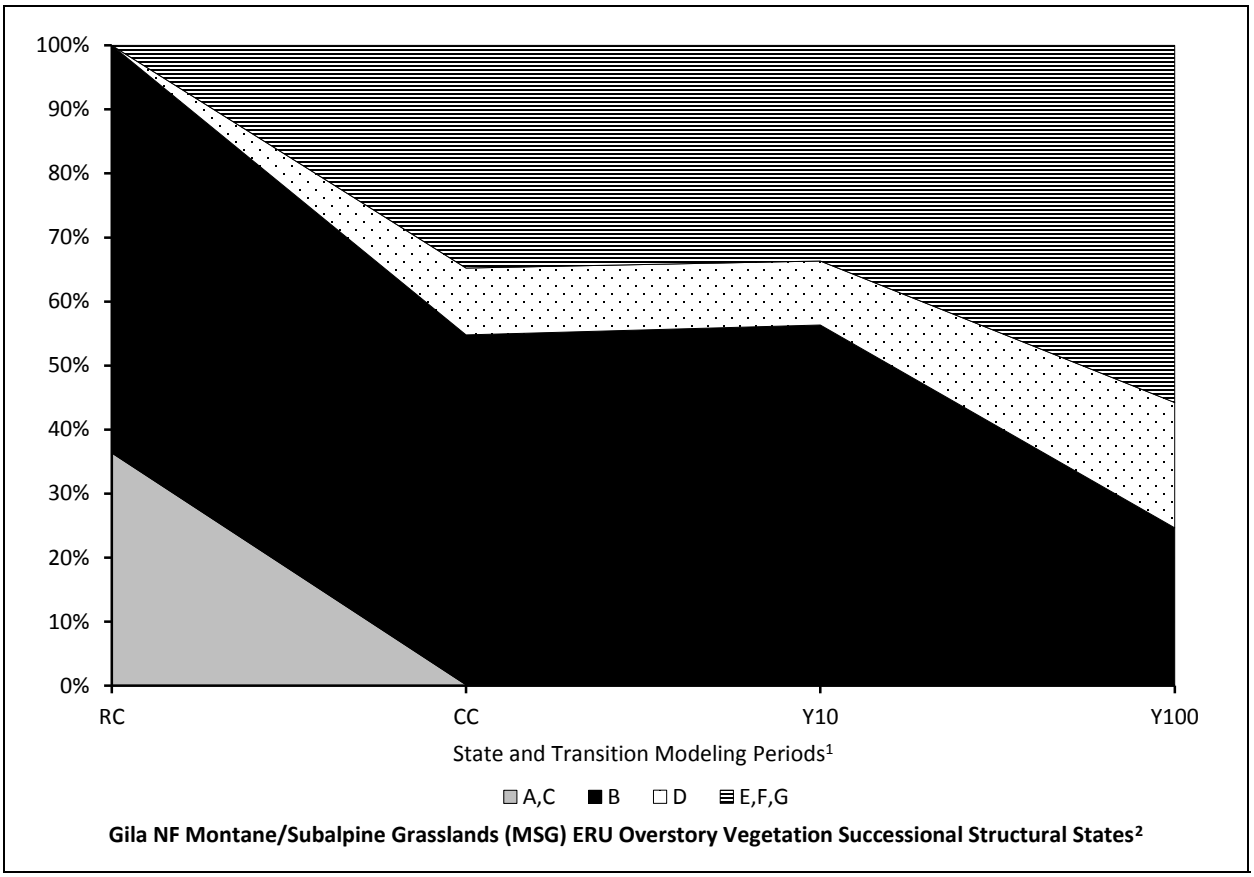


**Figure 68. Gila NF overstory vegetation successional structural states for montane/subalpine grasslands (MSG) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 45% or moderate departure from RC
Y10 = State and transition modeling results at 10 years = 41% or moderate departure from RC
Y100 = State and transition modeling results at 100 years = 56% or moderate departure from RC
[2] See Table 68 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend:

There is no coarse woody debris and snag density assessment data for this ERU.

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 309 to 726 ac.
Current: 301 ac.
Departure: Low

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average fire rotation = 12 yrs. and stand replacement fire rotation = 12 yrs.
Current: FF = 32.4 yrs.
Departure: Moderate

‡ Schussman et al. 2006; Wahlberg et al. 2014; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire within the MSG ERU is 3,512 acres; roughly 88% at low severity, 7% at moderate severity and 5% at high severity (Table 70). Current fire severity is rated at 18.3%, lower than reference condition's 87.5% (Schussman et al., 2006), giving it a moderate departure rating.

**Table 70. Gila NF local unit MSG 19-year (1996-2015) average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 106 ac. | | | Black Range 115 ac. | | | Little Colorado-San Agustin Fringe 571 ac. | | | Lower Gila River | | | Mogollon Front 7 ac. | | | Upper Gila River 2,713 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 98 | 2 | 0 | 98 | 2 | 0 | 97 | 2 | 1 | † | | | 13 | 54 | 33 | 87 | 7 | 6 |

‡ 19-year period is 1996 through 2015
† Burn severity levels are: L = low; M = moderate; and H = high
† Empty cells indicate no data is available for that variable

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

| | | | | |
|---|---|---|---|---|
| Reference: | FRCC‡ II | | | |
| Current: | FRCC I = 0.0% | FRCC II = 43.7% | FRCC III = 50.2% | No data = 6.1% |
| Departure: | Moderate, trend is expected to continue away from reference conditions | | | |

‡ Schussman et al. 2006; Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 485 acres. The highest level occurred in 2014 at 3,497 acres. Overall, nearly 8% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases activities in the MSG ERU.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the MSG ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein and bullthistle; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; in addition, the current trend is away from reference conditions (gray cells in Table 71) leading to *potential for high risk; therefore evaluate stressors and system reversibility* within the montane/subalpine grasslands ERU.

**Table 71. Gila NF Montane/subalpine grasslands ERU risk assessment matrix**

| Current MSG ERU Departure from RC (41%, moderate) | MSG ERU Trend after 100 Years (departure from RC 56%, moderate) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static (± 5% change) | away from RC (> 5% change) |
| significant Departure (34-100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant Departure (0-33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

According to Swetnam and Falk (2015), a predicted net decline in summer precipitation relative to winter precipitation may lead to woody plants being favored over grasses in certain locations, thus increasing woody encroachment. Alternately, colonization of previously forested areas by grasses and other herbaceous species following high-severity fire is one potential outcome of continued wildfire activity (Savage and Mast 2005; Savage et al. 2013).

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes. Probably the most significant stressor to this ERU is the encroachment and infilling of woody species. This phenomenon is contributing to loss of grasslands as an ecological type along with those species that are grassland dependent.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *COLORADO PLATEAU/GREAT BASIN GRASSLANDS (CPGB) ERU*

### Spatial Niche

The CPGB ERU is widespread and has 2,804,141 acres (6.0%) within the context area and 89,186 acres (2.7%) of the Gila NF. This ERU ranks 4th largest in the context area and 9th largest on the Forest. The Gila NF's niche for this ERU is approximately 3.2% of the ERU within the ecoregion sections. In addition, it has a lower proportional representation on the Forest (-0.37) than in the context area. This ERU has a 70% departure rating (Table 73), however, within the CPGB, across the Forest this varies from a low of 70% to a high of 83%. The context area departure for this ERU is 66%. The influence of the Gila NF on the sustainability of this system is limited to other areas on the landscape not because of its significantly high departure level (on and off Forest), but because of the large proportional representation of this ERU off the Forest. Seral state representation within the context area follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally open grassland to a tree encroached grassland that in some locations looks like forest or woodland.

Figure 70 and Figure 71 show that the majority of this ERU occurs in the northern and eastern portion of the context area and the northern portion of the Forest. Table 72 displays the acreage and proportion of the CPGB ERU within the local units and Forest.

**Table 72. Colorado Plateau/Great Basin grasslands ERU acreage distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 31,992 | 35.9 | 214 | 0.2 | 38,759 | 43.5 | 3,505 | 3.9 | 12,815 | 14.4 | 1,901 | 2.1 | 89,186 | 2.8 |

This ERU ranges from a high 38,759 acres (43.5%) to a low of 214 acres (0.2%) in the Little Colorado-San Agustin Fringe and Black Range local units, respectively. Over half of the ERU, nearly 79% occurs within two local units, the Little Colorado-San Agustin Fringe and Apache.

### General Description

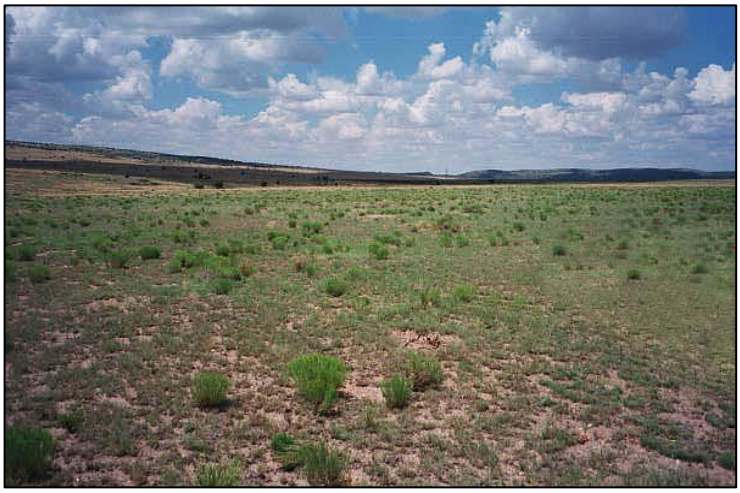

**Figure 69. Colorado Plateau/Great Basin grasslands ERU (Wahlberg et al. 2014)**

The Colorado Plateau/Great Basin grasslands ERU (Figure 69) is typically found along elevational and temperature gradients above semi-desert grassland and below montane/subalpine grasslands. It occupies cooler and wetter sites than semi-desert grasslands and is common above the Mogollon Rim in Arizona. This ERU is typically associated with piñon-juniper grass along the grassland-woodland ecotone in cool climates. Generally, annual precipitation ranges from 12 to 18 inches, with 40% coming between October 1st and March 31st. Vegetation coverage consists of mostly grasses and interspersed shrubs. Grass species may include but are not limited to: Indian ricegrass (*Achnatherum hymenoides* (Roem. & Schult.) Barkworth), threeawns, blue grama, fescues, needle and

thread grass (*Hesperostipa comata* (Trin. & Rupr.) Barkworth), spike fescue (*Leucopoa kingii* (S. Watson) W.A. Weber), muhlys, James' galleta (*Pleuraphis jamesii* Torr.), western wheatgrass, and Sandberg bluegrass (*Poa secunda* J. Presl). Shrub species may include but are not limited to: big sagebrush (*Artemesia tridentate* Nutt.), saltbushes (*Atriplex* spp. L.), jointfir (*Ephedra* spp. L), snakeweed (*Gutierrezia* spp. Lag.), winterfat (*Krascheninnikovia lanata* (Pursh) A. Meeuse & Smit), one-seeded juniper, Utah juniper and wax currant (*Ribes cereum* Douglas). As described, this ERU may have had over 10% shrub cover historically, but had less than 10% tree cover. Other works (e.g., Robbie, 2004) have treated the Colorado Plateau grassland separately from Great Basin grassland. While the floristic distinction between these two is recognized here, the coarse ecosystem dynamics driving the two systems are similar, and therefore they are considered to be a common ERU in this guide. As the understanding of ecosystem processes evolves for these systems, and as state and transition models are developed, subclasses may be developed in the future. The reader is referred to Robbie (2004) for a description of the differences between the two grassland types.

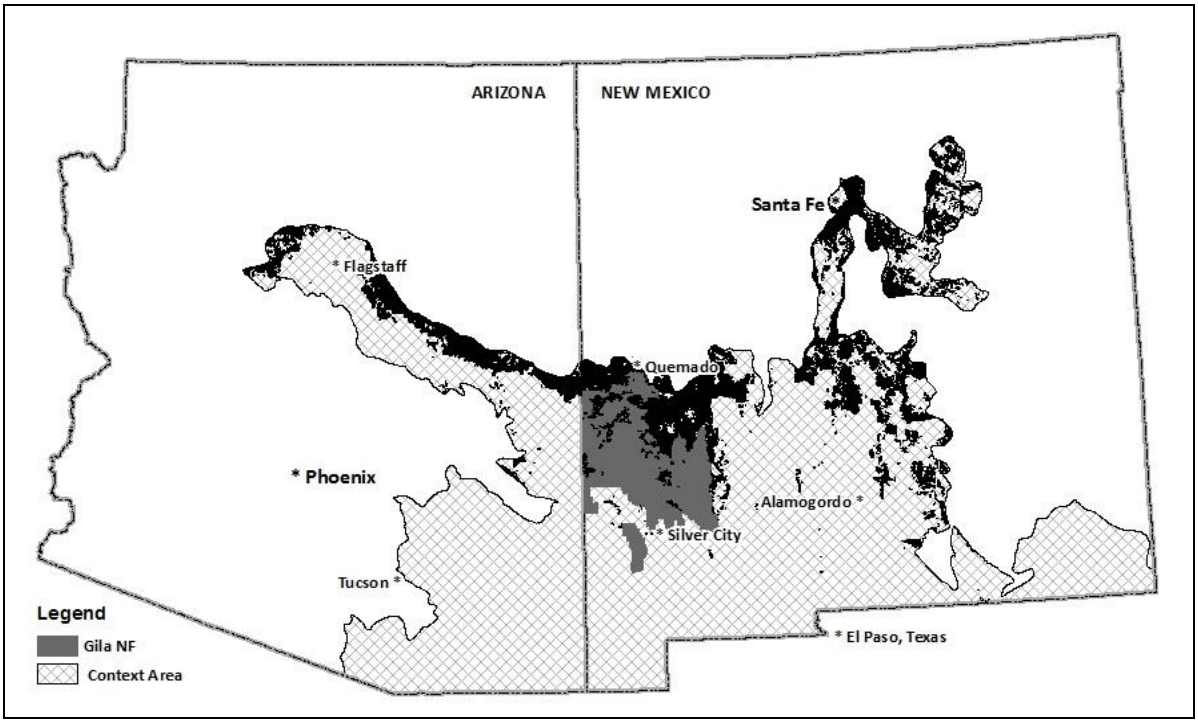


**Figure 70. General location (in black) of the Colorado Plateau/Great Basin grasslands (CPGB) ERU within the context area**

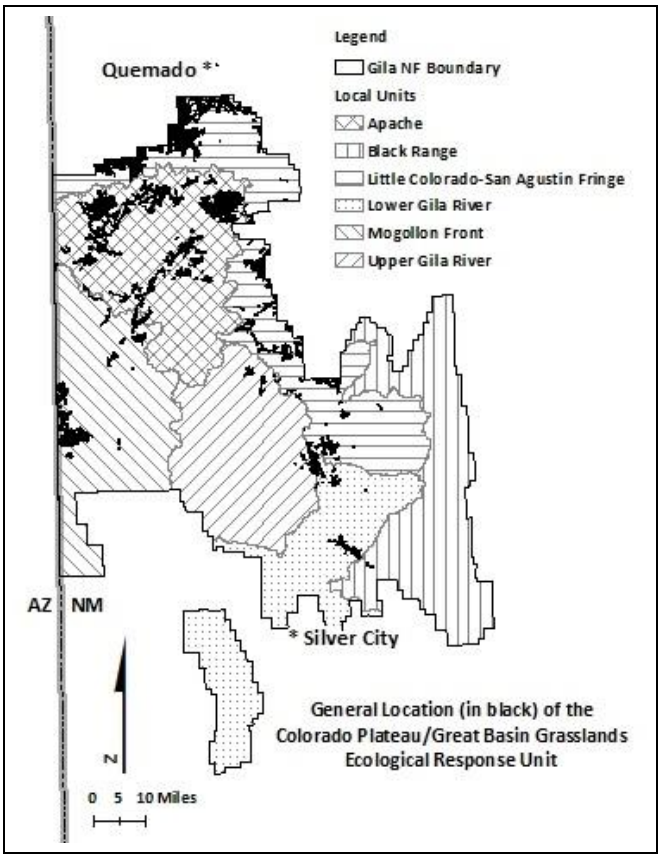


**Figure 71. General location (in black) of the Colorado Plateau/Great Basin grasslands (CPGB) ERU within the Gila NF and the six local units**

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions this ERU was dominated by herbaceous vegetation (Table 73). Grasses provided the largest amount of biomass, however, forbs provided the greatest number of individual plant species (White 2002). At present, these grasslands have a significant amount of woody species encroachment.

**Table 73. Seral state make-up of the CPGB ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Low- to mod-seral: Grass, forb, sparsely vegetated or recently burned with very open (< 10%) woody canopy cover | 5 | 13 | 2 | 5 | 2 |
| B | High-seral: Herbaceous layer dominated by late successional perennial grasses with very open woody canopy cover | 70 | 0 | 7 | 0 | 7 |
| C,E | Low- to mod-seral, woody encroachment: Herbaceous layer dominated by early-mid successional vegetation, and all size shrubs and trees with open (≥ 10% & < 30%) woody canopy cover | 25 | 62 | 74 | 25 | 25 |
| D | Low- to mod-seral, woody encroachment: Herbaceous layer dominated by early successional weedy species, and all size shrubs and trees with closed (≥ 30%) woody canopy cover (*occurs on contemporary landscapes only…)* | 0 | 24 | 17 | 0 | 0 |
| Total | | 100 | 100 | 100 | 30 | 34 |

Departure Index Rating† = 100 – ∑ (similarity values): Gila NF = (100 – 30) = 70 or HIGH; and Context Area = (100 – 34) = 66 or MODERATE

‡ TNC 2006; USDA FS 2016b

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High)

### Gila NF Seral State Proportion (Vegetation Structure) – Current Departure

Departure: High. Currently there is a sizeable over representation of shrub and tree encroachment (seral states C, E and D). Two of the primary encroaching shrub species within seral states C, E and D, are broom snakeweed (*Gutierrezia sarothrae* (Pursh) Britton & Rusby), and rubber rabbitbrush (*Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & Baird.) and a concurrent under representation of an herbaceous layer dominated by late successional perennial grasses with very open woody canopy cover (seral state B).

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 70% in five of the six local units to a high of 83% in the Black Range local unit (Figure 72). All of the local units, have high departure from reference conditions.

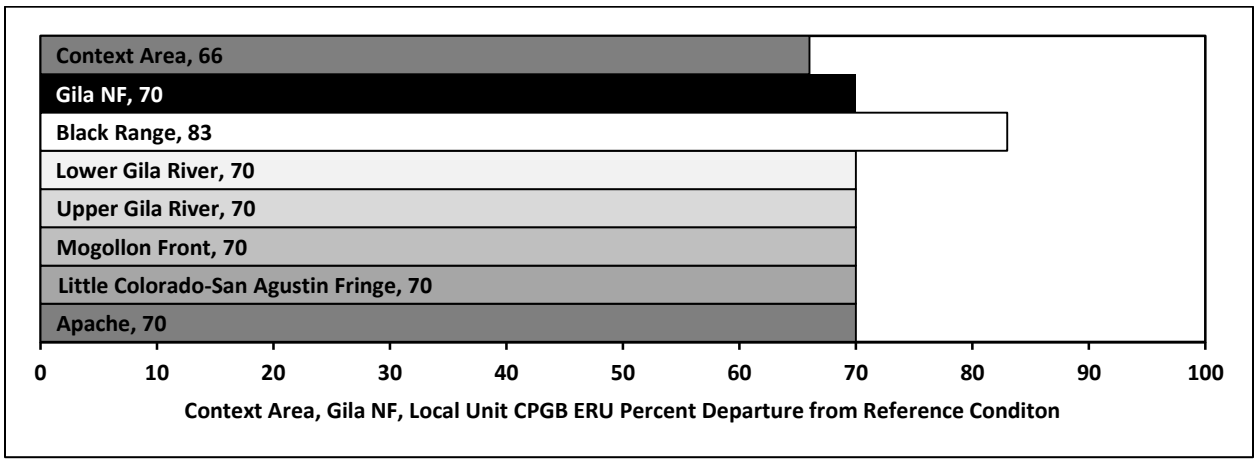


**Figure 72. Variations in seral state departure from reference condition for CPGB ERU at the context area, Forest and local unit scales**

### Climate Change Vulnerability

Table 74 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the CPGB ranges from low to very high, with the greatest level of vulnerability occurring within the Upper Gila River local unit. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) range from low to high for all local units considered.

**Table 74. Colorado Plateau/Great Basin grasslands ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| M | M-H | ǂ | | L-M | M-H | M-H | M | | | VH | L | M | M |

[1] USDA FS 2013a and 2015a; Triepke, et al. 2014; and Triepke 2015

[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)

[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)

ǂ Empty cells indicate no data is available for that variable

### Gila NF Proportion (Successional Structural States) Seral State Departure and Trend

Figure 73 displays the state and transition modeling results for the CPGB ERU. A very large segment of these grasslands are dominated by trees and shrubs (seral state C, E and D) and that carries on into the future under current management. There is also a concurrent decline in high seral condition herbaceous vegetation (seral state B) within this ERU in the future. Departure is trending away from reference conditions.

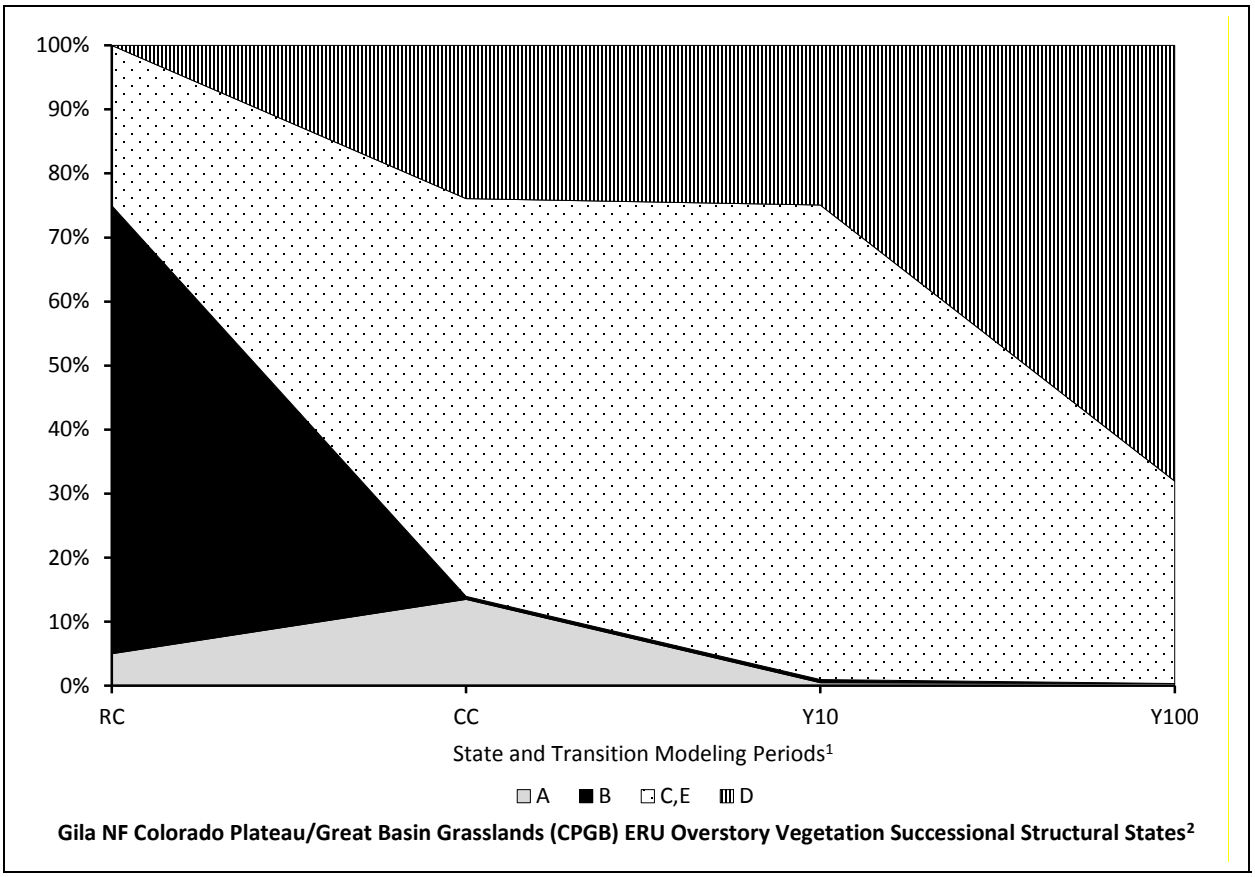


**Figure 73. Gila NF overstory vegetation successional structural states for Colorado Plateau/Great Basin grasslands (CPGB) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 70% or high departure from RC
Y10 = State and transition modeling results at 10 years = 74% or high departure from RC
Y100 = State and transition modeling results at 100 years = 75% or high departure from RC
[2] See Table 73 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Departure and Departure Trends:

There is no coarse woody debris and snag density assessment data for this ERU.

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

| | |
|---|---|
| Reference: | 184 to 272 ac. |
| Current: | 201 ac. |
| Departure: | Low |

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

| | |
|---|---|
| Reference: | FF‡ = average fire rotation = 15 yrs. and stand replacement fire rotation = 15 yrs. |
| Current: | FF = 564 yrs. |
| Departure: | High |

‡ Schussman et al. 2006; Wahlberg et al. 2014; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS):** The 19-year (1996-2015) average annual acres burned by wildfire is 160 acres; roughly 98% at low severity, 2% at moderate severity and 0% at high severity (Table 75). Current fire severity is rated at 13.3%, lower than reference condition's 87.5% (Schussman et al. 2006), giving it a high departure rating.

**Table 75. Gila NF local unit CPGB 19-year (1996-2015) average annual acres burned by wildfire and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache 13 ac. | | | Black Range | | | Little Colorado-San Agustin Fringe 26 ac. | | | Lower Gila River 39 ac. | | | Mogollon Front 4 ac. | | | Upper Gila River 75 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 100 | 0 | 0 | ϯ | | | 98 | 2 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 96 | 4 | 0 |

‡ 19-year period is 1996 through 2015
† Burn severity levels are: L = low; M = moderate; and H = high
ϯ Empty cells indicate no data is available for that variable

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

| | | | | |
|---|---|---|---|---|
| Reference: | FRCC‡ II | | | |
| Current: | FRCC I = 0.0% | FRCC II = 93.7% | FRCC III = 0.0% | No data = 6.3% |
| Departure: | Low, trend is expected to continue away from reference conditions | | | |

‡ Schussman et al. 2006; Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 450 acres. The highest level occurred in 2003 at 5,334 acres. Overall, nearly 9% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases activities in the CPGB ERU.

### Gila NF Invasive Plant Species

There is no current data that shows how many acres within the MSG ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, bullthistle, weeping lovegrass, and cheatgrass; occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Stressors and Risk Assessment

In relation to reference condition, departure is significant; in addition, the current trend is away from reference conditions (gray cells in Table 76) resulting in an assessment of potential for high risk due to legacy of past management or deviation from ongoing activities; which entails evaluation of stressors and system reversibility to the Colorado Plateau/Great Basin grasslands ERU.

**Table 76. Gila NF Colorado Plateau/Great Basin grasslands ERU risk assessment matrix**

| Current CPGB ERU Departure from RC (68%, high) | CPGB ERU Trend after 100 Years (departure from RC 74%, high) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static (± 5% change) | away from RC (> 5% change) |
| significant Departure (34-100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant Departure (0-33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes. Probably the most significant stressor to this ERU is the encroachment and infilling of woody species. This phenomenon is contributing to the loss of grasslands as an ecological type along with those species that are grassland dependent.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

## *SEMI-DESERT GRASSLAND (SDG) ERU*

### Spatial Niche

The semi-desert grassland ERU is widespread within the context area and at 16,091,824 or 34.3%, it is the largest ERU in the context area. Within the Gila NF, the SDG contributes 55,988 acres, roughly 1.7% of the Forest. It is the 11th largest ERU on the Forest. The Gila NF's niche for this ERU is extremely small, approximately 0.3% of the ERU within the ecoregion sections. In addition, it has the lowest proportional representation on the Forest (-0.90) than any other ERU in the context area. This ERU has a 96% departure rating (Table 78), however, within the SDG, across the Forest this varies from a low of 95% to a high of 97% within the Apache, and Black Range and Lower Gila River local units, respectively. The SDG ERU has a 95% departure rate within the context area. The influence of the Gila NF on the sustainability of this system is limited to other areas on the landscape not because of it's high departure level (on and off Forest), but because of the large proportional representation of this ERU off the Forest. Seral state representation within the context area does not follows the same overall pattern as within the Gila NF. In general, this ERU has gone from a normally open grassland to a tree and shrub encroached grassland that in some locations looks like forest or woodland.

Figure 74 and Figure 75 show that the majority of this ERU occurs in the southern portion of the context area and scattered locations across the Forest with the major concentration in the southwestern portion of the Forest. Table 77 displays the acreage and proportion of the SDG ERU within the local units and Forest.

**Table 77. Semi-desert grassland ERU acreage distribution at the local unit scale**

| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mollogon Front | | Upper Gila river | | Gila NF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % |
| 6,424 | 11.5 | 1,747 | 3.1 | 2,896 | 5.2 | 14,982 | 26.8 | 28,231 | 50.4 | 1,708 | 3.1 | 55,989 | 1.7 |

This ERU ranges from a high 28,231 acres (50.4%) to a low of 1,708 acres (3.1%) in the Mogollon Front and Upper Gila River, respectively. Half of the ERU, nearly 50% occurs within the Mogollon Front local unit.

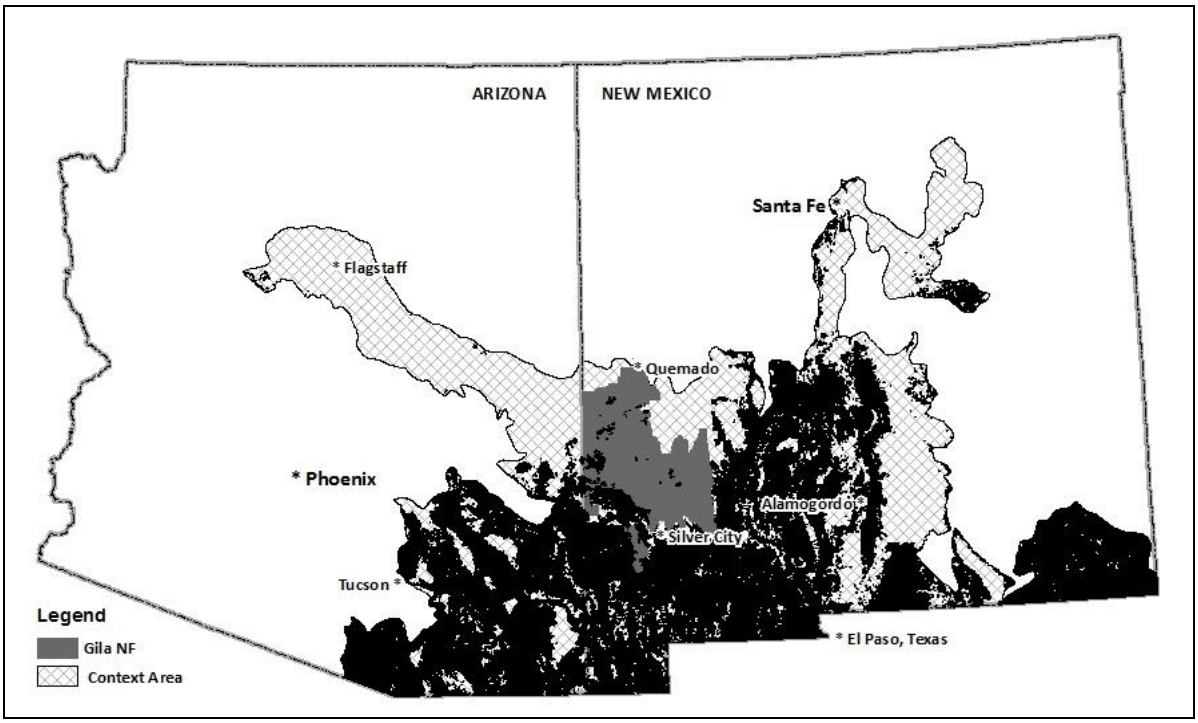


**Figure 74. General location (in black) of the semi-desert grassland (SDG) ERU within the context area**

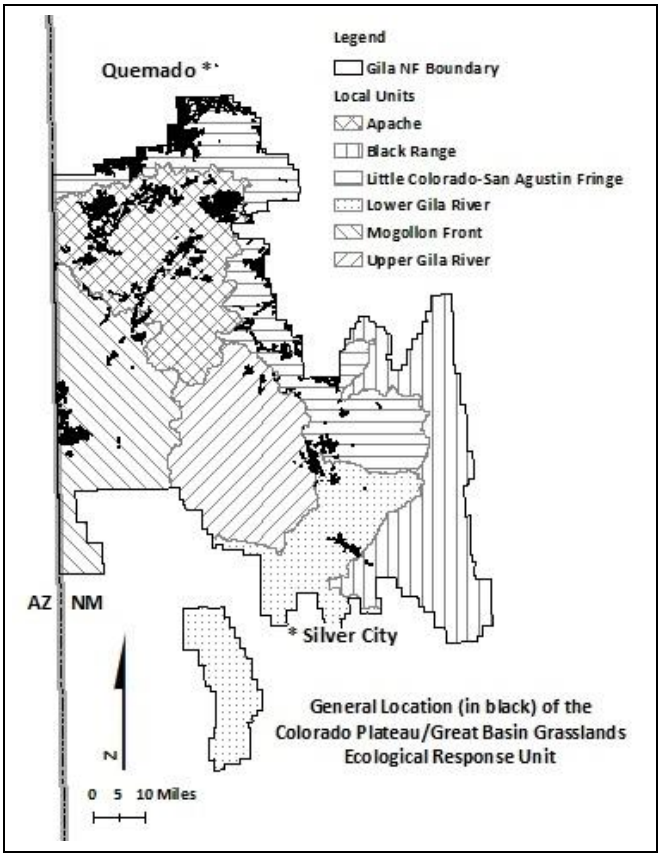


**Figure 75. General location of the semi-desert grassland (SDG) ERU within the Gila NF and the six local units**

## General Description

**Figure 76. Semi-desert grassland ERU (Photo by M.R. White 2002)**

The semi-desert grassland ERU (Figure 76) occurs throughout southeastern Arizona and southern New Mexico at elevations ranging from 3,000 to 4,500 feet. These grasslands are bounded by Sonoran or Chihuahuan desert at the lowest elevations and woodlands or chaparral at the higher elevations. Species composition and dominance varies across the broad range of soils and topography that occur within the two states. Generally, annual precipitation ranges from 13 to 21 inches, with 40% coming between October 1st and March 31st. Dominant grassland associations/types are black grama grassland, blue grama grassland, curly mesquite (*Hilaria belangeri* (Steud.) Nash) grassland, tobosagrass (*Pleuraphis mutica* Buckley) grassland, big sacaton (*Sporobolus wrightii* Munro ex Scribn.) grassland, mixed native perennial grassland, and non-native perennial grassland. Shrubs (mesquite (Prosopis spp. L.), catclaw acacia (*Senegalia greggii* (A. Gray) Britton & Rose), catclaw mimosa (*Mimosa aculeaticarpa* Ortega), etc.) also occupy these grasslands and their abundance and species composition also varies. As described, this ERU may have had over 10% shrub cover historically, but had less than 10% tree cover. Semi-desert grassland tends to occur adjacent to and above desert communities, and below interior chaparral and woodlands. The boundary between semi-desert grassland and desert communities is sometimes hard to distinguish as desert shrub species can be common in this ERU (Girard and Robbie 2003) as they share similar overarching ecosystem properties (Wahlberg et al. 2014).

Subclasses: There are currently four subclasses described for this ERU – Piedmont Grassland, Foothill Grassland, Semi-Desert Lowland Grassland, and Sandy Plains Grassland. Other works (R3 Climate Change Vulnerability Assessment (Triepke et al. 2015)) have split Semi-Desert Grassland into more general subclasses based on moisture gradient.

The foothill grassland model best describes the SDG on the Gila NF. The SDG found on the Forest is typical of colluvial foothill slopes of desert mountain ranges. These often rocky sites are typically dominated by sideoats grama, curlyleaf muhly, New Mexico feathergrass (*Hesperostipa neomexicana* (Thurb. ex J.M. Coult.) Barkworth), and bullgrass (*Muhlenbergia emersleyi* Vasey). Other dominant or co-dominant grasses may include purple grama (*Bouteloua radicosa* (Fourn.) Griffiths), tanglehead (*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.), blue grama, hairy grama, southwestern needlegrass *(Achnatherum eminens* (Cav.) Barkworth), and slim tridens (*Tridens muticus* (Torr.) Nash). While shrubs and sub-shrubs are clearly subordinate in these grasslands, they are always common and sometimes abundant, forming a shrub-steppe. The most diagnostic tall shrubs are mesquite, catclaw acacia, common sotol (*Dasylirion wheeleri* S. Watson), sacahuista (*Nolina microcarpa* S. Watson), soaptree yucca (*Yucca elata* (Engelm.) Engelm.), banana yucca (*Y. baccata* Torr.), Torrey's yucca (*Y. torreyi* Shafer), ocotillo (*Fouquieria splendens* Engelm.), resinbush (*Viguiera stenoloba* S.F. Blake), along with sub-shrubs such as mariola (*Parthenium incanum* Kunth), featherplume (*Dalea formosa* Torr.), agaves (*Agave* spp. L.), and plumed crinklemat (*Tiquilia greggii* (Torr. & A. Gray) A.T. Richardson). Where the combination of drought, livestock grazing, and reduced fire frequency have impacted sites, shrubs typical of Chihuahuan Desert scrub can encroach. These include viscid acacia (*Acacia neovernicosa* (Britton & Rose) Seigler & Ebinger), American tarwort (*Flourensia cernua* DC.), and turpentine bush (*Ericameria laricifolia* (A. Gray) Shinners).

### Seral State Proportion (Vegetation Structure) – Reference and Current Conditions

Under reference conditions the majority of the SDG was comprised of herbaceous layers dominated by late successional perennial grasses with very open woody canopy cover (Table 78). As mentioned earlier, historically this ERU may have had over 10% shrub cover historically, but had less than 10% tree cover.

**Table 78. Seral state make-up of the SDG ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | CA | Gila NF | CA |
| A | Low- to mod-seral: Sparsely vegetated or recently burned with very open (< 10%) woody canopy cover | 23 | 0 | 2 | 0 | 2 |
| B | High-seral: Herbaceous layer dominated by late successional perennial grasses with very open woody canopy cover | 74 | 1 | 0 | 1 | 0 |
| C,D | Low- to mod-seral, woody encroachment: Shrub and tree dominated (encroached) with open ( ≥ 10 & > 29%) woody canopy cover, low ecological status herbaceous layer dominated by early-mid successional vegetation | 3 | 91 | 54 | 3 | 3 |
| E,F,G,H | Low- to mod-seral, woody encroachment: Shrub and tree dominated (encroached) with closed ( ≥ 30%) woody canopy cover, low ecological status herbaceous layer dominated by low ecological status exotic dominated herbaceous layer (*occurs on contemporary landscapes only…)* | 0 | 8 | 44 | 0 | 0 |
| Total | | 100 | 100 | 100 | 4 | 5 |
| Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 4) = 96 or HIGH; and Context Area = (100 – 5) = 95 or HIGH | | | | | | |

‡ Schussman 2006; USDA FS 2016c

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski (1913), as cited in Kent and Coker, 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High)

### Gila NF Seral State Proportion (Vegetation Structure) –Current Departure

Departure: High, in fact this is the most highly departed ERU in the context area as well as the Forest. Currently there is a sizeable over representation of an herbaceous layer dominated by early-mid successional vegetation, and all size shrubs and trees with open woody canopy cover (seral state C, D), and a significant under representation of a herbaceous layer dominated by late successional perennial grasses with very open woody canopy cover (seral state B). This is also the case within the context area landscape, which has a one-point lesser departure rating than the Gila NF (Table 78). Natural succession in the absence of fire, human ground disturbance and vegetation manipulation, ungulate grazing/browsing, and the influence of a changing climate have been the primary system drivers and stressors.

### Gila NF Local Unit Variability in Seral State Departure from Reference Condition

Within the Forest, at the local unit scale, departure from reference condition ranges from a low of 95% in the Apache local unit to a high of 97% in the Black Range and Lower Gila River local units (Figure 77). All of the local units, have high departure from reference conditions.

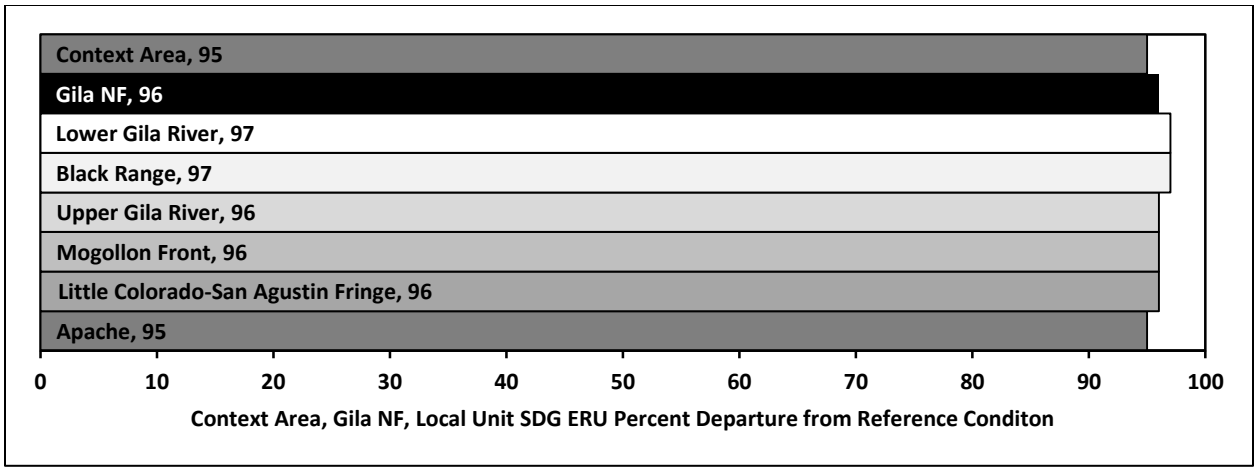


**Figure 77. Variations in seral state departure from reference condition for SDG ERU at the context area, Forest and local unit scales**

## Climate Change Vulnerability

Table 79 provides an indication of the level of susceptibility of this ERU to the potential negative impacts of climate change (Triepke 2015). Vulnerability to climate change within the SDG ranges from low to moderate. Uncertainty generated by differences in the climate change modeling results (Triepke 2015) range from low to moderate for all local units considered.

**Table 79. Gila NF semi-desert grassland ERU climate change vulnerability assessment (CCVA)[1, 2] and uncertainty assessment (UA)[3].**

| Gila NF Local Units | | | | | | | | | | | | Overall Rating | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | | |
| CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA | CCVA | UA |
| L-M | M | ǂ | | | | M | M | M | M | | | L-M | M |

[1] Triepke et al. 2014; Triepke 2015
[2] Climate change vulnerability assessment (CCVA) = low (L); moderate (M); high (H); and very high (VH)
[3] Uncertainty regarding climate change vulnerability assessment (UA) = low (L); moderate (M); and high (H)
ǂ Empty cells indicate no data is available for that variable

## Gila NF Seral State Proportion (Successional Structural States) Departure and Trend

Figure 78 displays the state and transition modeling results for the SDG ERU at the plan scale. A very large segment of these grasslands are dominated by trees and shrubs with open canopy cover (seral state C, D) and that carries on into the future under current management (joined by seral state E, F, G, H with closed tree and shrub canopy cover). There is also a concurrent maintenance of a minimal representation of seral state B (high seral condition herbaceous vegetation) within this ERU in the future. However, departure is static in relation to reference conditions.

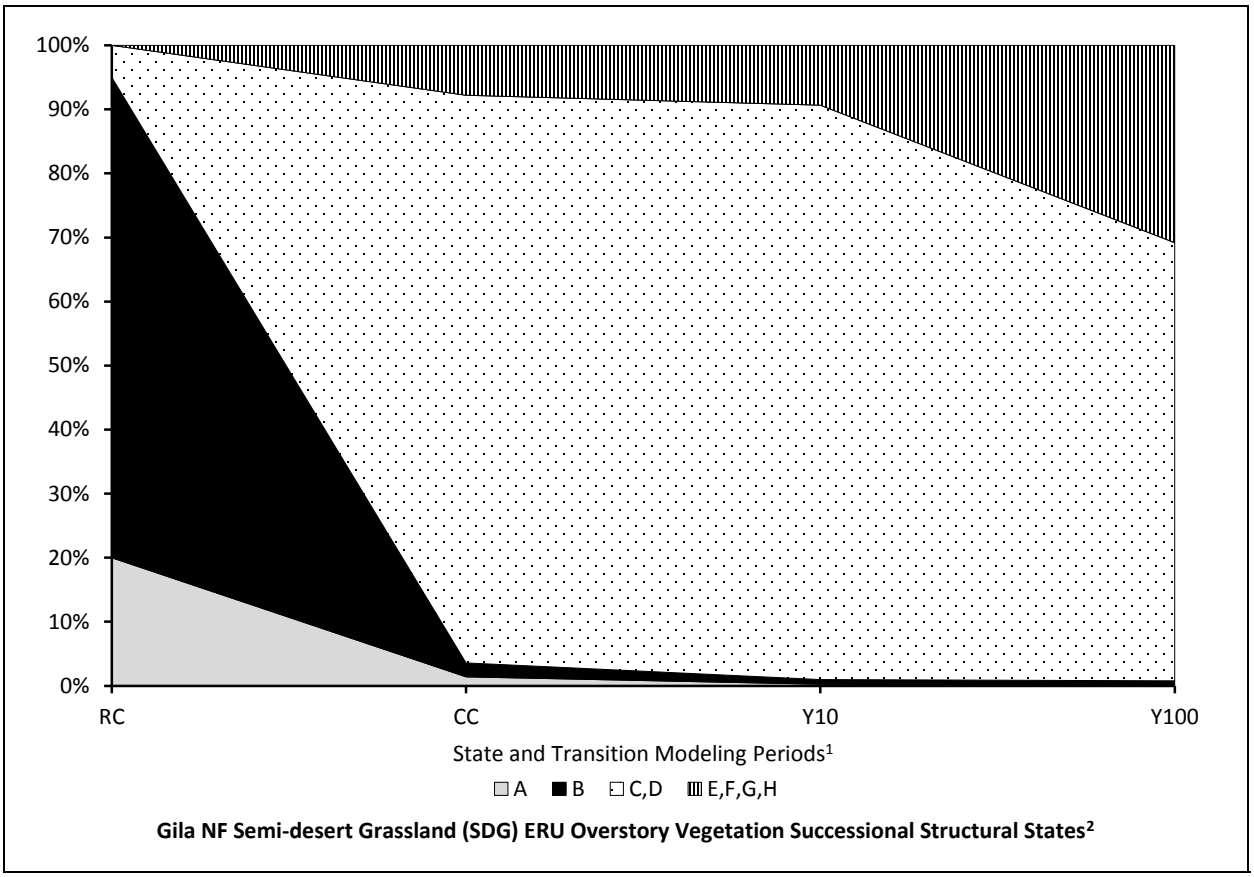


**Figure 78. Gila NF overstory vegetation successional structural states for semi-desert grassland (SDG) ERU under reference conditions (RC), current conditions (CC), and following state and transition modeling results at 10 and 100 years, based on current Forest management activities**

[1] RC = Reference conditions
CC = Current conditions = 96% or high departure from RC
Y10 = State and transition modeling results at 10 years = 94% or high departure from RC
Y100 = State and transition modeling results at 100 years = 94% or high departure from RC
[2] See Table 78 for a description of the overstory vegetation successional structural states

### Gila NF Coarse Woody Debris and Snag Density – Reference Conditions and Current Condition Departure and Departure Trend:

There is no coarse woody debris and snag density assessment data for this ERU.

### Gila NF Mean Patch Size – Reference Conditions and Current Departure

Reference: 143 to 182 ac.
Current: 115 ac.
Departure: Low

### Gila NF Fire Regime (Fire Frequency (FF) and Fire Severity (FS)) – Reference Conditions and Current Departure

Reference: FF‡ = average fire rotation = 6.3 yrs. and stand replacement fire rotation = 6.3 yrs.
Current: FF = 760.2 yrs.
Departure: High

‡ Kaib et al. 1996; Swetnam and Betancourt 1998; Schussman et al. 2006; Schussman 2006; Wahlberg et al. 2014; Krausmann and Triepke 2015

**Gila NF Fire Severity (FS** The 19-year (1996-2015) average annual acres burned by wildfire within the SDG ERU is 74 acres; roughly 98% at low severity, 2% at moderate severity and 0% at high severity (Table 80). Current fire severity is rated at 20.8%, lower than reference condition's 87.5% (Schussman et al., 2006), giving it a moderate departure rating.

**Table 80. Gila NF local unit SDG 19-year (1996-2015) average annual acres burned and percent burn severity by local unit.**

| Gila NF Local Unit 19-Year‡ Average Annual Acres Burned and at What Percent Burn Severity Level† | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AP < 1 ac. | | | BR | | | LCSAF 1 ac. | | | LGR 45 ac. | | | MF 12 ac. | | | UGR 16 ac. | | |
| L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| 100 | 0 | 0 | † | | | 100 | 0 | 0 | 65 | 35 | 0 | 99 | 1 | 0 | 97 | 3 | 0 |

‡ 19-year period is 1996 through 2015
†Burn severity levels are: L = low; M = moderate; and H = high
† Empty cells indicate no data is available for that variable

### Gila NF Fire Regime Condition Class (FRCC) – Reference Conditions and Current Departure)

Reference: FRCC‡ II

Current: FRCC I = 0.0% FRCC II = 0.0% FRCC III = 88.7% No data = 11.3%

Departure: High, trend is expected to continue away from reference conditions

‡ Schussman et al. 2006; Krausmann and Triepke 2015

### Gila NF Insects and Disease – Reference and Current

Over the last 18 years, on an annual average basis, insects and disease have affected nearly 87 acres. The highest level occurred in 2003 at 1,378 acres. Overall, nearly 3% of this ERU has been affected by insect and disease activities since 1997. There is no information regarding specific insects or diseases activities in the SDG ERU.

### Gila NF Invasive Plant Species

There is no current Forest data that shows how many acres within the MSG ERU that are occupied by non-native invasive plants; however, anecdotal evidence suggests that the primary species are mullein, field bindweed (*Convolvulus arvensis* L.), cheatgrass, red brome (*Bromus rubens* L.) and weeping and Lehmann lovegrass (*Eragrostis lehmanniana* Nees); occurring at low levels. Many roadsides within this ERU have established populations of sweetclovers.

### Gila NF Stressors and Risk Assessment

In relation to reference condition, departure is significant; however, the current trend is static (gray cells in Table 81) leading to *potential risk due to legacy of past management or deviation from ongoing activities; which requires evaluation of stressors and system reversibility* with the semi-desert grassland ERU.

**Table 81. Gila NF Semi-desert grassland risk assessment matrix**

| Current SDG ERU Departure from RC (96%, high) | SDG ERU Trend after 100 Years (departure from RC 94%, high) | | |
|---|---|---|---|
| | toward RC (> 5% change) | static (± 5% change) | away from RC (> 5% change) |
| significant Departure (34-100%) | risk addressed; continue current management and identify restoration opportunities | potential risk due to legacy of past management or deviation from ongoing activities; evaluate stressors and system reversibility | potential for high risk; evaluate stressors and system reversibility |
| non-significant Departure (0-33%) | no risk; continue current management | no risk; continue current management | potential risk; evaluate magnitude of future deviations, threats and system reversibility |

Other major system stressors elevate risk and include airborne pollution; drought; fire suppression policy; forest management practices (vegetation treatments); human-caused fire; insects, disease; invasive plant species; livestock grazing/browsing; loss of herbaceous vegetation; off-highway vehicles (OHVs); roads, highways and utility corridors; uncharacteristic erosion (soil loss); uncharacteristic wildfire; wild ungulate grazing/browsing; woody species infilling; and climate change. Many of these risks when functioning together are additive and have compounding affects with negative consequences to ecological composition, structure, function and processes. Specifically by affecting vegetation health (atypical composition, structure and function), soil compaction, erosion, sedimentation and loss of soil fertility, altered watershed and hydrologic functions, reduced water quality and quantity, riparian, aquatic and terrestrial locales loss encompassed by this ERU, degradation and fragmentation of these habitats within this ERU, altered fire regime, introduction and spread of invasive plants, modification of natural processes, change in ecological potentials, reduction in species population(s) and/or habitat(s), uncharacteristic wildfire, and inability to re-establish natural wildfire processes. Probably the most significant stressor to this ERU is the encroachment and infilling of woody species. This phenomenon is contributing to the loss of grasslands as an ecological type along with those species that are grassland dependent.

Some consequences posed by potential stressors are not reversible under Forest Service authority such as: drought. Even though this stressor is not within agency authority, the Forest has a responsibility to assess, address, develop and implement appropriate management responses that mitigate undesirable consequences to National Forest System Lands. Consequences from some stressors such as epidemic insect and disease outbreaks may be partially reversible depending on spatial scale. With uncharacteristic fires – there may be irreversible conditions – soil loss, uncharacteristic succession, habitat modification, loss and/or fragmentation (reduces species' population and/or viability). Some effects of infestations by invasive plants and areas of infestation are reversible depending on species and spatial scale. Consequences from fire suppression, human-caused fires, and roads, highways and corridors, and OHVs can be minimized and in many cases be reversed. Some effects of livestock grazing/browsing are also reversible depending on severity of change and spatial scale. According to Loeser et al. (2007), changes in climate affecting precipitation may cause some ecological alterations to be persistent. For more information on stressors, see the System Drivers and Stressors Chapter.

# Summary of Ecosystem Characteristics for Upland Vegetation

## Seral State Proportion

Departure at the context, plan, and local scale was calculated for all ERUs by comparing current seral state proportion to the reference. Plan scale departure was modeled at 10 and 100 years into the future using VDDT modeling program (ESSA 2006) for all the upland ERUs on the Gila NF. Modeled departure at 100 years is represented in Figure 79 by the diamond (◇). Future departure at the context and local scales was not modeled. As seral state departure increases, terrestrial ecosystems look less like their reference condition, which is the best estimate of a sustainable system. Therefore, high departure indicates that an ecosystem has lower integrity, therefore, less sustainable. However, for the PJC, the difference may be caused by the relative small representation on the Forest relative to the context area acreage.

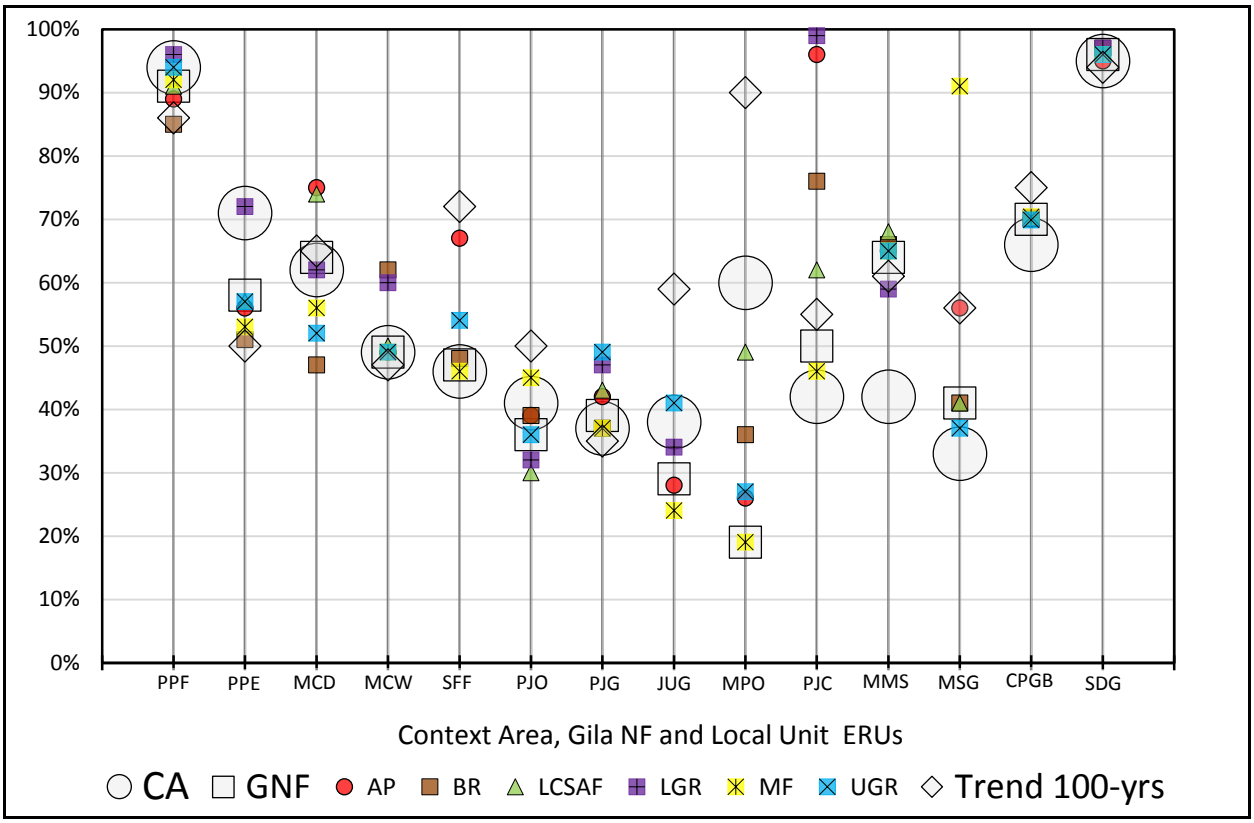


**Figure 79. Seral state departure for each ERU at each scale (context area, Gila NF, local units)[19], and 100-year modeling period results**

For seven ERUs, Gila NF departure is similar (± 5%) to context scale departure (Figure 79). PJC, MMS and MSG are more departed at the Forest scale, but seral state departure in the MSG ERU only measures tree encroachment, which is projected to continue to increase into the future. Ponderosa pine/evergreen oak (PPE), juniper-grass (JUG), and Madrean piñon-oak (MPO) departures at the context area scale are higher than at the Forest scale. PPE departure is predicted to decline. JUG and MPO departures are expected to increase. The frequent fire systems, ponderosa pine forest (PPF) and mixed conifer with frequent fire (MCD) are not different at the context and Forest scales, but are very highly departed everywhere, and projected to remain highly departed. The higher elevation spruce-fir forest (SFF) and mixed conifer with

[19] Abbreviations are: Context area (CA); Gila NF (GNF); and Local units AP = Apache, BR = Black Range, LCSAF = Little Colorado-San Agustin Fringe, LGR = Lower Gila River, MF = Mogollon Front, and UGR = Upper Gila River.

aspen (MCW) ERUs are moderately departed. SFF is predicted to become significantly more departed while MCW and MMS will remain moderately departed.

Piñon-juniper/grass (PJG) and piñon-juniper woodland (PJO) are moderately departed; PJG has a static trend while PJO is trending away from reference conditions. Colorado Plateau/Great Basin grasslands (CPGB) is moderately departed at the context area scale but highly departed at the Forest scale; its departure trend is static. Semi-desert grassland (SDG) is the most highly departed ERU in both the context area and Forest; its departure trend is also static.

The most notable feature of all of the Forest's ERUs is the increased densities of woody species. Ecologically, the most far reaching, long term negative affect due to shifts in grass and woody plant abundance is concurrent loss of soil, soil productivity, and species diversity; including some wildlife species (Peek et al. 2001), and alters the amount and distribution of water reaching the soil, and ultimately overall productivity (Thurow and Hester 2011). Shifts in compositions that change the vegetative structure from herbaceous species to woody species, has a direct effect on levels of surface runoff and soil loss (McGinty et al. 1995). As sediment production increases, total biomass decreases (Thurow et al. 1986; Thurow 1991). See the Soil Chapter for more information on ecological status, vegetative groundcover and soil condition.

According to Heitschmidt and Stuth (1991), remaining grasslands and savannas may become increasingly susceptible to woody plant encroachment in response to anticipated global changes that may generate warmer, drier climates characterized by greater variability (Emanuel et al. 1985a, 1985b). The ecological ramifications of the loss of herbaceous understory vegetation are hard to quantify; however, there are relationships between composition, structure, and processes that continually act upon one another to keep these communities functioning in a healthy manner. Pellant et al. (2005) define the three attributes of community health that can be directly related to loss of vegetation composition and structure: 1) soil and site stability; 2) integrity of the biotic; and 3) hydrologic function of the community. According to the Jacoby (1989), the degree to which these three attributes, as well as the ecological processes of the ecological system are in equilibrium and sustained is an indicator of overall health of the system.

## Coarse Woody Debris and Snag Density

**Table 82. Coarse woody debris (tons/acre) and snag (snags/acre) density for each ERU at the Forest scale‡**

| ERU | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands† | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPF | MCD | PPE | MCW | SFF | PJO | PJG | JUG | MPO | PJC | MMS | MSG | CPGB | SDG |
| Reference Coarse Woody Debris | 9.0 | 13.7 | 4.0 | 30.0 | 42.5 | 2.9 | 2.4 | 3.0 | 3.3 | 3.1 | | | | |
| Current | 35.1$^{H}$ | 59.1$^{H}$ | 23.8$^{H}$ | 81.7$^{H}$ | 87.2$^{H}$ | 15.4$^{H}$ | 13.4$^{H}$ | 13.8$^{H}$ | 18.3$^{H}$ | 13.3$^{H}$ | | | | |
| Reference Snags > 8" dbh/drc | 1.1 | 9.0 | 6.0 | 14.0 | 25.0 | 2.0 | 5.0 | 3.0 | 4.0 | 3.0 | | | | |
| Current | 5.9$^{H}$ | 19.3$^{H}$ | 6.4$^{L}$ | 27.1$^{H}$ | 19.0$^{M}$ | 6.3$^{M}$ | 4.4$^{M}$ | 3.4$^{L}$ | 4.3$^{L}$ | 4.7$^{M}$ | | | | |
| Reference Snags > 18" dbh/drc | 0.8 | 4.0 | 1.0 | 4.0 | 9.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | | | | |
| Current | 1.5$^{L}$ | 6.5$^{M}$ | 1.5$^{M}$ | 10.2$^{M}$ | 11.2$^{L}$ | 1.6$^{M}$ | 0.7$^{M}$ | 0.6$^{L}$ | 0.7$^{L}$ | 1.5$^{L}$ | | | | |

‡ Departure from reference conditions: low = L; moderate (M); and high (H).
† These characteristics do not apply in these types of ERUs

Table 82 also shows reference and current snags per acre in two diameter classes. The > 8-inch dbh/drc class is inclusive of the >18-inch dbh/drc class. In ERUs that are departed due to an uncharacteristic abundance of trees (i.e., PPF, MCD, PPE, PJO, JUG, MPO, PJC), there are more snags per acre. This is especially true of smaller diameter snags, because many larger trees have been harvested in the past or

the species does not frequently achieve diameters over 18 inches (as in PJO and PJG). Large snags are lower than reference in PJG, JUG and MPO reflecting a legacy of mature tree harvesting for fuelwood and/or novelty wood and residual stands that are younger than reference.

Snags are a vital component of the forest ecosystem (Bull 1978) providing habitat for many species of wildlife (Franklin et al. 1981). The hardness of a snag is an important characteristic in determining its value for nesting or foraging. Soft and rotten snags are most used by cavity-nesting wildlife. Dead and partially dead trees are important to many species of wildlife and function in a variety of ways (Grinnell and Storer 1924). According to Neitro et al. (no date) standing dead trees provide an amazing range of microhabitats. Deadwood is crucial to many insects, invertebrates, fungi, lichens, and mosses. Cavity-nesting birds such as nuthatches, swallows, wood ducks, owls and wood peckers as well as bats make their homes in snags. The majority of cavity-nesting birds are insectivorous, meaning that they feed off the insects that are residing in the snag. Because they make up a large proportion of the forest-and urban forest dwelling bird population, they play an important role in the control of insect pests. More recently, the importance of snags to wildlife has been investigated and described by many authorities (Bull and Meslow 1977; Bull 1978; Cline 1978; Mannan et al. 1980).

## Patch Size

Most ERUs on the Gila NF have become uniform in their species composition, as a result of selective grazing, harvest treatments and fire suppression activities, and patch size has increased as a result (Table 83) in PPF, MCD, PJG JUG. The grasslands' patch size has decreased due to woody species encroachment. The reasons for smaller patch size in the infrequent fire, stand replacement fire type ERUs vary. In the Spruce-Fir Forest and Mixed Conifer with Aspen ERUs, patch size is smaller due to altered fuel conditions as a result of fire suppression, coupled with cycles of drought resulting in large, uncharacteristic wildfire. In the PJ Woodland ERU, the primary cause is fire suppression.

**Table 83. Average patch size (acres) for each ERU at the Forest scale**

| ERU | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPF | MCD | PPE | MCW | SFF | PJO | PJG | JUG | MPO | PJC | MMS | MSG | CPGB | SDG |
| Reference Patch Size | 0.02-1 | 0.02-50 | 0.02-50 | 100-400 | 200-1,000 | 50-400 | 0.07-1 | 0.07-1 | ʈnd | nd | 174-206 | 309-726 | 184-272 | 143-182 |
| Current Patch Size | 71 | 64 | 35 | 62 | 79 | 20 | 28 | 5 | nd | nd | 34 | 301 | 201 | 115 |
| Change in Patch Size | > | > | ≅ | < | < | < | > | > | nd | nd | < | < | ≅ | < |
| Departure‡ | H | L | L | M | M | M | H | H | nd | nd | H | L | L | L |

‡ Departure from reference conditions: low = L; moderate (M); and high (H).
ʈ nd = no data

## Fire Frequency

Each ERU has developed under the influence of wildfire. The frequency of wildfire experienced by an ERU varies among ecological types, but each has adapted to withstand and even exploit a characteristic level of fire. If fires are uncharacteristically infrequent, plants may mature, senesce, and die without ever releasing their seed; species composition may shift to favor atypical combinations of shade tolerant species (i.e., white fir and Engelmann spruce commonly occurring in the PPF and MCD ERUs); or live and dead biomass may accumulate to abnormally high levels. Current fire frequency is measured in fire rotation, the number of years it would take for an area equal to the entire ERU to burn. A shorter cycle indicates more frequent fire in the system. Reference fire frequency is measured using the mean fire frequency, the average number of years between two successive fires in a given area. Table 84 displays fire frequency for each ERU at context area, Forest, and local unit scales. Superscripted letters indicate the

departure class: with low (L) = 0 to 33%; moderate (M) = 34 to 66%; and high (H) = 67 to 100% departure from reference fire return interval.

**Table 84. Fire frequency (years) for each ERU at context area, Forest, and local scales**

| ERU | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPF | MCD | PPE | MCW | SFF | PJO | PJG | JUG | MPO | PJC | MMS | MSG | CPGB | SDG |
| Reference Condition‡ | 11 | 13 | 13 | 120 | 156 | 255 | 20 | 13 | 13 | 206 | 18 | 12 | 15 | 6 |
| Context Area | 295$^{H}$ | 257$^{H}$ | 219$^{H}$ | 257$^{M}$ | 1,568$^{H}$ | 643$^{M}$ | 1,214$^{H}$ | 313$^{H}$ | 259$^{H}$ | 672$^{M}$ | 365$^{H}$ | 887$^{H}$ | 38,118$^{H}$ | 255$^{H}$ |
| Gila NF | 40$^{H}$ | 24$^{M}$ | 36$^{H}$ | 16$^{H}$ | 17$^{H}$ | 144$^{L}$ | 154$^{H}$ | 1,308$^{H}$ | 633$^{H}$ | 429$^{L}$ | 32$^{H}$ | 32$^{M}$ | 564$^{H}$ | 760$^{H}$ |
| Apache | 71$^{H}$ | 70$^{H}$ | 166$^{H}$ | 20$^{H}$ | 19$^{H}$ | 625$^{M}$ | 257$^{H}$ | † | | | 606$^{H}$ | 189$^{H}$ | 2,445$^{H}$ | 191,268$^{H}$ |
| Black Range | 33$^{M}$ | 28$^{M}$ | 32$^{M}$ | 19$^{H}$ | 19$^{H}$ | 129$^{M}$ | 718$^{H}$ | | | 633$^{M}$ | 29$^{L}$ | 60$^{M}$ | | |
| Little Colorado-San Agustin Fringe | 68$^{H}$ | 40$^{M}$ | 35$^{M}$ | 96$^{L}$ | | 99$^{M}$ | 279$^{H}$ | | | 192$^{L}$ | 99$^{H}$ | 65$^{H}$ | 1,493$^{H}$ | 3,244$^{H}$ |
| Lower Gila River | 52$^{H}$ | 34$^{M}$ | 87$^{H}$ | 37$^{M}$ | | 182$^{L}$ | 875$^{H}$ | 1,398$^{H}$ | | | 1,262$^{H}$ | | 89$^{H}$ | 331$^{H}$ |
| Mogollon Front | 118$^{H}$ | 28$^{M}$ | 66$^{H}$ | 16$^{H}$ | 18$^{H}$ | 326$^{L}$ | 274$^{H}$ | 1,116 | 13,118$^{H}$ | 443$^{M}$ | 40$^{M}$ | 19$^{L}$ | 2,883$^{H}$ | 2,418$^{H}$ |
| Upper Gila River | 13$^{L}$ | 11$^{L}$ | 13$^{L}$ | 14$^{H}$ | 16$^{H}$ | 39$^{H}$ | 30$^{L}$ | | 60$^{M}$ | | 18$^{L}$ | 18$^{L}$ | 25$^{L}$ | 108$^{H}$ |

‡ See individual ERU write for reference condition sources
† Empty cells indicate no data is available for that variable

Fire frequency for the ERUs at all scales range from high to low departure. The most significant appear to be the multi-millennial return intervals for CPGB, SDG, MPO and JUG. PPF, MCD, JUG, MPO, PJC, CPGB and SDG have less frequent fires than under reference conditions at the Forest scale this has led to increased forest and woodland densities and woody species encroachment into grasslands across much of the Gila NF. The most striking fire return interval can be found in the SDG within the AP local unit (191,268 years); fire has been virtually eliminated from this system, as well as CPGB, JUG and MPO on most of the Forest where they occur. Historically, grasslands supported the spread of low-intensity wildfires into and through savannah, woodland, and forest during the arid fore-summer and late fall (Liu et al. 2011; Dewar 2011, Swetnam and Falk 2015). Today grasslands utilized for grazing may not be capable of spreading fire (lack of fine fuels). The loss of fire in southwestern grasslands has led to encroachment and “infilling” of woody shrubs and trees (Brown and Archer 1989, 1999; Romme et al. 2009b; Swetnam and Falk 2015).

## Fire Severity

Forest ecologists define severity by the degree of overstory plant mortality. Although the thresholds are subjective, in general, overstory mortality below approximately 30% is considered low severity, 30 to 70% is considered moderate severity, and greater than 70% is considered high severity (Agee 1993, 2007; DeBano et al. 1998).

Soil burn severity is a category of fire effects related to the change in soil properties and is one major reason for post-fire assessments of fire severity is because it is believed to be an important indicator of the potential for water runoff and erosion (Robichaud et al. 2000; Wilson et al. 2001; Ruiz-Gallardo et al. 2004; Lewis et al. 2006), and changes in soil hydrologic function (Parsons 2003; Ice et al. 2004; Parsons 2010). The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. And according to Keeley (2009), ecosystem responses include those processes that are differentially affected by fire intensity, measured either directly, or indirectly with fire severity measurements, and include soil erosion, water run-off, vegetation regeneration, wildlife recolonization,

and restoration of community structure as well as a host of other environmental variables. Predicting how fire intensity or severity will affect these responses is critical to post-fire management.

The current distribution is more departed in some ERUs than in others, and the direction of departure is also ERU specific (Table 85). Fire severities in PPF, MCD, PPE, SFF and PJG all have a current higher level of severity than reference conditions, although all have a low departure rating. The higher levels are probably generated because of higher than normal dead and down fuels due to fire suppression. In PJS and PJO, fires over the past 20 years have burned with uncharacteristically low severity. There is less grass in the understory to carry a surface fire, and fires do not spread easily on the surface. A large proportion of these fires have been human caused and presumably were ignited under less extreme weather conditions than would support natural fire. Severity levels in MSG, CPGB and SDG have all declined, probably a reflection of the level of woody encroachment, and fires inability to move into the woody overstory because the abundance of fine fuels have been removed.

**Table 85. Fire severity for each ERU at context area, Forest, and local scales**

| ERU | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPF | MCD | PPE | MCW | SFF | PJO | PJG | JUG | MPO | PJC | MMS | MSG | CPGB | SDG |
| Reference Condition‡ | 13 | 18 | 17 | 65 | 58 | 64 | 13 | 13 | 13 | 69 | 73 | 88 | 88 | 88 |
| Context Area | | | | | | | | | | | | | | |
| Gila NF | $17^{L}$ | $29^{L}$ | $19^{L}$ | $43^{L}$ | $62^{L}$ | $19^{M}$ | $17^{L}$ | $14^{L}$ | $14^{L}$ | $15^{M}$ | $24^{M}$ | $18^{M}$ | $13^{H}$ | $21^{M}$ |
| Apache | $17^{L}$ | $30^{L}$ | $15^{L}$ | $42^{L}$ | $15^{M}$ | $16^{M}$ | $16^{L}$ | † | | | $19^{H}$ | $13^{H}$ | $13^{H}$ | $13^{H}$ |
| Black Range | $21^{L}$ | $44^{M}$ | $22^{L}$ | $51^{L}$ | $63^{L}$ | $21^{M}$ | $21^{L}$ | | | $16^{M}$ | $26^{M}$ | $14^{H}$ | | |
| Little Colorado-San Agustin Fringe | $17^{L}$ | $22^{L}$ | $17^{L}$ | $24^{M}$ | | $15^{M}$ | $14^{L}$ | | | $16^{M}$ | $40^{L}$ | $13^{H}$ | $13^{H}$ | $13^{H}$ |
| Lower Gila River | $20^{L}$ | $33^{L}$ | $19^{L}$ | $40^{L}$ | | $15^{M}$ | $14^{L}$ | $13^{L}$ | | | $13^{H}$ | | $13^{H}$ | $25^{M}$ |
| Mogollon Front | $20^{L}$ | $35^{L}$ | $26^{L}$ | $44^{L}$ | $62^{L}$ | $22^{M}$ | $18^{L}$ | $14^{L}$ | $13^{L}$ | $14^{M}$ | $25^{M}$ | $58^{L}$ | $13^{H}$ | $13^{H}$ |
| Upper Gila River | $16^{L}$ | $21^{L}$ | $18^{L}$ | $42^{L}$ | $61^{L}$ | $20^{M}$ | $18^{L}$ | | $14^{L}$ | | $24^{M}$ | $20^{M}$ | $14^{H}$ | $14^{H}$ |

‡ See individual ERU write for reference condition sources
† Empty cells indicate no data is available for that variable

As displayed in Figure 80, fire severity levels (based on 19-year average) within individual ERUs probably are a close reflection of reference conditions. PPF, MCD, PJG, JUG, MPO and CPGB generally experienced low severity fires replacing less than 25% of the upper canopy. However, they are experiencing some level of fire at a higher severity level. In MCW, according to Evans et al. (2011), high-severity patches, as opposed to extensive areas of high-severity fire, have been relatively common in the Gila NF with high-severity patches accounting for 20% of the area burned of all the fires in MCW (Holden et al. 2009). SFF also has a similar severity level as MCW.

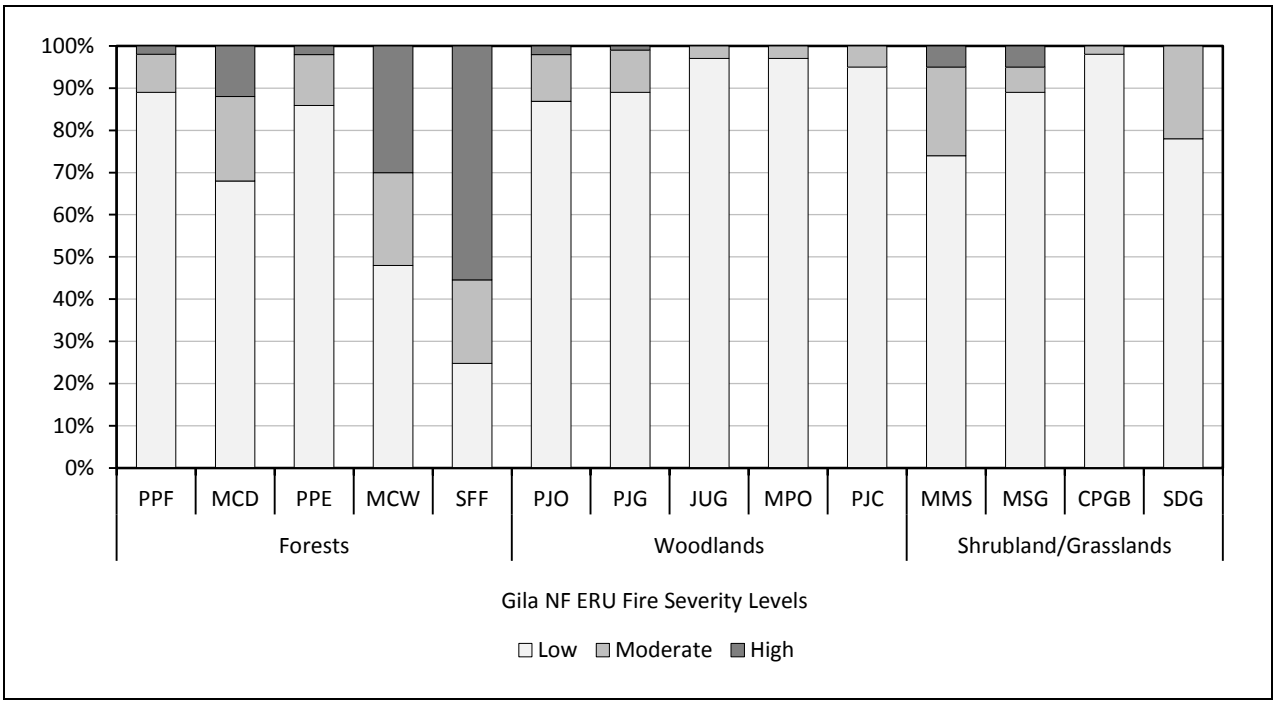


**Figure 80. Fire severity at each severity class for each ERU at the Forest scale**

## Fire Regime Condition Class

Fire regimes are a critical foundation for understanding and describing effects of changing climate on fire patterns and characterizing their combined impacts on vegetation and the carbon cycle (Clark 1988; Grissino-Mayer and Swetnam 2000; Schoennagel et al. 2004; Pechony and Shindell 2010). In general a fire regime characterizes the spatial and temporal patterns and ecosystem impacts of fire on the landscape (Brown and Smith 2000; Morgan et al. 2001; Keeley et al. 2009). The two most important factors for determining fire regimes are vegetation type (or ecosystem) and weather and climate patterns. Fire history provides evidence of past relationships between fire and climate. That evidence makes it clear that changing climate will profoundly affect the frequency and severity of fires in many regions and ecosystems in response to factors such as earlier snowmelt and more severe or prolonged droughts (Westerling et al. 2006; Kitzberger et al. 2007; Morgan et al. 2008; Bowman et al. 2009; Flannigan et al. 2009; Littell et al. 2009). Changing climate will alter the growth and vigor of existing vegetation, with resulting changes in fuel structure and dead fuel loads

A fire regime is a generalization based on fire histories at individual sites. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval (NWCG, 2008).Fire regime condition class (FRCC) is a summary measure of ecological departure from reference conditions under a natural fire regime. It is calculated by averaging seral state departure and fire regime departure (0-100 scale) and then classified into low (I), moderate (II), high (III) departure classes. FRCC for each ERU is generally consistent across local scales on the Gila NF. And they are all showing some level of departure.

As displayed in Table 86, all of the Forest's ERUs are departed in their FRCCs, both at the Forest and local unit scales. The context area departures are very similar to the Forest's as well. The three grasslands and MMS vary the most between local units because of differing levels of tree encroachment. PPF, MCD and PPE are the most altered, the have transitioned from low/mixed severity to stand replacement probably due to increased tree densities augmented by large amounts of biomass accumulation due to fire suppression.

**Table 86. Fire regime condition class for each ERU for the Forest and local units**

| | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PPF | MCD | PPE | MCW | SFF | PJO | PJG | JUG | MPO | PJC | MMS | MSG | CPGB | SDG |
| Reference Condition | I | I | I | III | III, IV | III | I | I | I | IV | IV | I, II | I | I, II |
| Context Area | III | II | III | II | II | II | II | II | III | II | II | II | II | II |
| Gila NF | III | II | II | II | II | II | II | II | II | II | III | III | II | II |
| Apache | III | II | II | ʇ | | II | II | | | | | III | III | III |
| Black Range | III | II | II | II | | II | | | | III | II | | | |
| Little Colorado-San Agustin Fringe | III | II | II | | | II | II | | | II | | III | III | |
| Lower Gila River | | | II | | | II | II | II | | | III | | | III |
| Mogollon Front | | II | II | II | II | II | II | II | II | II | II | | III | III |
| Upper Gila River | II | II | II | II | II | | II | | | | II | II | | |

ʇ Empty cells indicate no data is available for that variable

## Insect and Disease

Forest health insect and disease surveys have been annually conducted on the Gila NF since 1998 (see the System Drivers and Stressors chapter). Other information can be found on the Southwestern Region's Website (http://www.fs.usda.gov/main/r3/forest-grasslandhealth/insects-diseases). Insect and disease outbreaks from multiple agents affect all ERUs on the Gila NF (Table 87). The most heavily impacted ERUs are SFF and PJC with their entire areas affected and some areas having repeated insect and disease impacts.

**Table 87. Gila NF Insects and diseases impacts; acres and percent of each ERU, and largest single year of recorded effects (1997-2014). ERUs are arranged by percent of area showing effects.**

| ERU | SFF | PJC | MPO | MCW | PPF | MCD | PPE | PJO | CPGB | MSG | PJG | JUG | SDG | MMS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percent | 149 | 137 | 68 | 67 | 19 | 12 | 10 | 10 | 9 | 8 | 5 | 3 | 3 | 1 |
| Acres affected | 35,435 | 14,594 | 11,812 | 49,804 | 118,735 | 49,367 | 38,591 | 84,596 | 8,056 | 8,720 | 15,270 | 3,685 | 1,563 | 1,689 |
| Largest single year total | 18,837 (2014) | 13,434 (2003) | 8,170 (2003) | 28,278 (2013) | 50,741 (2003) | 13,435 (2001) | 13,731 (2003) | 60,449 (2003) | 5,334 (2003) | 3,497 (2014) | 7,034 (2003) | 1,991 (2003) | 1,378 (2003) | 663 (2013) |

The 2002-2004 piñon Ips outbreak caused significant mortality in all ERUs where piñon pine occurs; somewhat more than 94,000 acres between PJC, MPO, PJO, PJG and JUG. The drier, more frequent fire forested ERUs were also showing increasing insect and disease impacts during this same time period.

Western spruce budworm is the most common pathogen on the Gila NF, with persistent defoliation leading to mortality in many instances. It is most common in MCD, MCW, and SFF across the Forest. Currently no insect or disease agent occurs at levels that threaten the integrity of an ecosystem. There have been large outbreaks in some ERUs, but none have been outside the natural range of variation (Ryerson 2015).

# Stakeholder Input

It was nearly universally recognized that the forests are denser and more overgrown compared to historical conditions, which has many ecological and socioeconomic implications. There were concerns about encroachment of woody species into grasslands where meadows and open spaces have disappeared

leading to less understory vegetation for livestock/wildlife and to slow erosion. Many people attribute the under representation of early seral habitat on the National Forest to historic wildfire suppression policy and lack of active management. There is broad interest in the collaborative restoration of these ecosystems to restore the natural mosaic of habitats and functions using extensive prescribed burning programs and various timber harvest, firewood gathering (esp. more fuelwood areas), and thinning practices. It was further suggested to work with willing partners across the Forest boundary to promote landscape level restoration in conjunction with entities such as the Bureau of Land Management, State Forestry, and Soil and Water Conservation Districts. A need was identified to develop infrastructure and industry to make it economically feasible to accept/process the amount of material that needs to be removed, which would also benefit local economies. It was also suggested to use herbicide to control alligator juniper resprouting after thinning treatments for maintenance of treated areas.

Negative changes witnessed also include more insect infestations and invasive species, and extreme events such as uncharacteristic fire, drought and floods. Overall, participants felt the system has weakened and has less ability to recover from these extreme events.

# Chapter 3. Baseline Carbon Assessment

## Introduction

The emission of greenhouse gases (GHGs) by human activities and natural processes contribute to the warming of the Earth's climate. Warming could have significant ecological, economic, and social impacts at regional and global scales (IPCC 2007). In 2005, US forests were estimated to be sequestering nearly 220.5 million tons of carbon (Cameron et al. 2013), suggesting that forests and woodlands of the Southwest could have a significant role to play in the sequestration of carbon and climate change mitigation. The US Forest Service has directed a baseline assessment of carbon stocks as part of the forest plan revision assessment process (36 CFR 219.6(b)(4)).

In this chapter, the major carbon components of Southwest ecosystems are considered including biomass, carbon emissions, and soil organic carbon. Some estimates are provided for biomass and soil carbon on the Gila NF in southwestern New Mexico. For the moment, the carbon emissions component has been characterized by using a case study synthesis from the Apache-Sitgreaves NFs. The description of other carbon components, such as forest products, would provide a fuller accounting of carbon stocks and flux; for the time being, inclusion of the major components of biomass, emissions, and soil carbon will suffice for strategic purposes of Forest planning.

## Carbon Stocks on the Gila NF

### Biomass (vegetative carbon)

Vegetative biomass serves an integral component in forest carbon cycles. Forest vegetation, through the process of photosynthesis, converts atmospheric carbon dioxide to carbohydrates (referred to as carbon fixation). These carbohydrates (sugars) are used by plants to grow both aboveground biomass in the form of stems and leaves, and belowground biomass in the form of roots and tubers. Conversely, through the process of decay, dead plant material slowly releases carbon into the atmosphere as it decomposes. Total carbon stored in vegetative biomass is referred to as the biomass carbon stock, and this is a value that changes through time. The primary influences on biomass carbon stock are plant growth (primary productivity) which serves to increase biomass carbon stock, decay and decomposition which slowly decreases biomass carbon stock, and disturbance in the form of fire and harvest. Wildland fire provides a major source of carbon emissions in a forest setting, and is discussed in detail in the carbon emissions section of this document. Biomass harvest plays a varying role in carbon emissions, depending largely on the use of the wood products. For example, wood products utilized as saw timber in construction tends to provide long term carbon storage with slow release, while wood products used as fuelwood and burned for heat provide increased carbon emissions into the atmosphere. As forest and grassland ecosystems are constantly changing through natural succession and disturbance, biomass carbon stock also changes through time. This section will focus on biomass carbon stocks over time on lands of the Gila National Forest (NF). For the purpose of this chapter, biomass carbon stock includes aboveground live biomass, standing dead biomass, downed woody debris, litter and duff, and belowground live biomass (in forest and woodland systems; not yet quantified for grassland and shrubland systems); Belowground nonliving plant material is considered in soil organic carbon. The methods for deriving biomass values for seral states within forest and woodland ecosystems are included in Appendix B, and below for seral states within grassland and shrubland systems.

#### *Current Conditions: Biomass Carbon Quantities*

The Gila NF can be stratified into fourteen major ecosystem types referred to as Ecological Response Units or ERUs (Table 88). Each ERU contributes differently to carbon stocks and their flux based on its spatial extent, vegetation community composition and structure, and ecosystem dynamics. Generally speaking,

relative contributions to carbon stocks are lowest in desert and grassland ERUs, with increasing contributions by shrubland, woodland, and forest ERUs, respectively.

**Table 88. Major Ecological Response Units on the Gila NF in acres and percent.**

| System Type | Ecological Response Unit | ERU Code | Acres | Percent of Gila NF |
|---|---|---|---|---|
| Grassland | Colorado Plateau Great Basin Grasslands | CPGB | 89,187 | 2.7% |
| | Montane Subalpine Grasslands | MSG | 113,784 | 3.5% |
| | Semi-Desert Grassland | SDG | 55,988 | 1.7% |
| Shrubland | Mountain Mahogany Mixed Shrubland | MMS | 166,489 | 5.1% |
| Woodland | Juniper Grassland | JUG | 114,396 | 3.5% |
| | Madrean Piñon Oak Woodland | MPO | 17,361 | 0.5% |
| | Piñon Juniper Evergreen Shrub | PJC | 10,679 | 0.3% |
| | Piñon Juniper Grassland | PJG | 291,648 | 8.9% |
| | Piñon Juniper Woodland | PJO | 848,443 | 25.9% |
| Forest | Mixed Conifer - Frequent Fire | MCD | 395,573 | 12.1% |
| | Mixed Conifer with Aspen | MCW | 74,072 | 2.3% |
| | Ponderosa Pine – Evergreen Oak | PPE | 378,156 | 11.6% |
| | Ponderosa Pine Forest | PPF | 630,278 | 19.3% |
| | Spruce Fir Forest | SFF | 23,778 | 0.7% |
| *Total Area of Major ERUs on Gila NF* | | | 3,209,832 | 100% |
| *Total Area of Gila NF Planning Unit* | | | 3,271,487 | 98.1% |

The figures and tables presented in this chapter represent carbon stock for current conditions, reference conditions, and for upland ERUs, modeled future conditions under current management intensities. Each ERU is referred to by its assigned two- to three-letter code; for reference, these appear in the third column of Table 88. Carbon stock values are presented below both by ERU and collectively for the Gila NF. For each seral (or successional) state in each ERU, carbon stock coefficients were assigned based on either information gleaned from the scientific literature and web resources (for desert, grassland, and shrubland ERUs; Boyd and Bidwell 2001, Brooks and Pyke 2001, Scott and Burgan 2005, USDA FS 2012a) or (for woodland and forest ERUs) from FIA sample data and the carbon submodel of the Forest Vegetation Simulator (Weisz et al. 2010) – Fire and Fuels Extension (Rebain et al. 2015). Carbon stock totals for each ERU are derived by multiplying the current or forecasted total acreage in each seral state by the corresponding carbon coefficient, and summing across all seral states. As demonstrated below, the current Forest carbon stock overall is about 114% of that present in reference (historic) conditions in the Gila's major ERUs. While this increase suggests little change over reference conditions, a more complete picture can be drawn by looking at relative contributions from individual ERUs. As illustrated in Table 89 and Figure 81, the biomass carbon stock has decreased somewhat in two woodland ERUs (JUG and PJO), while increasing in three others (MPO, PJC, PJG). Carbon stocks have increased in the shrubland (MMS) and fire-adapted forest systems (PPF, PPE, and a slight increase in MCD). Finally, we've seen reductions in the carbon stock in infrequent fire forest systems (MCW and SFF).

Several of these changes are quite dramatic. Three woodland systems hold a third to 50% more carbon than in reference conditions. Two of the dry forest systems hold from 40% more to over double the carbon held by these systems in reference conditions. Conversely, the system with the most infrequent fire regime under reference conditions – Spruce Fir Forest (SFF) – holds less than half the carbon it would have historically.

For the most part, carbon increases coincide with fire-adapted (frequent fire) ecosystems, while decreases are coincident with those systems of low to moderate fire frequency. Carbon increases in the fire-adapted

types are presumably associated with land management patterns, including the decades-long policy of fire suppression, and limited harvest of trees in the most recent years and decades. The reduction in biomass in some of the woodland systems may be associated, at least in part, with chaining and other modifications that have resulted in overstory removal.

**Table 89. Biomass carbon stock per ERU in reference and current conditions.**

| System Type | ERU | Reference Condition (tons) | Current Condition (tons) | Percent Departure from Reference Condition |
|---|---|---|---|---|
| Grassland | CPGB | 263,439 | 497,201 | 88.7% |
| | MSG | 412,495 | 1,136,150 | 175.5% |
| | SDG | 172,309 | 105,515 | -12.6% |
| Shrubland | MMS | 2,929,457 | 4,287,219 | 46.3% |
| Woodland | JUG | 1,664,786 | 1,158,639 | -30.4% |
| | MPO | 241,468 | 323,785 | 34.1% |
| | PJC | 129,631 | 179,544 | 38.5% |
| | PJG | 4,143,103 | 6,096,919 | 47.2% |
| | PJO | 18,609,466 | 15,370,609 | -17.4% |
| Forest | MCD | 23,200,258 | 24,479,078 | 5.5% |
| | MCW | 6,498,028 | 5,349,893 | -17.7% |
| | PPE | 6,234,129 | 12,883,777 | 106.7% |
| | PPF | 18,839,009 | 26,523,826 | 40.8% |
| | SFF | 2,278,489 | 1,053,616 | -53.8% |
| | *Totals* | 85,617,142 | 97,615,424 | 14% |

Note: Shading in orange (warmer) indicates an increase in carbon stock, and shading in blue (cooler) indicates a reduction in carbon stock. In both cases, deeper hues reflect greater departure from reference conditions.

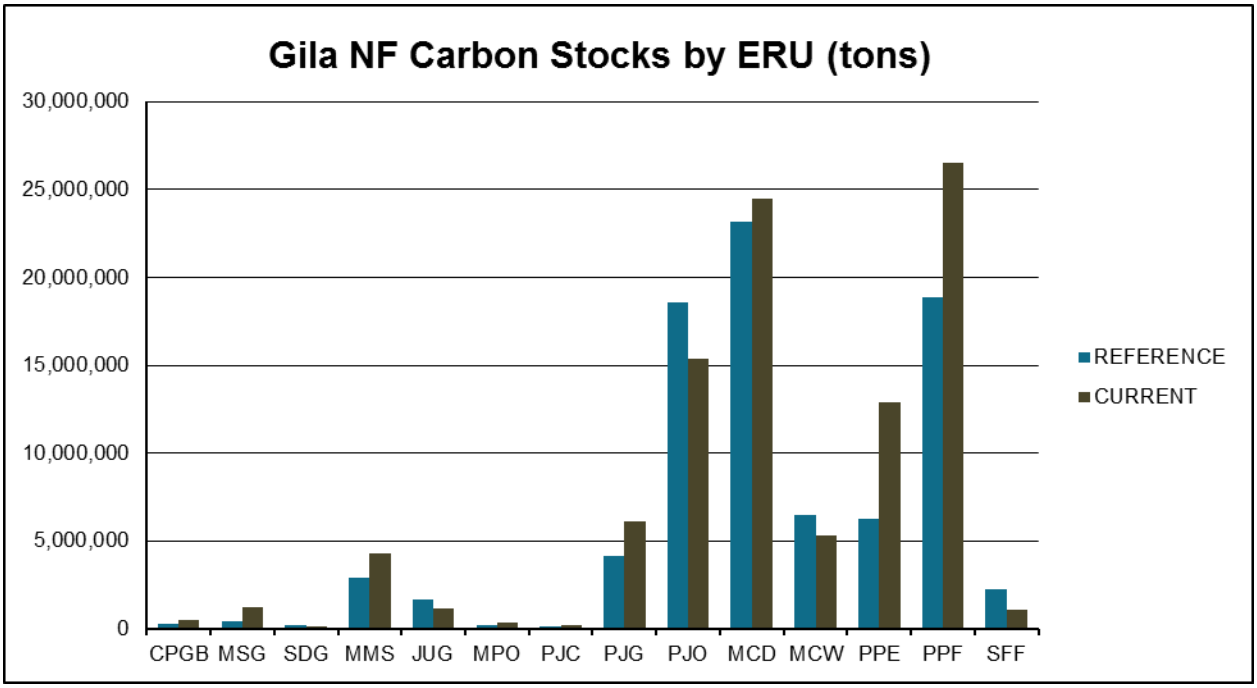


**Figure 81. Biomass carbon stock by ERU in current and reference conditions.**

Also of note is the considerable shift in biomass regimes of the grassland systems. Our results show an increase in biomass carbon from reference conditions in two of the three grassland systems. Semi-desert grassland show a decline of nearly 14%

### *Trends: Biomass Projections*

Many factors will influence future carbon stocks on the Gila NF, and this assessment is in no way a comprehensive accounting of all possible outcomes. Factors such as climate change, fire frequency and severity, and management budgets are all outside the control of Gila Forest managers, and as such, this assessment may be useful in conveying only general patterns and trends. However, general ecosystem dynamics in southwestern systems are fairly well understood, and provide a good starting point for assessing trends in biomass carbon stocks. Vegetation conditions on the Gila NF have been modeled into the future for most of its predominant ERUs using State and Transition Modeling (STM), including assumptions based on current management and disturbance patterns[20]. This allows the projection of relative biomass carbon contributions through time for key ERUs (see a full description of process and methodology in Appendix B). Using past observations of stand development dynamics and management applications for future projections is, admittedly, inherently problematic in light of projected climate changes.

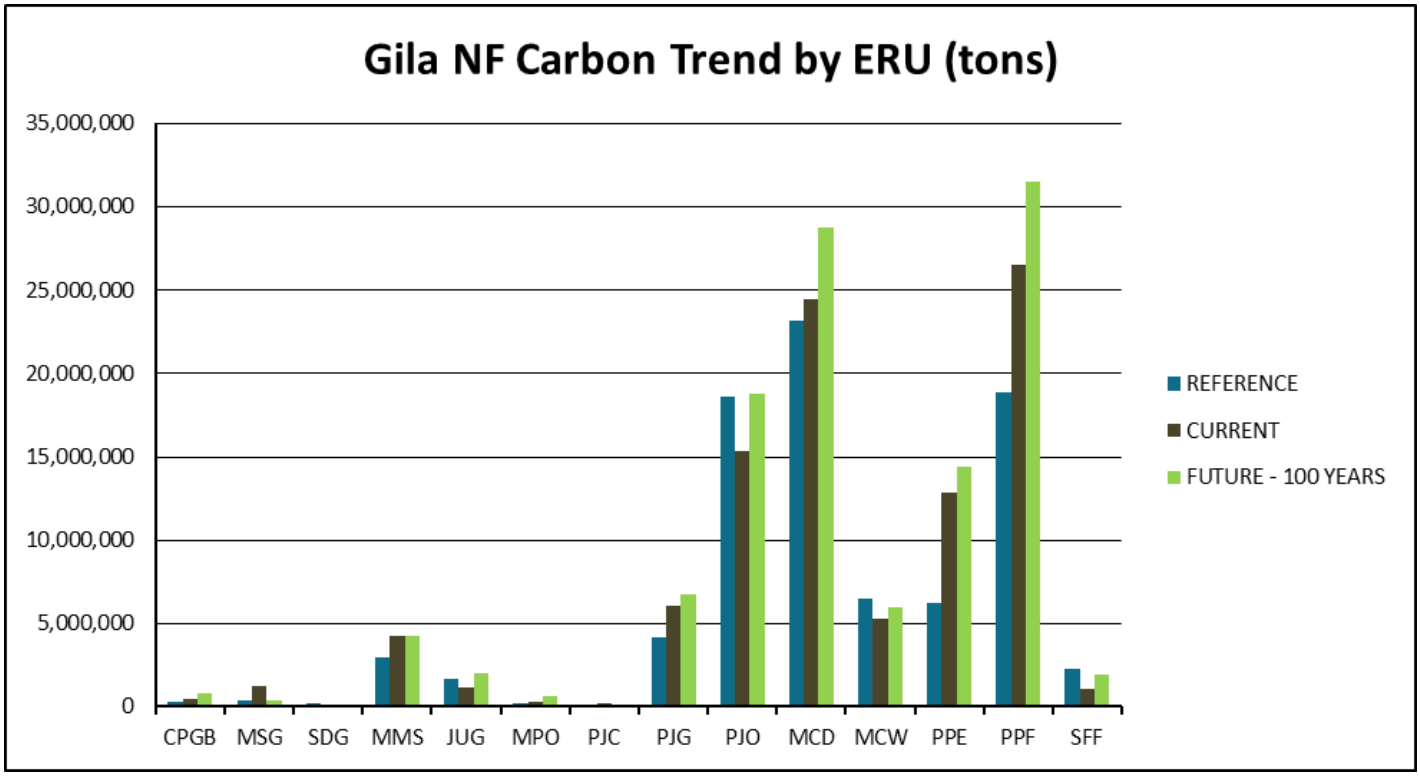


**Figure 82. Trends in Carbon Stocks for Gila NF ERUs.**

[20] Modeling was conducted by the Gila National Forest and Region 3 staff, October 2015 – March 2016.

**Table 90. Projected Carbon Stocks for Major ERUs of the Gila NF**

| ERU | Current Condition (tons) | Projected +100yrs (tons) | *Projected +100yrs % Change from Current* |
|---|---|---|---|
| **CPGB** | 497,201 | 857,380 | 72.4% |
| **MSG** | 1,136,150 | 408,577 | -64.0% |
| **SDG** | 150,515 | 149,834 | -0.5% |
| **MMS** | 4,287,219 | 4,270,530 | -0.4% |
| **JUG** | 1,158,639 | 1,076,888 | -7.1% |
| **MPO** | 323,785 | 661,472 | 104.3% |
| **PJC** | 179,544 | 108,673 | -39.5% |
| **PJG** | 6,096,919 | 4,248,051 | -30.3% |
| **PJO** | 15,370,609 | 11,977,427 | -22.1% |
| **MCD** | 24,479,078 | 22,651,858 | -7.5% |
| **MCW** | 5,349,893 | 4,727,850 | -11.6% |
| **PPE** | 12,883,777 | 9,179,903 | -28.7% |
| **PPF** | 26,523,826 | 30,936,901 | 16.6% |
| **SFF** | 1,053,616 | 1,965,124 | 86.5% |
| ***Total*** | ***97,615,424*** | ***91,282,698*** | ***-6.5%*** |

Figure 82 and Table 90 depict 100-year projections for primary Gila NF ERUs against current and reference conditions. These projections assume a continuation of current management, and are not reflective of changes in management that may emerge from the Gila's ongoing effort to revise its land management plan. However, these results do provide meaningful trend information regarding biomass carbon storage in the near future. The overarching pattern of biomass carbon stock projections on the Gila NF (assuming continuation of current management patterns) indicates a decrease in total carbon storage below current conditions in most modeled ERUs. We see such decreases in all woodland systems except MPO, in some of the frequent fire forest systems (MCD and PPE) and in MCW (an infrequent fire system). Exceptions, which display increases in vegetation biomass carbon stocks, include most of the frequent fire systems (all grassland ERUs, as well as MPO and PPF) and SFF. SFF has been heavily impacted by wildfires in recent years, and our results highlight the resultant reduction in current biomass carbon stocks in this system as well as the anticipated future increase in carbon stock in this system as trees regenerate.

## Carbon Emissions – Synthesis of Study by Vegh et al. (2013)

### Introduction

For the Gila NF assessment, carbon emissions have been characterized below by using a case study synthesis from the Apache-Sitgreaves NFs (Vegh et al. 2013), relevant to forested ecosystems of the Southwest in terms of natural processes and common management activities. The study provides a surrogate solution for emissions assessment in lieu of emissions data and analysis specific to the Gila NF.

### *Background*

To date there has been no binding commitment by the federal government or US Forest Service for the regulation of carbon dioxide ($CO_2$), though there has been increasing activity at state and regional levels to control carbon emissions to the atmosphere, prompting regulation, voluntary carbon exchanges, and carbon inventory and monitoring programs (Wiedinmyer and Neff 2007). The US Forest Service Planning Rule directs forests to assess baseline carbon stocks as part of the forest planning process (36 CFR 219.6(b)(4)), and though there are other carbon constituents released in wildfire and prescribed burning, $CO_2$ is the primary carbon compound and primary greenhouse gas associated with fire emissions (Table 91).

**Table 91. Proportion of constituents of wildfire emissions for both greenhouse gases (GHG) and carbon compounds (NRC 2004).**

| Species | Proportion GHG | Proportion Carbon Constituents |
|---|---|---|
| Carbon Dioxide | 72.14% | 90.82% |
| Water | 21.18% | |
| Carbon Monoxide | 5.57% | 7.02% |
| Atmospheric particulate matter <2.5µ | | 0.60% |
| Nitric Oxide | 0.39% | |
| Methane | 0.27% | 0.34% |
| Volatile Organic Compounds | 0.24% | 0.31% |
| Organic Carbon | | 0.31% |
| Non-methane Hydrocarbon | 0.20% | 0.25% |
| Particulate Matter > 10µ | | 0.22% |
| Particulate Matter <10µ and >2.5µ | | 0.11% |
| Elemental Carbon | | 0.03% |
| | 100.00% | 100.00% |

Though emissions by fire and other forest processes (e.g., methane from the decomposition of wood) have a relatively minor impact on carbon stocks and flux, atmosphere-based emissions are strongly impacted by biosphere-atmosphere carbon fluxes at regional scales, and represent the carbon component directly involved in the positive feedback of greenhouse gas forcing on climate change. In a given year in the Southwest, carbon emission from fire can exceed fossil fuel emissions at regional scales (Wiedinmyer and Neff 2007). In their study of fire emissions, Wiedinmyer and Neff (2007) found that on average carbon emissions were 4–6% of the total anthropogenic emissions for the US. In a separate study, Woodbury et al. (2007) estimated that 10% of total anthropogenic emissions in the US are captured by forest vegetation, to suggest that forests can sequester more carbon than they emit and become an offsetting solution for anthropogenic emissions. The Intergovernmental Panel on Climate Change (IPCC) recognizes the potential for forest and woodland ecosystems, in particular, to perform climate change mitigation (IPCC 2007). In assessing carbon dynamics and emissions in the Southwest, Hurteau and others (e.g., Hurteau et al. 2008, North et al. 2009, Hurteau and North 2010) went further and proposed that large releases of carbon to the atmosphere could be minimized by reducing stand densities. Prior to the Apache-Sitgreaves NF study (presented below), it had been hypothesized, and shown through dynamical modeling and observation (Kobziar et al. 2009, Martinson and Omi 2013, Pollet and Omi 2002), that the reduction of stand densities precludes large pulses of wildfire emissions with a reduction in uncharacteristic fire, such as stand replacement fire in ponderosa pine forests. Preliminary research indicates that the sustainable management of forests, along with careful consideration of byproducts and management residues, would not only balance forest carbon stocks but could also partially mitigate global climate change through increased carbon storage.

### *Apache-Sitgreaves Study Overview*

Recent research on carbon dynamics and emissions related to various conventional forest management activities, focused specifically on the Apache-Sitgreaves (A-S) National Forests in eastern Arizona, provides surrogate information to guide National Forests of the Southwest in the assessment and management of carbon (Vegh et al. 2013), which we are using here in lieu of more specific analysis of carbon emissions.

A key objective of the A-S study was to determine the long-term (100 years) difference in carbon stocks and carbon emissions between treated and untreated forest ecosystems. While the study was focused on the Ponderosa Pine Forest ERU, the results can be abstracted to other forest and woodland ecosystem types for purposes of characterizing general trends among reference condition, no-action, and treatment scenarios, in terms of 1) fire carbon emissions, 2) total (live and dead) above-ground biomass, and 3) live

above-ground biomass. And while the Vegh et al. (2013) study did not consider the effects of forest restoration per se (sensu Region 3 desired conditions), they did evaluate the effects of reduced tree densities on carbon stocks and flux.

### *Analysis*

In their study, Vegh et al. (2013) compare the effects of different management alternatives on overall carbon stocks and emissions. They apply three management alternatives – no action, light thinning, heavy thinning – to determine the overall management effects on carbon sequestration and emissions flux. The researchers used the Forest Vegetation Simulator (FVS) to model stand dynamics over a 100-year simulation and report outcomes for carbon stocks and emissions. For annual treatment in the analysis simulation, all suitable stands on the A-S NFs were prioritized in order of the following conditions:

4. Wildland Urban Interface (WUI) areas in high departure plant communities
5. WUI areas in moderate departure plant communities
6. non-WUI areas in high departure plant communities
7. non-WUI areas in moderate departure plant communities
8. WUI areas in low departure plant communities
9. non-WUI areas in low departure plant communities

In all cases, "departure" is a measure of similarity between the current and reference (historic) vegetation structure, with high departure reflecting vegetation heavily altered from past structural conditions, and low departure indicating a distribution of structural states that are highly similar to those we would have expected pre-European settlement. In the FVS simulations, individual stands were further prioritized for treatment according to basal area (BA) and quadratic mean diameter (QMD), so that stands with the greatest stocking (i.e., BA) and the smallest trees (i.e., QMD) would be given highest priority for treatment.

In their modeling, the investigators assumed conventional treatment scenarios and contemporary wildfire frequencies. Stands with a preponderance of large trees over 16" in diameter were not included, due to some social constraints. Carbon emissions were estimated for wildfires, prescribed burning, and pile burning. In the simulations, all thinning harvests were followed by pile burning in the second year, and by broadcast burning in the tenth year. The researchers also assumed that trees would regenerate successfully after burning.

### *Findings and Discussion*

In their results, Vegh et al. (2013) reported that carbon emissions and stocks were affected by both management alternatives and wildfire frequency. In the reporting, carbon stocks were divided into above-ground live biomass and into total carbon occurring above- and below-ground, both live and dead. The following results were generated from the 100-year model simulation:

- The no-action alternative resulted in the lowest total carbon emissions since no treatments would occur under these alternatives. The alternatives with management treatments produced approximately five times the total carbon emissions of the no-action alternative.
- Carbon emissions by wildfire were lower in the treatment alternatives than in the no-action, and wildfire emissions were lowest in the alternative with the greatest degree of thinning. Resulting wildfire emissions associated with the heavy thinning alternative were up to half the amount of emissions of the light thinning alternative, and about one third less than the no-action alternative.
- Total carbon stocks (above- and below-ground, live and dead) were lower in the treatment alternatives than in the no-action alternative, due to thinning and the removal of live tree biomass,

assuming similar wildfire frequency and severity as the last three decades (1980-2009). The lowest carbon stocks were found in the heavy thinning alternative.

- Carbon stocks for live above-ground biomass alone were highest in the treatment alternatives, particularly in the second half of the simulation due to the accumulation of carbon in large fire-resistant trees.

We might also conclude that at landscape scales, total above-ground carbon stocks would remain somewhat higher in the treatment scenarios than in the reference condition, because of the number of untreated plant communities and because of a lower overall fire frequency compared to reference (due to fire suppression activities and loss of fine fuels in some ecological systems).

## Soil Organic Carbon

Soil organic carbon (SOC) is the energy source for soil organisms which, through their activity and interactions with mineral matter, impart the structure to soil that affects its stability and its capacity to provide water, air, and nutrients to plant roots. The amount and kind of soil organic carbon reflects and controls soil development and, ultimately, ecosystem productivity (Van Cleve and Powers 1995).

Globally, SOC contains more than three times as much carbon as either the atmosphere or terrestrial vegetation (Schmidt et al. 2011). Forest soils are the largest active terrestrial carbon pool and account for 34 percent of the global soil carbon (Buchholtz et al. 2013). Accurate quantification of SOC stocks is key to modeling atmospheric CO2, soil productivity, and global climate. Soils represent a significant portion of the active carbon cycle, with estimates of organic C ranging from 1,500 to 2,000 Pg C, or roughly two thirds of the terrestrial organic C stocks (Rasmussen 2006).

Attempts to characterize regional soil carbon stocks include both ecosystem- and soil taxa-based approaches. The ecosystem approach involves averaging soil C data within a specific plant community or biome and multiplying the average soil C content by the estimated biome land area (Rasmussen 2006). This approach does not account for soil spatial heterogeneity and results in large variability of soil C estimations within an ecosystem or biome. The soil taxa approach has been extensively described in the soil science literature (Rasmussen 2006) and includes segregating landscapes by soil taxa (instead of biomes) and using average taxa soil C and estimated land area to calculate soil C stocks. However a soil taxa as mapped may have more than one associated biome.

The process used for the Gila NF soil C stock assessment involved the ecosystem-based approach through the aggregation of terrestrial ecological units (soil/vegetation/climate) into ecological response units (ERU) that represent the major potential natural vegetation communities on the Gila NF.

### Methods

Soil organic carbon was calculated from multiple sources for this assessment. Soil pedons (basic units of soil classification) that were selected for physical and chemical characterization within the Gila National Forest Terrestrial Ecosystem Survey and forests within New Mexico (Cibola and Santa Fe NFs) were also used to establish average soil organic carbon reference values for Ecological Response Units (ERU). Soil organic carbon pedon data on the Gila NF were limited. The Cibola and Santa Fe NFs have soil organic carbon pedon data for similar soil taxa as found within Gila NF ERUs.

The soil pedons chosen were representative for each ERU. Other kinds of soil may also occur within ERU's. Soil pedon data were also downloaded from the National Cooperative Soil Survey Characterization Database (NCSS 2016) that were within the Gila NF ERU context scale.

Ecological Response Units at the Gila National Forest context scale were intersected with New Mexico and Arizona STASTGO2 data and the associated soil organic carbon 0-100 cm attribute table.

Bulk density was calculated from representative values from known soil textures using the Soil Water Characteristics: Hydraulic Properties Calculator (Saxton et al. 2009).

The Gila National Forest has a wide variety of soils that support many different terrestrial ecosystems. These soils have originated from igneous, sedimentary and metamorphic geologic sources and occur on a wide array of landforms. The differential weathering of soils by various climates and plant communities leads to the development of soil organic carbon.

## Current Conditions

Considerable SOC variation exists between ERUs due to the variable numbers of soils sampled, the different kinds of soil taxa per ERU, and the scale for which map unit composition values represent both fine and coarse scales (Table 92). Soil pedon data were not available for all soil taxa within each ERU.

The Piñon Juniper Woodland, Ponderosa Pine Forest, Mixed Conifer Frequent Fire and Ponderosa Pine Evergreen Oak ERUs contribute significantly to the overall SOC stock for the Gila NF. Collectively they account for approximately 77,106,878 tons of SOC or 69% of the SOC stock by land area (Figure 83).

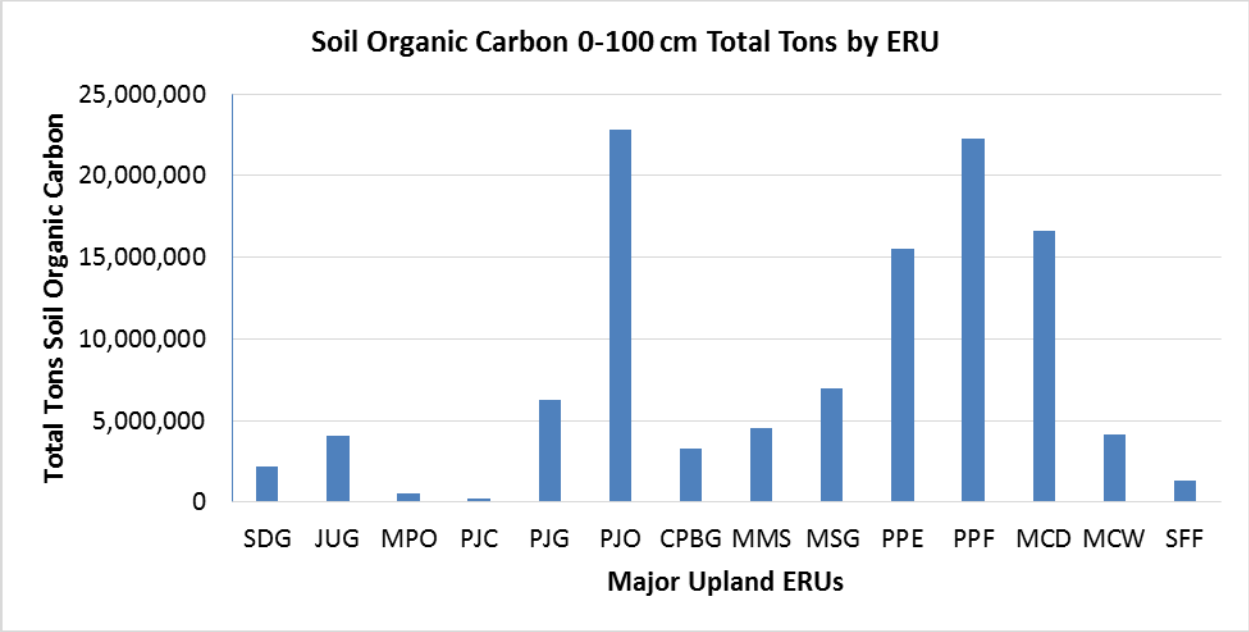


**Figure 83. Soil organic carbon (tons) for major Gila NF ERUs**

Average soil organic carbon stock for ecological sites (pedons) on upland ERUs of the Gila NF is generally greatest in the Montane Subalpine Grassland (61 tons/ac), Spruce Fir Forest (57 tons/ac) and Mixed Conifer with Aspen (56 tons/ac) (Figure 84). Although these ERUs have high average soil organic carbon (tons/ac) they account for relatively small land area within the Gila NF.

Riparian systems are ecologically important on the Gila NF, but account for only 2% of the total land area. These Riparian ERUs all have very similar and relatively low average SOC (when compared to upland ERUs) ranging from 9 tons/ac to 13 tons/ac. These ERUs account for 722,683 tons of SOC or less than 1% of the SOC stock by land area (Table 92).

**Table 92. Soil Organic Carbon by ERU**

| System Type | Ecological Response Unit | ERU Code | ERU % of Gila NF | SOC (tons/acre) | SOC (tons) |
|---|---|---|---|---|---|
| **Riparian** | **Desert Willow** | 130 | 0.35% | 12.57 | 143,910 |
| | **Cottonwood Group** | | | | |
| | Sycamore - Fremont Cottonwood | 270 | 0.34% | 12.68 | 140,407 |
| | Fremont Cottonwood - Oak | 170 | 0.003% | 10.93 | 924 |
| | Fremont Cottonwood / Shrub | 180 | 0.10% | 9.35 | 29,294 |
| | Narrowleaf Cottonwood / Shrub | 230 | 0.93% | 9.75 | 301,510 |
| | **Walnut-Evergreen Tree Group** | | | | |
| | Arizona Walnut | 300 | 0.04% | 10.92 | 15,591 |
| | Little Walnut - Ponderosa Pine | 370 | 0.01% | 10.46 | 3,872 |
| | **Montane Conifer-Willow Group** | | | | |
| | Ponderosa Pine / Willow | 350 | 0.03% | 10.05 | 8,902 |
| | Arizona Alder - Willow | 110 | 0.10% | 9.34 | 31,853 |
| | Willow - Thinleaf Alder | 290 | 0.03% | 9.58 | 10,382 |
| | Upper Montane Conifer / Willow | 280 | 0.02% | 9.8 | 6,565 |
| | **Herbaceous Wetland** | 190 | 0.10% | 8.73 | 29,474 |
| **Grassland** | **Colorado Plateau / Great Basin Grassland** | CPGB | 2.70% | 37.05 | 3,304,098 |
| | **Semi-Desert Grassland** | SDG | 1.70% | 39.24 | 2,197,108 |
| | **Montane / Subalpine Grassland** | MSG | 3.50% | 61.25 | 6,969,634 |
| **Shrubland** | **Mountain Mahogany Mixed Shrubland** | MMS | 5.10% | 27.18 | 4,525,386 |
| **Woodland** | **Juniper Grassland** | JUG | 3.50% | 35.27 | 4,034,949 |
| | **Piñon Juniper Grassland** | PJG | 8.90% | 21.44 | 6,254,320 |
| | **Madrean Piñon-Oak Woodland** | MPO | 0.50% | 29.22 | 507,352 |
| | **Piñon Juniper Evergreen Shrub** | PJC | 0.30% | 21.07 | 224,995 |
| | **Piñon Juniper Woodland** | PJO | 25.90% | 26.85 | 22,780,141 |
| **Forest** | **Ponderosa Pine - Evergreen Oak** | PPE | 11.60% | 40.98 | 15,496,830 |
| | **Ponderosa Pine Forest** | PPF | 19.30% | 35.28 | 22,235,313 |
| | **Mixed Conifer w/ Aspen** | MCW | 2.30% | 55.99 | 4,147,144 |
| | **Mixed Conifer - Frequent Fire** | MCD | 12.10% | 41.95 | 16,594,593 |
| | **Spruce-Fir Forest** | SFF | 0.70% | 57.09 | 1,357,484 |

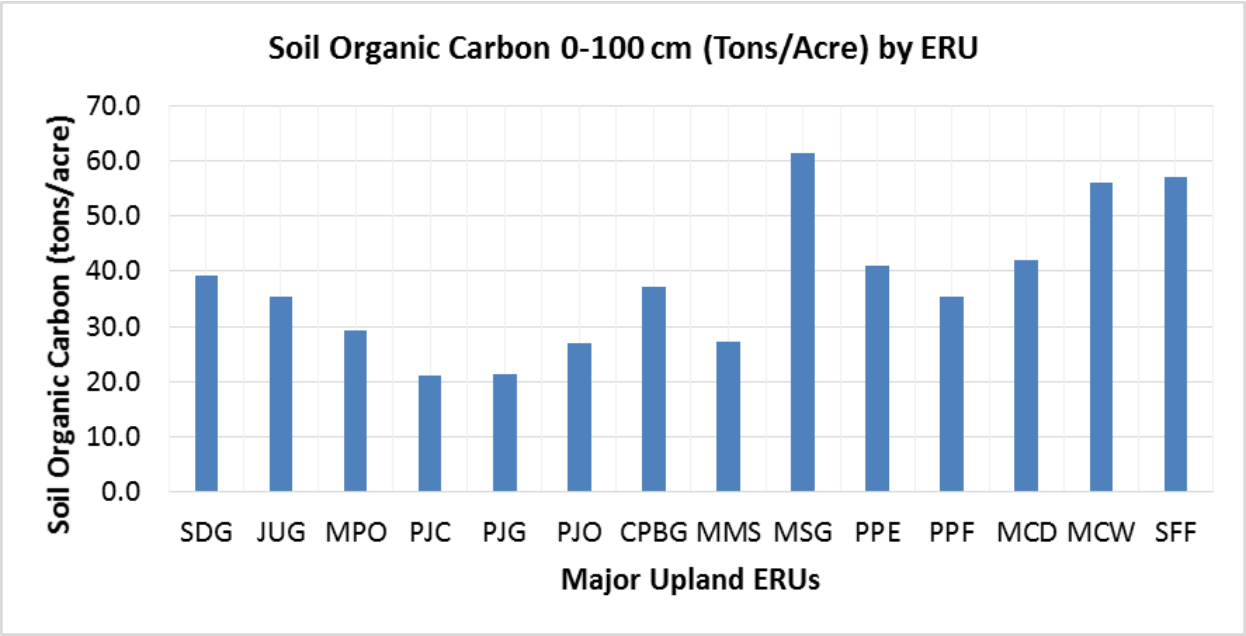


**Figure 84. Average Soil Organic Carbon by ERU**

### Trends

The current trend of sustaining SOC is strongly influenced by growth and yield of vegetation inherent to the ERUs and by those activities that remove biomass from the soil surface; including climatic factors that provide temperature and moisture conditions for weathering and decomposition of above- and belowground biomass. Given the projection that biomass carbon will potentially increase into the future, it is logical to assume that SOC will remain the same or potentially increase under current rates of decomposition. Current Forest Service Southwestern Region soil quality technical guidance is to maintain surface coarse woody material in woodlands and forests to ensure microbial populations for nutrient cycling (Graham et al. 1994).

The exception to this would be the Grassland and Shrubland ERUs where surface biomass has decreased due to consumptive harvesting by ungulates, erosion (wind and water) and other disturbances (e.g., fire).

## Summary and Conclusions

### Biomass

Table 89 summarizes reference (historic) and current carbon conditions for ERUs of the Gila NF. As one might expect, on an acre-for-acre basis the grassland ecosystems (SDG, MSG and CPGB) had the least biomass carbon concentration historically (about 3-4 tons/ac), while the infrequent fire forest systems had the greatest (88 and 96 tons/acre in MCW and SFF, respectively). The remaining ERUs ranged from 12 to 59 tons per acre, with forest ERUs having the greatest concentrations, followed by woodland and shrubland ERUs.

Of all of the ERUs on the Gila NF, SFF has experienced the largest reduction from reference conditions in biomass carbon stocks. While stand replacing fire is to be expected in this system, across a large landscape there would have been stands that did not burn, and overall carbon stocks would remain high. On the Gila there are just under 24,000 acres of SFF and in the last several years nearly 100% of this ERU has been burned, or reburned; mostly (76%) at the moderate to high severity levels, resulting in over a 50% reduction in carbon stocks in this system. Model projections indicate recovery of this carbon stock in the future, with carbon stocks almost reaching reference condition levels after 100 years. Carbon stocks in the

other infrequent fire forest system, MCW, also show a reduction from reference conditions, though far less dramatic. Loss of carbon is expected to continue in this system due to more frequent fires occurring in MCW now than in reference conditions.

The greatest increases in current carbon stocks from reference conditions are observed in two of the three frequent fire forest systems, PPE and PPF (with a 107% and 41% increase, respectively). These increases are likely the result of a history of fire suppression that has resulted in high fuel loading. Interestingly, carbon stocks in MCD, the remaining frequent fire forest system, are only 5.5% greater than those present under reference conditions. Carbon stocks within this ERU have been reduce because nearly 85% of it has burned or reburned in the last 20 years and at least a third of that was at the moderate to high severity level. Future predictions are for a decrease in carbon stocks in MCD and PPE, but a continued increase in PPF. These patterns may be driven by a greater rate of ingrowth within the PPF and the maintenance of a significant level of the medium to large size trees closed canopy, carbon-rich, seral state into the future. This pattern is not reflected in either MCD or PPE.

Carbon stocks have decreased from reference conditions in two woodland ERUs. In JUG this is a result of a shift toward early seral stages that hold less biomass than stages with larger trees, a pattern that is forecasted to continue in the modeled future. In PJO this is a result of a shift toward both earlier and more open seral stages than the more mature and closed canopy stages that would have dominated under reference conditions. Again, the current observed pattern is expected to continue in the future, with departure in carbon stocks increasing. Continuation of this trend is a reflection of the extension of current management into the future.

In the remaining three woodland systems (MPO, PJC, PJG), carbon stocks are greater than in reference conditions, likely due to a history of wildfire suppression. In all three of these ERUs there are presently more acres of larger, closed canopy, carbon-rich stands than would have existed in reference conditions. In MPO there is a strong shift further in this direction, resulting in a doubling of the carbon stock present in reference conditions. Conversely, in PJC and PJG we expect reductions in closed canopy bringing carbon stock levels closer to those existing in reference conditions.

Not surprisingly, carbon stocks are lowest in the grassland ERUs under reference, current and future conditions. The three grassland ERUs all currently hold less carbon than in reference conditions, primarily due to the reduction of acreage in high ecological status, where carbon stored in grasses is expected to be higher than in low to moderate condition states. However, we predict gains in carbon stocks in all three of these systems in the future through tree and shrub encroachment. In CPGB and MSG carbon stocks are expected to exceed those in reference conditions within 100 years.

Overall, current management appears to be moving the biomass carbon levels on the Gila's ecological systems toward reference conditions, though again, it is important to look at patterns within each ERU. Across the Gila, while the current biomass carbon stock levels are 14% greater than in reference conditions, the current management regime is projected to result in carbon stocks that exceed reference conditions by a reduced 6.6%. This will leave biomass carbon stocks at over 5.6M tons greater than reference condition levels in 100 years.

## Carbon Emissions

Similar to implications of biomass conditions and resource management, the research synthesis on carbon emissions convey significant trade-offs among potential carbons strategies. Although the total carbon emissions were higher for the harvest alternatives in the study considered here (Vegh et al. 2013), thinning and fuels reduction did reveal lower wildfire emissions and reduced risk of uncharacteristic wildfire. The study also suggests that, in the long term, systematic thinning and burning ultimately lead to greater live above-ground sequestration. It's also important to keep in mind that the A-S is starting with

uncharacteristically high levels of biomass on the heels of a century of fire suppression, and that strategies to maximize carbon sequestration and sustain carbon stores are not necessarily compatible (Hurteau and Wiedinmyer 2010). The indirect goal of contemporary management goals is to reduce, at least in part, current carbon stocks to pre-settlement levels.

In the future, the benefits to reduced emissions and increased carbon sequestration may be more pronounced. First, because live trees continually sequester carbon and are a more stable carbon sink than dead biomass generated in particular by uncharacteristic fire, insect outbreaks, drought, and other stress, proactive management and broad-scale fuel reduction may be preferable for the long-term mitigation of atmospheric carbon. Second, there is the related issue of trees regenerating poorly or not at all following uncharacteristic fire in some forest types (Savage and Mast 2005). Others investigators (Dore et al. 2008) also show that poor regeneration after stand replacement fire in ponderosa pine can render plant communities as C sinks for many years after the fire, casting further doubt on the sustainability of a strategy that intends to maximize sequestration while indirectly promoting uncharacteristic fire and reduced ecosystem productivity (Hurteau and Wiedinmyer 2010).

The A-S study by no means represents a comprehensive analysis of the carbon emissions involved with forest management scenarios. A full accounting would include emissions involved in the harvest, transfer, and processing of any wood products, along with the sequestration and decomposition of those products and other forest residues, and the emissions involved with the associated energy consumption (Cameron et al. 2013). Cameron and others (2013) determined, on a 100-year model simulation, that even with an industrial forestry theme that the ratio of storage to emissions was 0.58. They also showed that if wood destined for paper and pulp was instead redirected to less lucrative biomass consumption that the storage ratio could increase substantially to 2.7.

Also for consideration are the effects by increased CO2 levels on vegetation productivity and the potential for negative feedback by emissions on climate forcing. Such a feedback loop would involve carbon emitting processes, increased CO2 levels and fertilization of the atmosphere, followed by an increase in vegetation production and increased carbon capture and sequestration (mitigation). Some research indicates that vegetation productivity does increase with elevated CO2 levels, but productivity rates soon level off as other factors appear to compete with the growth benefits (Archer 2011, Penuelas et al. 2011).

Finally, some have forwarded the notion of carbon carrying capacity as a potential foundation for carbon management plans (Keith et al. 2009, 2010, Hurteau et al. 2010). Carbon carrying capacity is the maximum amount of above-ground carbon that can be sustainably stored, according to climatic conditions and the disturbance regime of a system. Carbon carrying capacity may be a useful consideration for optimizing carbon stocks according to the inherent capabilities and processes of a given ecosystem.

## Soil Organic Carbon

While most woodland and forest ERU's will maintain biomass carbon in support of SOC for the future, the continued loss or displacement (patchiness) of grassland and shrublands surface biomass could result in slower and diminished contributions to SOC stocks, and influence long-term soil productivity. Ecological response units where existing soil conditions that are rated impaired or unsatisfactory, due to the lack of surface litter, are most susceptible to continued reductions of SOC over time. Soil conditions that are rated satisfactory will continue to maintain SOC values and a loss of long-term soil productivity is unlikely.

The effects of climate change on the decomposition rates and stability of SOC are currently being researched (Davidson and Janssens 2006).

# Chapter 4. Soil

## Introduction

Soil is a complex and dynamic system that consists of a mineral component, organic matter, air, water and living soil organisms. It is formed over time by interactions between climate, parent material, topography, and organisms, both above and below ground. Due to the slow rate of formation in the arid Southwestern climate, soils are essentially a non-renewable resource (USDA FS 1986a).

Key ecosystem characteristics of the soil resource include those that determine the capacity of soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health (Doran and Parkin 1994). This analysis describes upland soil diversity and distribution on the Gila NF and evaluates three key characteristics:

- Ecological status (canopy cover by species)
- Soil Loss
- Soil condition

The subsections that follow include:

- Ecosystem services of soils
- Data
- Analysis methods
- System drivers and stressors
- Soil diversity and distribution
- Analysis of key ecosystem characteristics
- Risk assessment
- Stakeholder input received
- Summary

Riparian soils are analyzed in the Riparian Chapter. Assumptions, limitations and uncertainty associated with this analysis are disclosed in the Analysis Methods section and discussed in greater detail where relevant in this chapter.

## Ecosystem Services of Soils

Soil provides many ecosystem services but is often overlooked and undervalued (Bridges and Van Baren 1997; Comerford et al. 2013). It provides provisioning services in the form of construction, landscaping and industrial materials. Many important medicines, such as penicillin and other antibiotics, are produced by soil microorganisms. The activities of soil microorganisms are also the primary means by which nitrogen, a necessary nutrient, is made available to plants. Soil provides supporting ecosystem services as it is the primary medium for plant growth and provides habitat for micro and macro soil organisms. A single handful of soil can contain more biodiversity than an entire forest.

Regulating services provided by the soil resource include cycling of nutrients, water and energy. It contributes to global regulation of greenhouse gases including carbon dioxide which is stored as soil organic carbon. It regulates water storage and release, water filtration and purification, and provides for erosion control and sediment retention. Soil also provides thermal regulation, absorbing heat energy when temperatures are high, and releasing it when temperatures are cool. Soil microorganism provide for biological control of crop pests and bioremediation of contaminants. Soil is the land that provides

economic, recreation, education, research and personal enrichment opportunities and as such, provides many cultural ecosystem services.

## Data

### Terrestrial Ecological Unit Inventory

The Terrestrial Ecological Unit Inventory (TEUI), previously referred to as the Terrestrial Ecosystem Survey, maps relationships between climate, geographic location, geology, geomorphology, aspect, slope, soil and vegetation at the scale of a standard United States Geological Survey (USGS) map.[21] The Terrestrial Ecological Unit Inventory classifies ecological types and maps ecological units to interpret site potential and current ecosystem characteristics. The conditions under site potential are those that exist at the latest successional stage, or steady-stable-state as reflected by stable, diverse and functioning climate-soil-vegetation systems.

The Gila NF's draft Terrestrial Ecological Unit Inventory (TEUI), which includes data from several surveys completed at the project level, is the primary dataset for this analysis. Completed surveys provide statistical summaries of survey data and management interpretations,[22] including those equivalent to key characteristics analyzed for the assessment. The 2012 Planning Rule does not require further modification of datasets or statistical analysis. Additionally, the size of the dataset (more than 7,000 sample locations) and assessment timeframes prohibit a robust statistical summary. Due to draft status of the Gila NF's TEUI, updates to interpretation protocol currently in progress, and differences in the summary process,[23] interpretations developed for the final TEUI at a finer scale may or may not produce the same results as this assessment.

## Analysis Methods

The TEUI mapping process includes three general types of documentation: observations, transects, and ecological site descriptions. Observations and transects are the least intensive form of documentation and are used to develop quantitative descriptions of characteristics defining site potential for a given map unit. In the process of gathering data, conditions that represent site potential, and those that represent other successional states are documented. Ecological site descriptions are the most intensive form of sampling and are used to document site potential, once it has been defined through observations and transects. In this analysis, representative[24] observations and transects are used to describe current conditions and ecological site descriptions are used as a contemporary reference condition.

There are multiple TEUI units in each ERU. Departure is assessed at the TEUI level using a similarity analysis (Czekanowski 1913 as cited in Kent and Coker 1992) to describe variability in conditions within each ERU. Departure is simply the inverse of similarity. The TEUI unit departure rating that represents the largest percentage of the ERU area is used as a single departure rating for each ERU.

Because TEUI data are point in time measurements of representativeness, not repeat measurements, trends cannot be identified. Monitoring data collected using methods and measures compatible with TEUI would be required to assess trend.

[21] The scale of a standard USGS map is 1:24,000 meaning that one inch on the map equals just under 0.4 miles on the ground.
[22] Interpretations are "predictions of soil behavior for specified land uses and specified land management practices. They are based on soil properties that directly influence the specified use of the soil" (USDA NRCS 2005).
[23] This assessment is driven by the data contained in each map unit, rather than by the draft map unit legend which will change as more data is collected and map unit concepts are refined. Only the major component, or ecological type in each TEUI map unit is used in this assessment unless other components represent limitations, or lack thereof. Soil depth, clay content and particle size class were the basis for determining limitations, or lack thereof.
[24] See previous footnote.

Not all TEUI units contain the same number of observations, transects and ecological site descriptions. There is less uncertainty associated with larger datasets and greater uncertainty associated with smaller datasets. In particular, Spruce-Fir Forest, Madrean Piñon-Oak Woodland, PJ Evergreen Shrub and Mountain Mahogany Mixed Shrubland are associated with smaller datasets. However, there is low uncertainty associated with the Spruce-Fir Forest analyses because of the large extent of stand replacement fire that this ERU has experienced. Assumptions can be and are made about the status of key ecosystem characteristics within areas of recent high and moderate burn severities as described below. There is low uncertainty associated with these assumptions because of both formal and informal post-fire monitoring. Additionally, because the TEUI provides a point of reference, it is possible that ERUs with the highest actual departure from historic conditions can demonstrate a low analysis departure due to the inability to find reference sites that still represent historic conditions.

### Ecological Status

Current conditions resulting from high and moderate burn severity that are not captured in the TEUI dataset are accounted for by scaling the degree of departure from the date of the burn to established values for recovery time. With respect to ecological status in forested systems, time scales were taken from literature produced by the Nature Conservancy (Smith 2006a, 2006b, 2006c, 2006d). Limited information to set a time scale from stand replacement fire to recovery of pre-fire shrub species and canopy cover exists for the Mountain Mahogany Mixed Shrubland. Due to the relatively small proportion of acres burned at high and moderate severity each year in this ERU, the analysis was not sensitive to the time scale used. Any length of time produced the same departure and trend results as discussed below. No adjustments were made for those ERUs with high and moderate severities over less than five percent of their area. Acres that were seeded and seeded/mulched for emergency stabilization, as described in the fire discussion in System Drivers and Stressors Chapter, were scaled to a time frame five years shorter than the literature values based on BAER monitoring and professional judgement.

As applied to the ecological status characteristic, departure is categorized at the TEUI unit level using the following thresholds:

- 0-33% Departure = Low
- 34-66% Departure = Moderate
- 67-100% Departure = High

### Soil Loss

A certain amount of soil loss occurs as a natural geologic process, even under reference conditions. This is referred to as the baseline, minimum or natural rate of soil loss (NSL). Some amount of soil loss greater than the minimum rate can occur without impairing natural soil productivity. This rate varies by soil and ecological system. The reference condition for soil loss is based on the assumption that soil loss rates would have been below some threshold in most places on the Gila NF. Under previous modeling protocol, this rate was described as a tolerance rate (TSL). However, this protocol is not compatible with the model used in this analysis.

Annual soil loss rates are predicted from the Rangeland Hydrology and Erosion Model (RHEM) v2.3, developed by the Agricultural Research Station. This model is in the public domain and available at http://apps.tucson.ars.ag.gov/rhem. In the past, the only available soil loss models were based on cropland data. The RHEM model is based on rangeland data and is the most current, accepted model for use in rangeland and forest systems by the Southwestern Region. Instead of a TSL rate, a Threshold rate is determined using the RHEM (v2.3) risk function. Departure is not categorized as low, moderate or high. The Regional soil condition guidance discussed in the next subsection, differentiates the modeled soil loss indicator of soil stability function between condition categories based on whether or not CSL exceeds TSL.

As applied to departure, this means departure either exists or it does not. Where they are below the Threshold rate, departure is low for that TEUI unit. Where CSL rates exceed the Threshold rate, departure from the reference is categorized as significant for that TEUI unit. ERU departure is determined by applying the same 33 percent threshold as is used in the assessment of vegetation related characteristics. If more than 33 percent of the ERU area is represented by TEUI units in significant departure, than departure is significant for that ERU.

CSL rates are those occurring under vegetative canopy and groundcover conditions as documented by TEUI observation and transect data and NSL by the ecological site descriptions. ERU acres burned at high and moderate severities are not represented by modeled data. It is assumed that CSL rates exceed the NSL and Threshold rates on these acreages for five years post-fire. This assumption is based on soil loss modeling for BAER assessments, Forest monitoring data, and professional observation and judgement.

The RHEM model is only capable of modeling sheet and rill erosion. Therefore, gully and wind erosion are not considered. The processes involved in gully erosion are more like stream channel processes, and while there may be some capable watershed models, it is beyond the scope of this assessment. Gully erosion is considered qualitatively based on notes that accompany the TEUI documentation and on the ground knowledge but is not used to assess soil loss, rather it is accounted for in the soil condition assessment.

Wind erosion is generally considered a larger issue in cropland systems than in forest and rangeland systems. Currently, no wind erosion models developed for forest or rangeland data are available. Although the Air Chapter does include quantitative data on particulate matter, it cannot be used to estimate wind erosion on the Forest as the origins of that particulate matter cannot be traced to a specific area of land.

The value in modeling soil loss, or anything for that matter, is not to arrive at an absolutely correct number or answer. It is the relative difference between management scenarios that is important.

## Soil Condition

Soil condition is an evaluation of soil quality based on an interpretation of factors that affect vital soil functions. Soil quality is the capacity of soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health (Doran and Parkin 1994). It is interpreted here using the USDA Forest Service Southwestern Regional guidance (USDA FS 2012b). The interpretation rates soils as they exist currently and reflects the effects of management (historic and current) and disturbance history. Condition assessed is based on three soil functions: the ability of soil to capture, store and release water (hydrologic function); to resist erosion (stability function); and to recycle nutrients (nutrient cycling function). The TEUI documentation, and the ecological status, and soil loss results are used to assess these functions. Soil condition categories are: satisfactory, impaired, and unsatisfactory (USDA FS 2012b).

The status of the stability function was determined using modeled soil loss rates, documentation of visible sheet, rill and gully erosion in the TEUI data and vegetative groundcover summary prepared for the soil loss analysis. The status of the nutrient cycling function was determined using the results of the ecological status and vegetative groundcover summary. Because hydrologic function influences the volume of soil in which nutrient cycling may take place, as well as the types and rates of reactions that can occur, it was also a consideration in determining nutrient cycling status.

The determination of hydrologic function status relied on documentation of soil surface structure, crusting, compaction and the stability and nutrient cycling status. Soil stability is required for hydrologic function and soil loss may expose subsurface layers that have different hydrologic properties than the naturally occurring topsoil.

The soil condition interpretation also assumed that any TEUI unit in a zootic disclimax state, could not be in satisfactory condition. Zootic disclimax states can occur under sustained or periodic use of vegetation by wild or domestic animals. Under such conditions vegetation can depart markedly in the structure and composition of the natural vegetation community under climax conditions (USDA FS 1986a).

Prior to European settlement, soil loss, hydrologic function and nutrient cycling would probably have been within functional limits for most soils that are not naturally unstable. Exceptions would have occurred during periods of drought and possibly localized areas impacted Native American populations and non-domestic herbivory. Natural fire disturbance would have had a limited effect on the extent of soil loss, only causing accelerated erosion in localized areas where total consumption of vegetative canopy and groundcover occurred. Most areas that are currently rated impaired or unsatisfactory for soil condition would probably have been rated satisfactory. The reference condition is "satisfactory" and is represented by the ecological site description documentation with current conditions described by observations and transects. Impaired and unsatisfactory ratings are associated with moderate and high departure ratings respectively.

The satisfactory rating indicates that soil function is being sustained within ecosystem boundaries and the ability of the soil to maintain resource values and sustain outputs is high. An impaired rating indicates a reduction of soil function, a reduced capacity to maintain resource values and sustain outputs, and an increased vulnerability to degradation. It should signal further investigation to determine causes and degrees of decline in soil function. Such investigations may identify a need for change in management (USDA FS 2012b), whether in project level work, or Forest scale planning such as the case here. The unsatisfactory rating indicates a loss of soil function has occurred and that degradation of vital soil functions is such that the soil is unable to maintain resource values, sustain outputs and recover from impacts. Soils rated in the unsatisfactory category signify a need for improved management practices or restoration designed to recover soil functions (USDA FS 2012b).

Previous soil condition protocols considered only the soil stability function when determining soil condition, with categories of satisfactory, unsatisfactory and unsuited. The unsuited category was reserved for soils that are naturally unstable.[25]

## Soil System Drivers and Stressors

Primary system drivers for all soil characteristics are climate, topography, parent material, biota (living organisms), and time. These are known as the five soil forming factors. Patterns in precipitation, temperature and wind influence the potential natural vegetation community, natural rates of soil formation and soil loss. The canopy and ground cover provided by the vegetation community and the timing, duration and intensity of precipitation and wind events greatly influence the ability of the soil to resist erosion. The vegetation community, including its composition and structure, determine the types and rates of organic matter contributions to the soil. Water availability and temperature largely determine the types and rates of physical and chemical weathering processes and the biological reactions involved in decomposition and nutrient cycling. Both of these factors are important determiners in the natural fertility and productive capacity of the soil. Climate change, including increased frequency and severity of drought conditions (IPCC 2007; Seager et al. 2007) is a stressor that is expected to have cascading effects. The predominant climate regime and climate change are characterized and discussed in the System Drivers and Stressors Chapter.

[25] Unsuited was defined as those soils where NSL rate is greater than the Threshold soil loss rate. In other words, the geologic rate of soil loss is greater than the rate of soil formation. The RHEM model automatically identifies the lowest soil loss rate as the NSL (RHEM calls it "baseline"), which means that all other scenarios (current or otherwise) will be represented by a soil loss rate greater than NSL. Soil loss modeling with RHEM cannot serve as the basis on which to identify naturally unstable soils.

Topography is a system driver in its influence on climate, vegetation and natural soil stability. Erosional and depositional areas are defined by the position they occupy on the landscape and the steepness of slope. The steepness of the slope also influences the lateral movement and redistribution of soil water. Regardless of the elevation, differences in solar radiation between north and south facing slopes influences the temperature and moisture regimes that control the rate of weathering and soil formation, and influences vegetative composition, productivity and the accumulation of soil organic matter. North facing slopes tend to be cooler and wetter than south facing slopes, which is reflected in both the degree of soil development and vegetation patterns across the Forest. At the lower elevational ranges of a given vegetation community, that community may only be found on north facing slopes, where at the upper end of its elevational range it may only occur on south facing slopes.

The term "parent material" describes both the primary origin of the matter from which soil is formed, either geologic or organic, and its last mode of transport. Parent materials on the Gila NF are geologic in nature and are dominated by volcanic and sedimentary rock types. Modes of transportation include flowing water, wind and gravity and those materials are referred to as alluvium, eolian and colluvium respectively. Lake deposits, such as those in the Buckhorn, NM area, are referred to as lacustrine, however soils formed from these lake deposits occur on a very limited extent on the Forest. If the material was not transported after its original deposition, it is referred to as residuum.

Parent material is a system driver in that the physical structure and chemical composition of the rock are largely responsible for the physical and chemical properties of the resulting soil. It is the combination of climate and these soil properties that ultimately determines the potential natural vegetation community.

For example, within the elevational-climatic gradient of woodlands on the Forest, the dominance of Emory oak a good indicator of soils formed from granite, while silver leaf oak tends to be more prevalent on soils formed from rhyolitic ash tuff.

In general, soils across the Forest formed from basalt or andesite are relatively stable and productive due to the types and amounts of clay minerals formed from weathering. Soils formed from basalt or andesite residuum or colluvium tend to be more stable than those formed from alluvium. Limestone also typically produces relatively productive and stable soils.

Datil soils, or those formed from volcanic sediment, can be productive, but are highly erodible if vegetative groundcover is not maintained. These soils are located in the northwestern portion of the Forest, primarily west of Highway 180 from the northern Forest boundary south to the Pueblo Park area. Soils formed from granite are primarily found in the Burro Mountains area. These soils have moderate productivity potentials and can also be very erodible if vegetative groundcover is not maintained. Sandstone and shale soils have similar tendencies.

Soils derived from Gila conglomerate, and other conglomerates are highly variable in their productivity depending on their composition, and generally tend to be very erodible, as do most soils derived from rhyolite. The Kneeling Nun rhyolite in the southern portion of the Forest is very productive and more stable than other rhyolites. Differences in the productivity and stability of soils derived from rhyolite are due to the age of the geologic formation, and hence the time over which weathering has occurred, and concentrations of potassium and calcium bearing minerals that make up the rock. Rhyolitic ash tuff soils tend to have low productivity potentials and are highly erosive.

There is a high specificity between plant species and species of soil microorganisms, meaning that the relationships are often, but not always exclusive. This is important because soil microorganisms are responsible for the majority of nutrient cycling. As a general principle, the greater the above ground diversity, the greater the below ground diversity which leads to a wider range of nutrient pathways under

a wider range of climatic conditions, and ultimately a more productive soil. Soil microorganisms have been linked not only to vegetative diversity, but also patterns of seedling establishment and interplant competition (Simard and Durall 2004). Biota other than microorganisms are important both as agents of natural disturbance and as contributors to the soil nutrient pool. The discussion of natural vegetation succession, in the System Drivers and Stressors Chapter, also applies to biota as a soil system driver.

Renewable resources are commonly defined as those that can be replenished or replaced within a single human life span. It has been estimated that in the Southwestern climate, the time it takes for an inch of soil to form under natural conditions can vary between 300 and 1,000 years (USDA FS 1986a). While vegetative groundcover, soil condition and ecological status can change within a single human lifespan, the loss of productivity potential and alteration of hydrologic function that accompanies soil loss cannot be renewed in that same time period.

As described in the System Drivers and Stressors Chapter, fire, ungulate grazing, insects and disease, mineral resource extraction, roads and trails, terrestrial invasive species and mechanical vegetation manipulation are all disturbance regimes that impact the soil resource. Those impacts are described in detail in that chapter. A summary is provided here.

Fire, ungulate grazing and insects and disease can be both soil system drivers and stressors. They are drivers when they are within the magnitude, extent and frequency of the Natural Range of Variation (NRV). When they are outside NRV, they are stressors. At present, insects and disease remain a system driver but are predicted to become a stressor as climate change progresses, potentially impacting ecological status and increasing the risk of high and moderate burn severities. Fire is both a primary system driver and stressor, and is expected to remain so into the future. When fire frequency and severity are with NRV, it serves to mitigate large scale negative effects to the soil resource that occur as a result of large extents of high and moderate burn severities. Ungulate grazing is a potential system stressor that has varied in significance after the arrival of Europeans. The legacy of historic overgrazing by livestock prior to current management remains evident in terms of ecological status departure, and in some cases altered hydrologic function, nutrient cycling status and gully erosion. Under the NRV approach recommended in the 2012 Planning Rule and directives, the continued presence of livestock under current management is still a stressor, but impacts are substantially less than historic management. Nevertheless, because time is a primary system driver the effects of historic and current management are cumulative.

Mineral resource extraction, roads and trails, invasive species and mechanical vegetation manipulation are all soil system stressors to varying degrees. Roads and trails currently have the greatest impact, primarily due to lack of maintenance but soil type, gradient and in some cases road density can contribute to that impact. Mineral resource extraction and terrestrial invasive species have small, localized impacts on the Gila NF soil resources at this time. Invasive species have the potential to become a greater stressor as climate change progresses. Mechanical vegetation manipulation also has a large impact on soil characteristics when and where it occurs, depending on a variety of factors including but not limited to: soil clay and moisture content, temperature and time between entries for treatment. Slope restrictions and other measures or methods designed to reduce impacts to the soil resource and protect water quality are recommended and implemented at the project level. Currently, the extent and frequency at which these manipulations occur are relatively limited but could foreseeably increase with the increasing emphasis on landscape scale restoration.

## Soil Diversity and Distribution

The Gila NF lies within the Mogollon-Datil section of the Colorado Plateau and the Mexican Highland section of the Basin and Range physiographic provinces. Physiographic provinces are land areas

characterized by their prominent landscape features, topography, geology and related processes (Fenneman and Johnson 1946), all of which influence soil diversity and distribution.

The Colorado Plateau Mogollon-Datil section is a transition zone in and of itself, as geologic structure and topography begins to change between those that define the Colorado Plateau north of the Mogollon Rim and the Basin and Range to the south. It is characterized by volcanic fields of various ages, lava flow plateaus, rugged uplifted mountain ranges and ancient lake bed sediments. Mesas and buttes formed from sedimentary materials and capped by lava flows also occur and can indicate areas prone to mass wasting.

The Basin and Range Mexican Highland section is characterized by broad depositional basins and the north-northwestern trending, relatively narrow mountain ranges. Playa lakes, where salts and clays accumulate, are often formed in lowland areas. These lowlands are influenced by the higher elevation Chihuahuan desert, where precipitation occurs more often during the summer, or the lower elevation Sonoran desert where precipitation occurs during both summer and winter months. These sometimes isolated mountain ranges produce abrupt changes in elevation, greatly influence jetstream flow patterns, and produce diverse climatic regions with highly variable rates of soil formation.

As the Forest is within a transitional zone between these physiographic provinces, it contains remnant volcanoes and calderas, high sedimentary plateaus capped with basaltic or andesitic lava flows, contiguous and isolated uplifted mountains made of volcanic, sedimentary and metamorphic rock, and valleys created by lowering of the land surface due to faults along the adjacent mountains. All of these features are dissected by ephemeral, intermittent and perennial streams.

Elevations in the southern portion of the Forest are generally higher than those found in the typical Chihuahuan deserts and Madrean woodlands, but is still influenced by the regional weather patterns and floristics of both of these systems. The Chihuahuan influence is more prominent and is strongest along the south and east of the Forest boundary. The Sonoran influence is greatest in the Burro Mountains and along southwestern side of the Forest.

Soil classification uses a taxonomic structure similar to that used in biotic taxonomy. This system is described in Table 93 and followed by a summary of the major types of soils found on the Forest.

**Table 93. Comparison of soil and biotic taxonomic classifications**

| Soil Taxonomy | Biotic Taxonomy |
|---|---|
| Order | Kingdom |
| Suborder | Phylum |
| Great Group | Class |
| Subgroup | Order |
| Family | Family |
| Series | Genus |
| Phase | Species |

Of the twelve soil orders, six have been mapped on the Gila NF: Mollisols, Alfisols, Vertisols, Andisols Entisols and Inceptisols. Andisols are not prevalent.

Mollisols have a dark-colored surface layer, are relatively high in organic matter and are highly fertile. Globally, this soil order occupies seven percent of the total ice-free land area (Brady and Weil 2008). These soils were first described in the grassland steppes of Russia and are frequently the dominant soils in grassland systems. This has contributed to the misconception that the occurrence of these soils is limited to grasslands. While there are soil indicators of historic grasslands,[26] soil order is not one of them. Mollisols

[26] Phytoliths are very small particles of precipitated silica that accumulate in plants. Their assemblages in the soil are particular to the plant communities they formed in and can be used to identify historic grasslands (Fisher et al. 1995).

can and do occur in other ecological types. In fact, they are found in every ERU, on most landforms and all parent materials except recent alluvium, and slopes ranging from zero to 80 percent across the Forest. They account for approximately 85 percent of the Forest.

Alfisols are also fertile soils, but less so than Mollisols. They typically develop in woodland or forest ecological types, but are known to occur in grassland systems on the Forest. Globally, Alfisols occupy about 10 percent of the total ice-free land area (Brady and Weil 2008). Alfisols are the second most common soil on the Forest. They occur on most ERUs but are more often found in the Mixed Conifer with Aspen, Ponderosa Pine Evergreen Oak, Ponderosa Pine Forest and Mountain Mahogany Mixed Shrubland on all landforms with slopes ranging from zero to 80 percent. They primarily form on rhyolite and tuff, but have been documented on alluvium, granite and basalt. They account for approximately six percent of the Forest.

Vertisols contain high amounts of clay minerals that visibly shrink and swell with changes in moisture. The shrink-swell properties of these soils often result in high amounts of surface rock as over time the churning action pushes subsurface rock upward. It is a common misconception that Vertisols are not productive soils. Vertisols and Mollisols with vertic properties, also referred to as vertic intergrades, are naturally fertile and productive soils. Productivity ranges from moderate to high, depending on the amount of surface and near surface rock fragments. Clayey soils such as these generally have high load bearing capacity (strength) when dry, but become increasingly susceptible to compaction with increasing moisture content because of their high cohesion and plasticity. Compaction reduces the volume of pore space available for the movement of air and water, increases bulk density and changes soil structure. When compacted, these soils have low productivity. Freeze-thaw action is a natural mechanism that can loosen or break-up compaction over time. True Vertisols are the least common of the five dominant soil orders on the Forest. They generally form on basalts or basaltic conglomerate on valley or elevated plains and mesas with slopes ranging from zero to 15 percent. They have been documented in the Colorado Plateau-Great Basin Grassland, Juniper Grass and PJ Grass. True Vertisols account for approximately one percent of the Forest. Vertic intergrades are included in the Mollisol percent of the Forest.

Entisols are relatively young soils with little to no subsurface development. These soils form in landscape positions where the parent material has not been in place long enough for soil-forming processes to create distinctive soil layers such as floodplains, alluvial fans or stream terraces. In general, these soils exist in setting where erosion or deposition is happening faster than the rate of soil formation. Globally, Entisols occupy 16 percent of the total ice-free area. Soil productivity ranges from very high to very low. Entisols may have very high productivity when formed in recent alluvium where topography is nearly level, there is a close proximity to water and periodic nutrient replenishment occurs with deposition of floodwater sediments. These Entisols are common in the Forest's riparian areas. Entisols are likely to have very low productivity if formed in shifting sand or on steep rocky slopes (Brady and Weil 2008). Most of the Entisols on the Forest occur along valley bottoms in riparian ERUs, although they are found on rhyolite in the Madrean Piñon-Oak Woodland and on steep mountain slopes in Mixed Conifer with Aspen. They account for approximately two percent of the Forest.

Inceptisols are more developed than Entisols but typically lack significant clay accumulations in the subsoil. They generally occur on relatively young landforms that are stable enough to allow for soil development. Globally, Inceptisols occupy 17 percent of the total ice-free land area (Brady and Weil 2008). The natural productivity of Inceptisols varies widely depending on clay and organic matter content. They are found primarily on rhyolite parent material in the forest ERUs. They are occasionally found on rhyolite in Madrean Piñon-Oak Woodland, and on alluvium in the Juniper Grass and Colorado Plateau-Great Basin Grassland. They account for approximately seven percent of the Forest.

Across the Gila NF, soils have predominantly dry moisture regimes and mild temperature regimes at the lower elevations and humid to sub-humid moisture regimes and cold temperature regimes at the higher elevations.[27] Soils range from fine (< 35 percent clay) to loamy, and skeletal (>35 percent rock fragments) to non-skeletal in nature. They occur on slopes ranging from 0-80 percent, with flat and vertical rock outcrops present in some areas. Soil texture varies with parent material.

Soil productivity is highly variable across the Forest depending on many factors including, but not limited to: soil climate, soil depth, stability, hydrologic function, nutrient cycling, soil biology, soil-water holding capacity, filtering and buffering capacities and the nature of the parent material.

## Analysis of Key Characteristics

As previously stated, the three key ecosystem characteristics analyzed for soils include ecological status, soil loss and soil condition. This section includes a subheading for each of these characteristics and includes a discussion of its importance to ecosystem integrity, reference and current conditions as described by the TEUI data, and factors contributing to departure from the reference condition.

### Ecological Status

Ecological status is a vegetative characteristic that describes canopy cover by species. It is relevant to the assessment of soil resources for two reasons. First, regardless of species, canopy cover is an important factor in soil stability as it intercepts raindrops and reduces the impact energies responsible for soil particle detachment. Second, as described in the soil system drivers and stressors subsection, above and below ground biodiversity are directly related. Therefore, ecological status is an indicator of nutrient cycling status (USDA FS 2012b). The following figure illustrates the variability in conditions across each ERU based on the TEUI data as described under Analysis Methods.

[27] For a complete explanation of soil temperature and moisture regimes, see Keys to Soil Taxonomy, (Soil Survey Staff 2014).

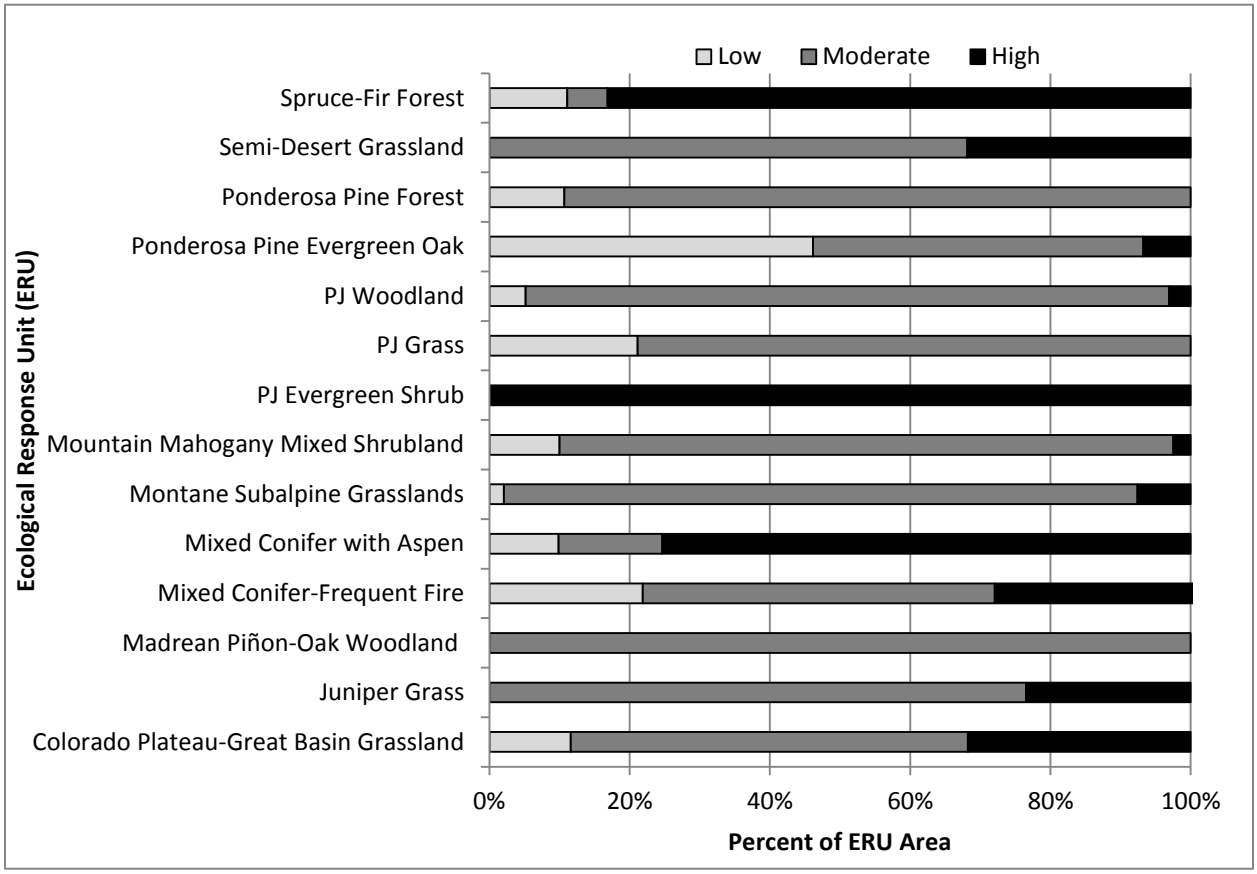


**Figure 85. Area weighted ecological status departure ratings across the Gila NF's upland ERUs**

With most of its area represented by TEUI units in low departure, Ponderosa Pine Evergreen Oak is considered to be in low departure overall  Spruce-Fir Forest, Mixed Conifer with Aspen and PJ Evergreen Shrub are in high departure, with the remaining ERUs in moderate departure overall.

However, there are limitations associated with the lack of a more robust statistical summary and several other factors that merit discussion.  Ecological status includes both over and understory structural components. There tends to be greater species richness in the understory, which is subject to a larger degree of seasonal and annual variability than the overstory due to species specific responses to weather patterns. The data describing each TEUI unit is composed of documentation taken at different times of the year and high species diversity is favored in the selection of sample point locations. The statistical summary conducted in the preparation of a final TEUI product results in a species composition summary that defines and describes the potential and current dominant tree, shrub, forb and graminoid species, and excludes species that are not defining components of the map unit. The analysis approach used in this assessment includes all species. The result is that understory conditions reflecting high species diversity, but not the same species at all sample sites, seasonal and annual variability, and/or variability due to site specific characteristics such as aspect, are interpreted as departure.

Species diversity tends to be higher in transition zones, which is reflected in the TEUI documentation. The PJ Evergreen Shrub (less than one percent of the Forest), Ponderosa Pine Evergreen Oak (12 percent of the Forest) and Madrean Piñon-Oak Woodland (one percent of the Forest) are all transitional ERUs on the Gila

NF.[28] Considering these factors, there is a fair amount of uncertainty associated with these analysis results, which may overestimate departure in most ERUs. On the other hand, seral state proportion and patch size departure, as discussed in the Upland Vegetation Chapter, suggest that ecological status departure is still likely as species composition is generally not the same across seral states.

In the grassland, shrubland and woodland ERUs, this departure is typically associated with lower diversity and abundance of grass species and higher percentages of woody species canopy cover. The Madrean Piñon-Oak Woodland has higher percentages of both shrub and tree species, but understory diversity remains high. The data describing the Mountain Mahogany Mixed Shrubland ERU is primarily from the Burro Mountains where historic grazing impacts were severe and extensive, very likely leading to higher shrub canopy cover and lower diversity and cover of grasses. However, much of this ERU occurs on steep slopes within designated wilderness areas and is not described in the TEUI data. It is reasonable to suspect that departure would be lower in the shrubland ERU if it included data collected in the wilderness.

These departures are due primarily to the interrelationships between historic and current fire and livestock grazing management, although herbivory by large herds of elk on the Quemado and Reserve Ranger Districts may be an additional stressor in those areas. Ungulate grazing and browsing has been a disturbance regime in these ecological types both before and after the arrival of Europeans. Domestic livestock grazing began in the late 1800s. Livestock grazing practices reduced herbaceous vegetation (fine fuels) and contributed to an increase in woody vegetation as a result of reduced competition for water and nutrients (Boucher and Moody 1998; Rummel 1951; Madany and West 1983, Savage and Swetnam 1990). At the turn of the 19th century, the policy of fire suppression disrupted the natural role of fire in these ecosystems and contributed to an increase in woody vegetation and fuel loading. Although the Gila NF began using fire as a restoration tool in the 1970s, and current grazing management has allowed for improvement in conditions, fire regimes remain departed in the grassland, shrubland and woodland ERUs (see Upland Vegetation Chapter) as the herbaceous understory vegetation that provides forage, is also the fine fuels needed to carry fire. Non-fire vegetation treatments (e.g. fuelwood harvest or pushing[29]) have been conducted in these ERUs. However, these activities have been fairly limited due to budget, staffing levels and Regional priorities. Without restoring ecological processes, like fire, these treatments that restore or otherwise alter existing vegetation structure or composition require maintenance. The historic and current status of non-vegetation treatments, fire and herbivory on the Gila NF are discussed in detail in the System Drivers and Stressors Chapter.

In some of the Mixed Conifer-Frequent Fire, this departure is associated with higher tree species canopy cover over reference condition and lower in others. There is corresponding lower abundance, but not necessarily diversity, of understory vegetation where tree canopy is higher. Where percentage of tree species canopy cover is lower, the canopy cover of juniper species, evergreen oaks and/or grass species tends to be higher depending on soil type, elevation and aspect. On the other hand, some of this departure is due to shifts in the relative dominance of individual tree species which is a reflection of the elevational-climatic gradient of this ERU, and not ecological status departure. Higher tree species canopy cover and lower diversity and abundance of understory vegetation between reference and current condition are all factors in the Ponderosa Pine Forest ERU. The TEUI data also documents some areas where Douglas fir is becoming established or may be higher in relative abundance in ponderosa pine stands between the reference and current condition. There are some map units that demonstrate departure in the opposite sense, with a lower percentage of ponderosa pine canopy cover accompanied by a shift in the dominant

[28] PJ Evergreen Shrub is a transitional ecological unit between Interior Chaparral and montane units. Ponderosa Pine Evergreen Oak is a transitional ecological unit between the Ponderosa Pine Forest on the Mogollon Rim and the woodland zone (USDA FS 2015a). As the southwestern portion of the Forest lies at the northern most edge of the Madrean influence, the Madrean Piñon-Oak Woodland, also represents a transitional zone.

[29] Pushing refers to uprooting individual trees with heavy machinery.

oak from Gambel oak to gray oak between current and reference condition. Gray oak prefers relatively warmer, drier sites as compared to Gambel oak. Again, some of this departure is due to shifts in the relative dominance of individual tree species which is a reflection of the elevational-climatic gradient of this ERU, and not ecological status departure. While this analysis categorizes departure in the Ponderosa Pine Evergreen Oak ERU as low, the TEUI data do show lower percentages of ponderosa pine and higher percentages of juniper and oak between reference and current conditions, as well as differences in the relative abundance of grass species.

The interrelationships between historic and current fire and livestock grazing management and their roles in ecological status departure in the grassland, shrubland and woodland ERUs also applies to the Mixed Conifer-Frequent Fire, Ponderosa Pine Forest and Ponderosa Pine Evergreen Oak ERUs, although herbivory has somewhat less explanatory value in the Mixed Conifer-Frequent Fire. Non-fire vegetation treatments (e.g. timber harvest) have more explanatory value in all three of these forested ERUs. While restoration or hazardous fuels reduction is the primary purpose for non-fire vegetation treatments, economics are a driving factor in where and what happens, or doesn't happen on the ground. Because Mixed Conifer-Frequent Fire, Ponderosa Pine Forest and Ponderosa Pine Evergreen Oak contain species that have higher economic value than the woodland and shrubland ERUs, more acres of non-fire vegetation treatments have occurred. Under current plan direction, these treatments are generally driven by single species wildlife habitat management concepts (e.g. goshawk or Mexican spotted owl), old growth management emphasis or hazardous fuels objectives, and not Terrestrial Ecological Unit or Ecological Response Unit concepts.

With respect to the Spruce-Fir Forest and Mixed Conifer with Aspen, there is greater accuracy and very little uncertainty associated with ecological status departure as it is driven by the extent of recent stand replacement fire that occurred due to drought and the legacy of past fire suppression.

### Soil Loss

A certain amount of soil loss occurs as a natural geologic process, even under reference conditions. As described under Analysis Methods, the reference soil loss rate is the minimum or natural rate (NSL). Some amount of soil loss greater than the minimum rate can occur without impairing natural soil productivity. However, when accelerated erosion exceeds a threshold, the productivity of the land is impaired and hydrologic function is altered. Reductions in vegetative canopy and/or groundcover can lead to accelerated erosion rates. Vegetative canopy cover intercepts raindrops and reduces the associated impact energies that detach soil particles and make them mobile. While the species that provide that cover are less important, not all vegetative lifeforms (e.g. bunch grass, sod grass, shrub, etc.) support soil stability to the same degree.

Vegetative groundcover includes basal area, litter, microbiotic crusts, lichens and mosses. Basal area is the area covered by tree trunks and stems of shrubs, forbs and graminoid species where they meet the ground. Effective litter includes all coarse woody and finer plant debris, a half inch or more in depth (USDA FS 1986a). Litter less than this depth is not considered effective in supporting soil stability. The distribution of litter is also important. Where litter is unevenly distributed and/or only associated with some vegetative layers, soil stability is lower than it would be if it were evenly distributed and associated with all vegetative layers (USDA FS 2012b). Microbiotic crusts can be a key component in helping hold soils in place and prevent erosion in some ecological types. On the other hand, they can also reduce infiltration rates. While these crusts exist all across the Forest to varying degrees, those with thicknesses great enough to contribute to overall soil stability are not extensive. The same can be said for lichens and mosses, except at high elevation where mosses can play a large role in soil stability after fire.

Vegetative groundcover plays a critical role in soil stability and site productivity as it also reduces the raindrop impact energy responsible for detachment of soil particles, limits the movement of detached particles and reduces the potential for concentration of surface runoff water that contributes to rill and gully erosion. Vegetative groundcover is also an indicator of nutrient cycling status.

Figure 86 displays the results of the soil loss modeling. Where departure is low, current soil loss rates are below the threshold rate. Significant departure indicates current soil loss exceeds the threshold rate.

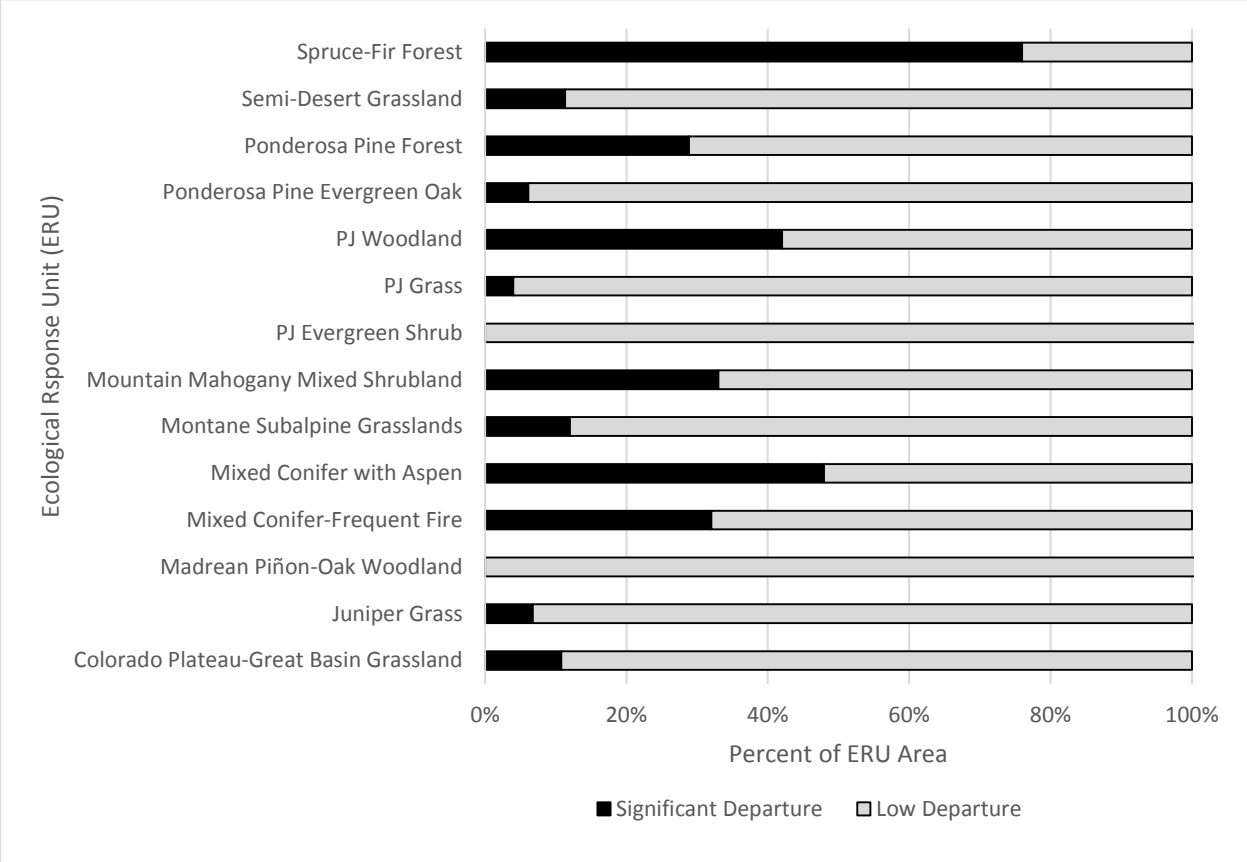


**Figure 86. Soil loss departure for Gila NF upland ERUs**

As described in the Analysis Methods, all ERUs with more than 33 percent of their area represented by TEUI units in significant departure are considered significantly departed as a whole. Those ERUs are Mixed Conifer with Aspen, PJ Woodland and Spruce-Fir Forest. While the remaining ERUs may be in low departure overall, most contain areas of significant soil loss departure.

The Spruce-Fir Forest and Mixed Conifer with Aspen ERUs are in high departure due to the large extents of high and moderate burn severities they have experienced. In the Mixed Conifer with Aspen, 76 percent of those areas in low departure have current soil loss rates within 25 percent of the threshold rate.

The reasons for significant departure in PJ Woodland, include a relatively large difference between the canopy cover of grasses between reference (more grass and litter) and current conditions (less grass and litter). Sixty three percent of those areas within the PJ Woodland that are in low departure are within 25 percent of the Threshold soil loss rate. The distribution of vegetative groundcover is also more uneven in the current condition as indicated by generally higher percentages of bare soil. Although overall departure in the PJ Grass, Juniper Grass and the grassland ERUs is low, there are areas where current soil loss rates

do exceed the Threshold rate. The differences in the canopy cover of grasses, litter and bare soil between reference and current conditions described for PJ Woodland also occur here. These differences are not offset by the higher canopy cover of trees and/or shrubs between the reference and current condition. Seventy eight percent of the PJ Grass area in low departure is represented by TEUI units with current soil loss rates within 25 percent of the Threshold rate. The equivalent percentages in Juniper Grass, Colorado Plateau-Great Basin Grassland, Montane Subalpine Grasslands, and Semi-Desert Grassland are 72, 46, 96 and 74 respectively. PJ Evergreen Shrub and Madrean Piñon-Oak Woodland are both in low departure overall and contain no TEUI units with modeled current soil loss over the Threshold rate. However, the single TEUI map unit representing the Madrean Piñon-Oak Woodland is within 25 percent of the Threshold rate, while just 25 percent of PJ Evergreen Shrub is within that range.

As previously stated the TEUI data describing the Mountain Mahogany Mixed Shrubland ERU is primarily from the Burro Mountains where historic grazing impacts on soils formed from rhyolite, andesite and very erodible granitic soils were severe and extensive and is in high soil loss departure. With 33 percent of its area represented by TEUI units that exceed the Threshold soil loss rate, this ERU sits on the threshold between low and significant departure. Eighty seven percent of those areas within this ERU that are in low departure are within 25 percent of the threshold rate. Natural recovery in this area is relatively slow as it is located at the warmer, drier end of the Forest's elevational-climatic gradient. Current grazing management has allowed for improvement in vegetative canopy and groundcover, but slows the natural rate of recovery. On the other hand, much of this ERU occurs on steep slopes within designated wilderness areas and is not described in the data.

High and moderate burn severities explain a small percentage of the departure in Mixed Conifer-Frequent Fire. Recall that the RHEM model inputs include both vegetative canopy cover by life form and vegetative groundcover. Although this ERU is not significantly departed overall, there are areas that are. Of those areas that are in low departure, 72 percent are within 25 percent of the Threshold soil loss rate. Where departure within this ERU is significant, there tends to be less canopy cover of trees and less litter associated with current conditions as opposed to the reference. For the most part, the difference is not offset by higher canopy cover of grasses. Past thinning activities explain both the lower tree canopy cover and litter. After removing trees, coarse woody debris is typically piled and burned. Coarse woody debris is also important for long-term nutrient cycling and soil productivity. The finer material can be displaced or redistributed during these activities.

Ponderosa Pine Forest and Ponderosa Pine Evergreen Oak ERUs, are in low soil loss departure overall, but both contain areas where current soil loss exceeds the Threshold rate. Thirty seven percent of the Ponderosa Pine Evergreen Oak area in low departure and 45 percent of Ponderosa Pine Forest area in low departure are within 25 percent of the Threshold rate. The previous discussion of thinning activities, and the discussion regarding the interrelationships between historic and current fire and livestock grazing management apply to both of these ERUs.

The discussion of the interrelationships between historic and current fire and livestock grazing management in the ecological status analysis also applies here. Where fire regimes are departed from historic conditions, there is a greater risk of large extents of high and moderate burn severities and accelerated erosion to occur. Drought increases this risk. Low severity fire, prescribed or natural, does not typically cause soil loss rates to exceed the Threshold and therefore serves to mitigate the risk of accelerated soil loss due to high and moderate burn severities. However, significant rill erosion has been observed post-fire in mixed conifer on some rhyolite and rhyolite ash tuff soils that experienced low severities. While current livestock management has allowed for improvements in soil condition over historic management, and range condition trends across the Forest are generally stable to slightly upward (Multiple Uses Chapter), current management does slow natural recovery.

Drought also plays a large role in both vegetative canopy and groundcover departures, particularly with regard to grass species. During periods of drought, vegetation may not be as vigorous, able to withstand disturbance, and may die, impacting both vegetative canopy cover and groundcover. The death of some grass plants has been observed in some places on the Forest over the last several years of drought. Drought stressed ponderosa pine at the southern extent of the 2013 Silver Fire that experienced low severity fire and were expected by Forest timber staff to survive, did not.

Another very important factor in soil loss departure is slope. In areas where slopes are steeper, smaller differences in vegetative canopy and groundcover are required to accelerate erosion. In areas that are relatively flat, larger difference are required to accelerate erosion. In some ERUs, a percentage of what is interpreted as departure in this analysis, is actually a reflection of natural instability. Natural instability is defined by soils where NSL rate is greater than the Tolerance, or Threshold soil loss rate. In other words, the geologic rate of soil loss is greater than the rate of soil formation. The RHEM model automatically identifies the lowest soil loss rate as the NSL (RHEM calls it "baseline"), which means that all other scenarios (current or otherwise) will be represented by a soil loss rate greater than NSL. Soil loss modeling with RHEM cannot serve as the basis on which to identify naturally unstable soils. Natural instability is due to interrelationships between bedrock composition and structure, parent material, soil texture, rock content, landform, and slope.

While slope is only one of many factors, slopes over 40 percent have been excluded from mechanical vegetation treatments on the Forest because of stability considerations. As a general rule, these slopes are also infrequently utilized by livestock. The most important disturbance regimes on these slopes are drought and fire. Roads and trails are also an important disturbance regime in some cases (USDA FS Gila NF 2013a). Approximately 29 percent of the Forest occurs on slopes 40 percent or greater. All ERUs contain some areas with slopes over 40 percent, but the largest percentages occur in the Mixed Conifer-Frequent Fire and Mixed Conifer with Aspen (>50 percent of each) and Mountain Mahogany Mixed Shrubland (65 percent). The ERU with the greatest number of acres on slopes over 40 percent are Mixed Conifer-Frequent Fire, Mountain Mahogany Mixed Shrubland and PJ Woodland. The Watershed and Soils Specialist Report for Travel Management (USDA FS Gila NF 2013a) references the General Terrestrial Ecosystem Survey, which mapped the same things at a broader scale (1:250,000) and rates 21 percent of the Forest as unsuited. However, the use of the soil loss model was the basis for that interpretation has been discontinued in favor of the RHEM model. While this information provides some idea of the extent and distribution of naturally unstable soils, natural instability cannot be identified using slope alone, or with RHEM. The protocol for delineating these areas is in the process of being updated.

Gully erosion has been documented by the TEUI in all grassland ERUs, PJ Woodland, PJ Grass, and Juniper Grass. Most of these processes were initiated as a result of historic grazing practices that are no longer practiced. However, some remain active to the current day as it takes long periods of time for natural processes to stabilize gully erosion. Just because the TEUI has not documented gully erosion in other ERUs does not necessarily mean they do not exist. In fact, gully erosion (as well as hillslope failure) is known to occur in recent high and moderate burn severities within the mixed conifer. Gully erosion is not used to modify the results of the modeling analysis, but is considered in the analysis of soil condition that follows.

### Soil Condition

As described in the Analysis Methods subsection, the soil condition characteristic relies on USDA Forest Service Southwestern Regional guidance (USDA FS 2012b) which rates soils as satisfactory, impaired or unsatisfactory based on hydrologic, stability and nutrient cycling functions. Departure is a direct interpretation of the soil condition rating with satisfactory ratings being low departure, impaired ratings

being moderate departure and unsatisfactory ratings being high departure. Current soil conditions aggregated to the ERUs are displayed in Figure 87.

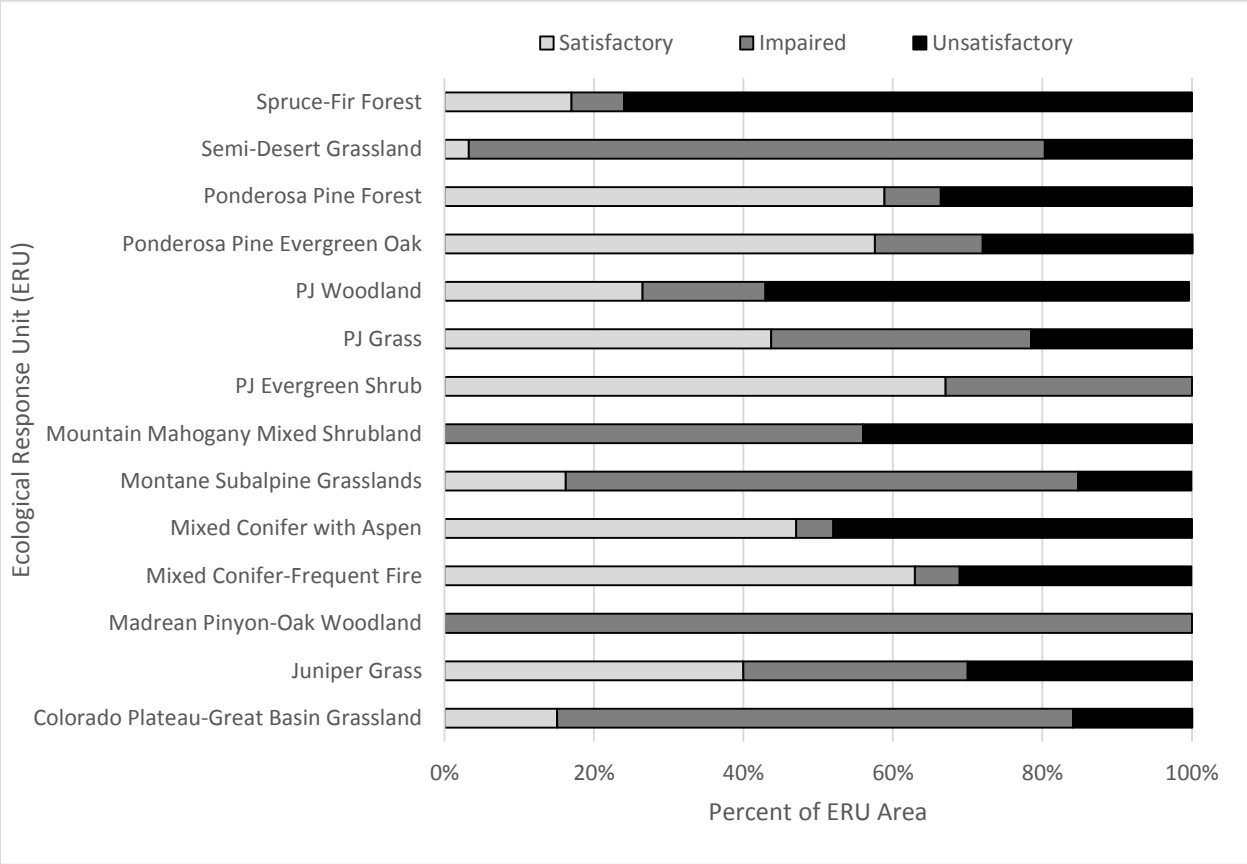


**Figure 87. Current soil condition across the Gila NF's upland ERUs**

Spruce-Fir Forest and Mixed Conifer with Aspen are in high departure overall with reductions in hydrologic, stability , and nutrient cycling functions for the same reasons discussed in the ecological status and soil loss analyses. PJ Woodland is also in high departure. Documentation of visible erosion, including gully erosion, deposition, and pedestalling of grasses not reflected in the soil loss analysis, as well as zootic disclimaxes. Zootic disclimax states can occur under sustained or periodic use of vegetation by wild or domestic animals. Under such conditions vegetation can depart markedly in the structure and composition of the natural vegetation community under late seral conditions (USDA FS 1986a). There is also documentation of these conditions in the grassland and shrubland ERUs, which are in moderate departure overall. Additionally, there is documentation of reductions in hydrologic function as a result of compaction in the Semi-Desert Grassland, which does not experience the same amount of freeze-thaw action as the other grasslands do. Freeze-thaw action is a natural process that breaks up compaction. That said, compaction has been observed in other grassland systems, often on Vertisols or on vertic intergrades (see Soil Diversity and Distribution). With respect to the Madrean Piñon-Oak Woodland which is also in moderate departure, visible erosion was observed within portions of the ERU during 2014 TEUI field reviews. The remaining ERUs may be in low departure overall, but all contain areas of moderate and high departure. Again, the factors contributing to these departures have been discussed.

The soil condition indicator of the watershed condition classification (see Water Chapter) considers attributes of soil erosion, productivity (nutrient cycling and hydrologic function) and contamination at a

subwatershed scale (Potyondy and Geier 2011). Although the risk of soil contamination, as represented by the soil contamination attribute, is not reflected using the Regional soil condition guidance (USDA FS 2012b), it does merit discussion. Contamination has been identified as an issue in approximately 38 percent subwatersheds with the risk of atmospheric deposition of nutrient nitrogen and/or acidic compounds being cited as the reason in most cases. Deposition of nutrient nitrogen can alter natural soil fertility which can affect plant growth, species composition, and above and below ground biodiversity. All of these can contribute to long-term alteration of nutrient cycling.

The data available for the Gila (period of record 1985-2012) shows nitrogen deposition rates have held constant. However, critical loads have only been developed for lichens on the Gila NF. Critical loads are the amount of atmospheric pollutant deposition below which no harmful ecological effects occur. No exceedances have been recorded for acid deposition. Atmospheric deposition and critical loads are discussed further in the Air Chapter.

In general, soils in the Southwest have a high capacity to withstand changes in pH and the risk of increased acidity is low. More information about atmospheric deposition can be found in the Air Chapter. On a subwatershed basis, old mines are associated with the second most common risk of soil contamination (8 percent), and leaky underground fuel tanks and old landfills accounting for one percent each.

## Risk

Risk is assessed by ERU for ecological status and soil condition using the matrix displayed in Table 94, followed by Table 95 which displays the risk matrix for soil loss.

**Table 94. Risk matrix for soil resource characteristics**

| Departure from Reference Condition | Trend | | |
|---|---|---|---|
| | Toward Reference | Unknown or Static | Away From Reference |
| High | Moderate Risk | High Risk | Very High Risk |
| Moderate | Low Risk | Moderate Risk | High Risk |
| Low | No Risk | Low Risk | Moderate Risk |

**Table 95. Risk matrix for soil loss**

| Departure from Reference Condition | | |
|---|---|---|
| Moderate or High | High Risk | |
| Low | >75 percent of low departure ERU area within 25 percent of Threshold soil loss rate | Moderate Risk |
| | <75 percent of low departure ERU area within 25 percent of Threshold soil loss rate | Low Risk |

To assess risk at the Forest and local unit scales, ERU risk ratings are area weighted to the Forest or local unit boundary and the risk rating representing the largest percentage of that area is assigned. ERU, Forest and local unit risk is summarized in Table 96.

**Table 96. Risk summary for key characteristics of soil.**

| ERU Name | Ecological Status Risk Rating | Soil Loss Risk Rating | Soil Condition Risk Rating |
|---|---|---|---|
| Colorado Plateau-Great Basin Grassland | Moderate | Low | Moderate |
| Juniper Grass | Moderate | Low | Low |
| Madrean Piñon-Oak Woodland | Moderate | Moderate | Moderate |
| Mixed Conifer-Frequent Fire | Moderate | Low | Low |
| Mixed Conifer with Aspen | High | High | High |
| Montane Subalpine Grasslands | Moderate | Moderate | Moderate |
| Mountain Mahogany Mixed Shrubland | Moderate | Moderate | Moderate |
| PJ Evergreen Shrub | High | Low | Low |
| PJ Grass | Moderate | Moderate | Low |
| PJ Woodland | Moderate | High | High |
| Ponderosa Pine Evergreen Oak | Low | Low | Low |
| Ponderosa Pine Forest | Moderate | Low | Low |
| Semi-Desert Grassland | Moderate | Low | Moderate |
| Spruce-Fir Forest | High | High | High |
| **Gila NF** | Moderate | Low | Low |
| **Local Units** | | | |
| Apache | Moderate | Low | Low |
| Little Colorado Headwaters-San Agustin Fringe | Moderate | Low | Low |
| Mogollon Front | Moderate | Low | Low |
| Black Range | Moderate | High | High |
| Upper Gila | Moderate | Low | Low |
| Lower Gila | Moderate | Low | Low |

There is always some degree of risk as a result of management action or inaction. For ecological status, patterns of risk at the ERU scale follow patterns of departure, which is reflected at the Forest and local unit scales. That said, the uncertainty associated with ecological status departure previously discussed, translates to the same uncertainty being associated with risk. .

High soil loss and soil condition risk occurs in the Spruce-Fir Forest, Mixed Conifer with Aspen and PJ Woodland ERUs. In Spruce-Fir Forest and Mixed Conifer with Aspen, which also have a high ecological status departure, this is due to the large extents of high and moderate burn severities these ERUs have experienced in recent years. Negative impacts to the soil stability and hydrologic function have been widespread. While high and moderate burn severities may accelerate nutrient cycling short-term as complete or nearly complete consumption of biomass releases nutrients that were previously unavailable, long term nutrient cycling is not necessarily enhanced and may be negatively impacted given the large extent of these burns. Biomass consumed is no longer available to support long-term productivity. It is not the severity of the burn that is uncharacteristic of these ERUs, rather the number of contiguous acres affected. Since 2000, 83 percent of the Spruce-Fir Forest and 60 percent of the Mixed Conifer with Aspen has seen these stand replacement type fires, most of this occurring in the Gila and Aldo Leopold wilderness areas. Approximately 65 percent of the Mixed Conifer with Aspen and 82 percent of the Spruce-Fir Forest are located within designated wilderness areas.

All of the management activities that could be justified to reduce current risk of erosion and protect soil productivity and hydrologic function have been completed as part of Burned Area Emergency Response emergency watershed stabilization activities. Over time, soil functions will return to these systems, however they may not recover to pre-fire conditions for hundreds of years. This depends on the degree of soil loss that occurs. Subsurface soil layers have different hydrologic properties than does topsoil. Climate change is a major stressor that elevates risk to all characteristics analyzed for the soil resource (see System Drivers and Stressors Chapter). These two high elevation ERUs have the highest vulnerability to climate change on the Forest. Climate change vulnerability represents the likelihood of an ecological type conversion (e.g. Spruce Fir Forest to Montane Subalpine Grassland or mixed conifer). Spruce Fir Forest and Mixed Conifer with Aspen are then at very high risk. While management does not have the ability to control or influence climate or climate change, it does have the ability to influence the risk to ecological status, soil loss and overall soil condition in the small percentage of these forests that remain in a late successional stage. It also has the ability to influence fire frequency in those areas that are now in early successional stages.

The PJ Woodland risk is the primary reason why the Black Range local unit has a high soil loss and soil condition risk as it makes up 50 percent of this local unit. However, some of this higher risk is likely associated with slope, one of the factors in natural soil instability, as this local unit is largely comprised of steep and rugged terrain. Recall that PJ Woodland is ERU with the fourth largest percentage of its area on slopes over 40 percent, with only the mixed conifer ERUs and Mountain Mahogany Mixed Shrubland containing higher proportions of these slopes. Parent material also plays a strong role in natural soil stability, on flat or steep terrain. Soils formed from volcanic sediment, granite, tuff, many rhyolites and conglomerates, as well as sandstone and shale can be highly erodible if vegetative groundcover is not maintained. PJ Woodland occurs on all of these parent materials.

While soil loss risk is generally low across the Forest, it is moderate in the Madrean Piñon-Oak Woodland, PJ Grass, Mountain Mahogany Mixed Shrubland and Montane Subalpine Grasslands. Although departure is characterized as low based on the higher percentage of soil loss rates that do not exceed Threshold rates, most current rates are within 25 percent of the Threshold. The closer soil loss rates are to the Threshold, the greater the risk current and future management activities that reduce vegetative canopy and ground cover might have. This provision in the assessment of soil loss risk is the reason why PJ Grass

has a lower risk to soil condition than it does to soil loss. The soil condition risk assessment does not have the same sensitivity.

Moderate risk in the Madrean Piñon-Oak Woodland is influenced by the parent material, increasing the importance of maintaining adequate vegetative cover in current and future management activities in this ERU. Provisions for soil stability, as well as hydrologic and nutrient cycling functions are typically made at the project level (i.e. Soil and Water Conservation Practices or Best Management Practices). Parent material is also a factor contributing to soil loss risk in the Mountain Mahogany Mixed Shrubland where it occurs on granite, but lower vegetative groundcover between the reference and current condition is the primary management consideration in this ERU, as is the case in the Montane Subalpine Grasslands and PJ Grass.

Soil condition risk is associated with both historic and current fire and livestock grazing management as described throughout this chapter. All management activities that impact vegetation, impact the soil resource and vice versa. Competition between the restoration of fire adapted ecosystems and current livestock grazing is a factor contributing to risk as the herbaceous understory vegetation that provides forage, is also the fine fuels needed to carry fire and the organic material contributing to soil stability, hydrologic and nutrient cycling functions. Moving toward the historic fire regime, particularly increasing low severity fire, mitigates the risk of high and moderate burn severities and negative impacts to the soil resource. While current livestock grazing management has allowed for improvements over historic management and resource conditions, it slows the rate of natural recovery that might be expected in the absence of this stressor.

Non-fire vegetation treatments (e.g. fuelwood or timber harvest) have been conducted in most ERUs to restore both vegetation structure and composition (ecological status), although most occur in the Ponderosa Pine Forest, Ponderosa Pine Evergreen Oak, Mixed Conifer-Frequent Fire and PJ Woodland (see Multiple Uses Chapter). These activities have been fairly limited due to budget, staffing levels and Regional priorities, but could foreseeably increase with increasing emphasis on landscape scale restoration. Mechanical treatments such as these can have a large impact on soil hydrologic, stability and nutrient cycling status, depending on a variety of factors including but not limited to: soil clay and moisture content, temperatures during treatment and time between entries (for maintenance treatments). Slope restrictions and other measures or methods designed to reduce impacts to the soil resource and protect water quality are recommended and implemented at the project level. However, without restoring ecological processes, like fire, these treatments require maintenance. Re-entry increases the risk to soil functions. Re-entry time could be increased, therefore decreasing the risk of negative impacts to the soil resource with the use of herbicides. Under current plan direction, these vegetation treatments are generally driven by single species wildlife habitat management concepts (e.g. goshawk or Mexican spotted owl), old growth management emphasis or hazardous fuels objectives, and not Terrestrial Ecological Unit or Ecological Response Unit concepts.

Natural cycles of drought are a significant risk factor that Forest management does not have the ability to control. Management can only adapt by preparing for and responding to drought. A moderate or greater vulnerability to climate change raises these risk ratings one level (e.g. low becomes moderate) which is the case for all ERUs, the Forest and each local unit. It also increases the importance of monitoring key ecosystem characteristics in an adaptive management strategy.

Additionally, while the best available science utilized in this assessment is based multiple corroborating lines of evidence, a need for a wider spectrum of reference condition datasets across environmental gradients has been identified in General Technical Reference (GTR)-310 (Reynolds et al. 2013). Return intervals are described by vegetation type (see Upland Vegetation Chapter) and only indirectly account for soil, slope, elevation, aspect, topography and local climate variability within those vegetation types. All of

these things have been directly or indirectly identified as important variables in pre-settlement fire regimes and in some cases, more important than vegetation type (Abolt 1997; Baisan and Swetnam 1990; Rollins et al. 2000; Parks et al. 2015). While such information would generate too fine-scale a portrait for use in forest plan revision, these local data are available in the form of the TEUI and can be used to guide project-level planning in the future.

## Data Needs

The Forest does need a completed TEUI product. Barring that, going forward from assessment into revision may require additional interpretations be developed from the draft TEUI data. These include, but are not limited to erosion hazard,[30] threshold vegetative cover and naturally unstable soils (formerly referred to as unsuited). These interpretations in concert with monitoring data, would be more informative about current and future risks to the sustainability of the soil resource and the influence of Forest management. Some existing protocols to develop these interpretations are not compatible with the RHEM model. Updated protocol is being developed, but work is not complete.

The TEUI data are point in time measurements. Repeat measurements associated with monitoring would give the Forest a better idea of trends and the effectiveness of management activities. However these data are most informative when tiered to a finished TEUI product. Some potentially efficient and effective monitoring protocols cannot be used without a completed TEUI.

## Stakeholder Input

Soil erosion and soil health are a concern to the Gila NF stakeholders. From input received during the assessment, the importance of soil stability and productivity to overall watershed condition, water quantity and quality and infrastructure were topics of concern. Observations concerning erosion related to wildfires, livestock grazing, recreation and motorized travel were common.

Some would like the Forest to take a more proactive approach to protect soil and watershed resources with more prescribed fire. Others are more concerned about motorized travel and the condition of the road system. A few were very concerned about soil health at and around recreational facilities. Some community members suggested that the construction of erosion control structures, and more road maintenance should be a priority. There are some that question the presence and numbers of cattle on the Forest, especially in riparian and areas of high erosion and would like this reassessed. These community members do not believe that adaptive livestock management has been successful. In general, the public perceives that the Gila NF is not demonstrating great enough concern for the soil resource. Some also pointed to the need for a completed and useable TEUI product.

## Summary

This assessment reviews the best available soils information at the Ecological Response Unit (ERU), Forest and local unit scales to explore the ability of the area's upland soils to sustain the key ecosystem services it provides under current Forest Plan direction. These ecosystem services are the product of soil hydrologic, stability and nutrient cycling functions reflected by key characteristics that include: ecological status (vegetation composition), soil loss and condition.

Soil hydrologic, stability and nutrient cycling can be defined and assessed individually, but are interrelated and inseparable on the ground. Soil condition represents the summation of these functions and relationships, while the other characteristics indicate specific issues. Departure and risk under current climate and management varies from low to high across the Forest's ERUs, but is generally low at the

[30] Erosion hazard describes the relative magnitude of accelerated soil loss should all vegetative groundcover be removed in terms of slight, moderate or severe ratings.

Forest and local unit scales. However risk is elevated by climate change (e.g. an increase from low to moderate risk).

Because of the relationships between climate, soil and vegetation, every management activity that is implemented, or not, influences soil condition. The causal factors of departure from the reference condition, which also contribute to risk, vary by ERU. However climate, climate change and the interrelationship between historic and current fire and livestock grazing management are the primary themes. Future risk due to non-fire vegetation treatments are expected to increase with the increasing emphasis on landscape scale restoration. This risk can be mitigated by Forest management, both at the plan and project level.

While climate change is beyond the control of Gila NF management, opportunities exist for the Forest to manage ecological outcomes and risk with regard to the soil resource. These opportunities can be defined through better understanding and integration of watershed, ecological and fire management strategies and objectives, as well as consistent, efficient and effective monitoring designed to document outcomes and assess the effectiveness of management actions relative to key soil characteristics.

# Chapter 5. Air

## Introduction

Air quality has long been recognized as an important resource. The 2012 Planning Rule requires national forests and grasslands to consider air quality when developing the revised plan. The purpose of this assessment is to evaluate the best available scientific information regarding current conditions and trends in air quality, and to project future conditions on and affecting the Gila NF. This will provide the basis for the evaluation of risk at the conclusion of this chapter. Additionally, this assessment will identify information gaps and disclose any uncertainty associated with the data.

This chapter includes the following components:

- Airsheds relevant to the plan area
- Location and extent of known sensitive air quality areas
- Federal, state and tribal governmental agency implementation plans for regional haze or sensitive air quality areas
- Emission inventories
- Ambient air quality
- Visibility
- Atmospheric deposition
- Public input received during the assessment relevant to air quality
- Summary of conditions, trends and risk

## Ecosystem Services of Air

Air resources on the Gila NF provide many ecosystem services from which society benefits or enjoys. Air, much like water, is necessary for the existence of life by supplying oxygen for respiration and carbon dioxide for photosynthesis. It provides both supporting ecosystem services as it contributes to primary production, nutrient cycling and soil formation; thereby contributing to provisioning services derived as fuelwood, fiber and food, such as meat from game and livestock. The chemical constituents of air provide regulating services as it influences climate and the water cycle. It also supplies cultural ecosystem services to society as the fresh air and sweeping views that high quality air provide are very much a part of the recreational value and personal enrichment experiences provided by National Forest System lands.

## Data

Emissions data used in this analysis comes from the Western Regional Air Partnership and can be found at the Intermountain West Data Warehouse website at http://views.cira.colostate.edu/tsdw/. The Partnership represents voluntary collaboration between states, tribes, federal land managers and the Environmental Protection Agency (EPA). This data represents an aggregation of county emissions for those counties included in the relevant airshed and the Mexican states of Sonora and Chihuahua. Additional data for analyzing ambient air quality, visibility and atmospheric deposition were taken from state and federal monitoring stations in and near the Gila NF. These stations are identified in Figure 88. Site labels in Figure 88 and the data from each station are described in Table 97.

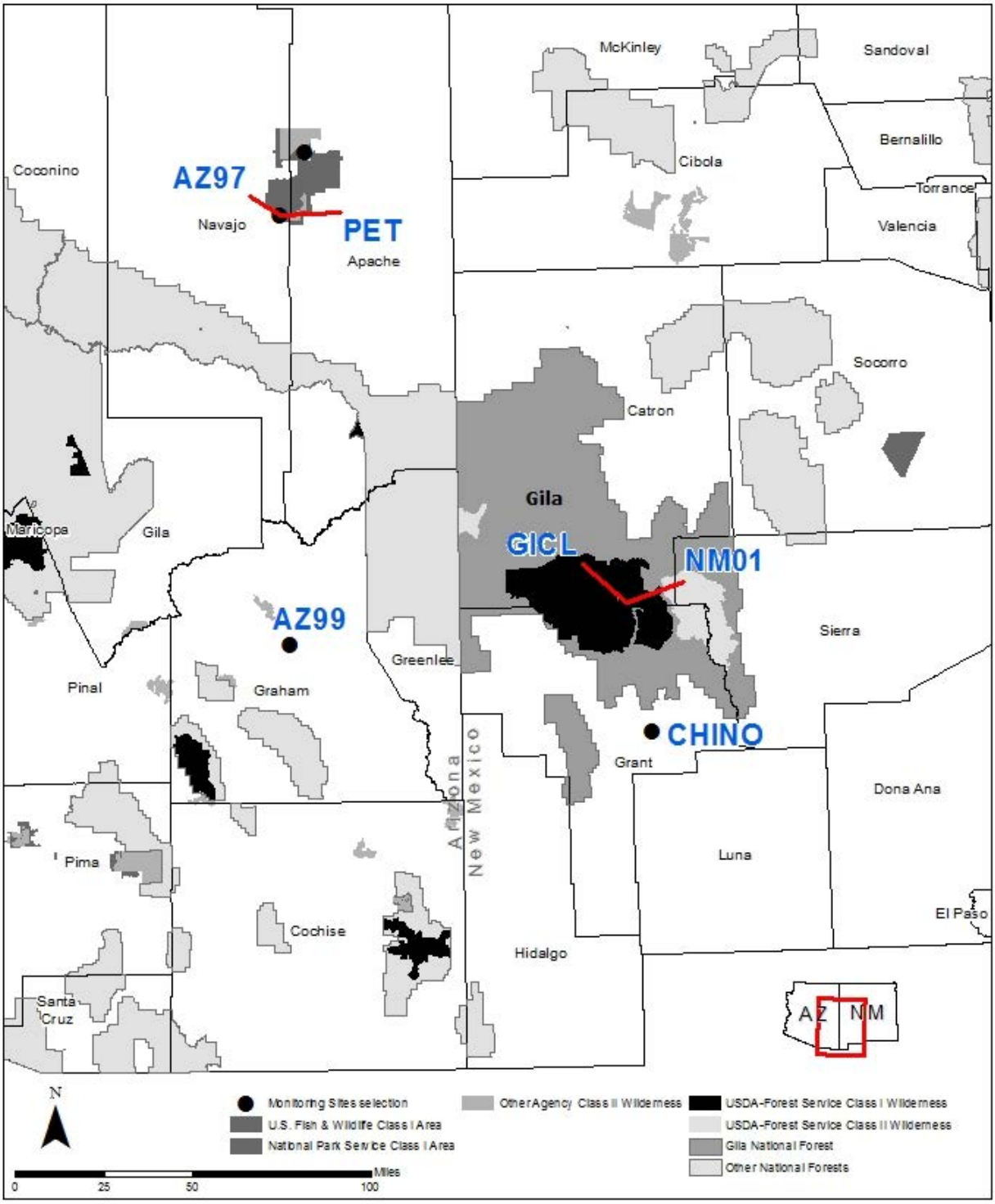


**Figure 88. Air quality monitoring sites relevant to the Gila airshed**

**Table 97. Characteristics of air quality monitoring sites relevant to the Gila airshed**

| Monitoring Site | Site Label | Pollutants Monitored and Period Reviewed[1] |
|---|---|---|
| Chino Copper Smelter | CHINO | $O_3$ (2005-2014)[2], $PM_{10}$ (2009-2014)[3], $SO_2$ (2000-2014)[4] |
| Gila Cliff Dwellings | GICL, NM01 | IMPROVE Aerosol, dv (1995-2014)[5], NADP/NTN (1985-2012)[6] |
| Oliver Knoll | AZ99 | NADP/NTN (1982-2014), |
| Petrified Forest National Park | PEFO-AQ , AZ97, PET427 | NADP/NTN (2002-14), CASTNET (2003-2013)[7] |
| Chiricahua National Monument | AZ98 | NADP/NTN (1999-14), CASTNET (1990-2013) |

[1]For this assessment, only measurements collected in and after the year 2000 were reviewed.

[2]$O_3$ is ozone

[3]$PM_{10}$ is coarse particulate matter

[4]$SO_2$ is sulfur dioxides

[5]IMPROVE Aerosol refers to a monitoring system that was put in place by the Interagency Monitoring of Protected Visual Environments. The system measures concentrations of atmospheric aerosols, such as sulfates and nitrates, and uses the data to assess the degree to which light is absorbed and/or scattered by air pollution. "dv" is a unit of measure that describes change in visibility conditions perceptible to the human eye.

[6]NADP refers to the National Atmospheric Deposition Program. NTN refers to the National Trends Network

[7]CASTNET is a monitoring system of the National Trends Network which collects data related to nitrogen and sulfur deposition. The Network operates these stations in cooperation with the National Park Service.

## Airsheds

Airsheds are similar to watersheds in that they are defined geographic areas that are frequently affected by the same air mass because of topography, weather patterns and/or climate. The difference is that air masses and air pollutants move between airsheds based upon larger weather and/or climatic patterns, whereas surface water does not naturally move between watersheds. As with watersheds, airsheds can be defined at multiple scales. This assessment defines the relevant airshed as the area within 300 kilometers (186.4 miles) of the Gila NF. This airshed was chosen because it is consistent with the area typically considered relevant during effects analysis and for some permitting requirements under the Clean Air Act. It includes most of Arizona and New Mexico, as well as portions of three Texas counties and the Mexican states of Sonora and Chihuahua as displayed in Figure 89. This area is hereafter referred to as the Gila airshed.

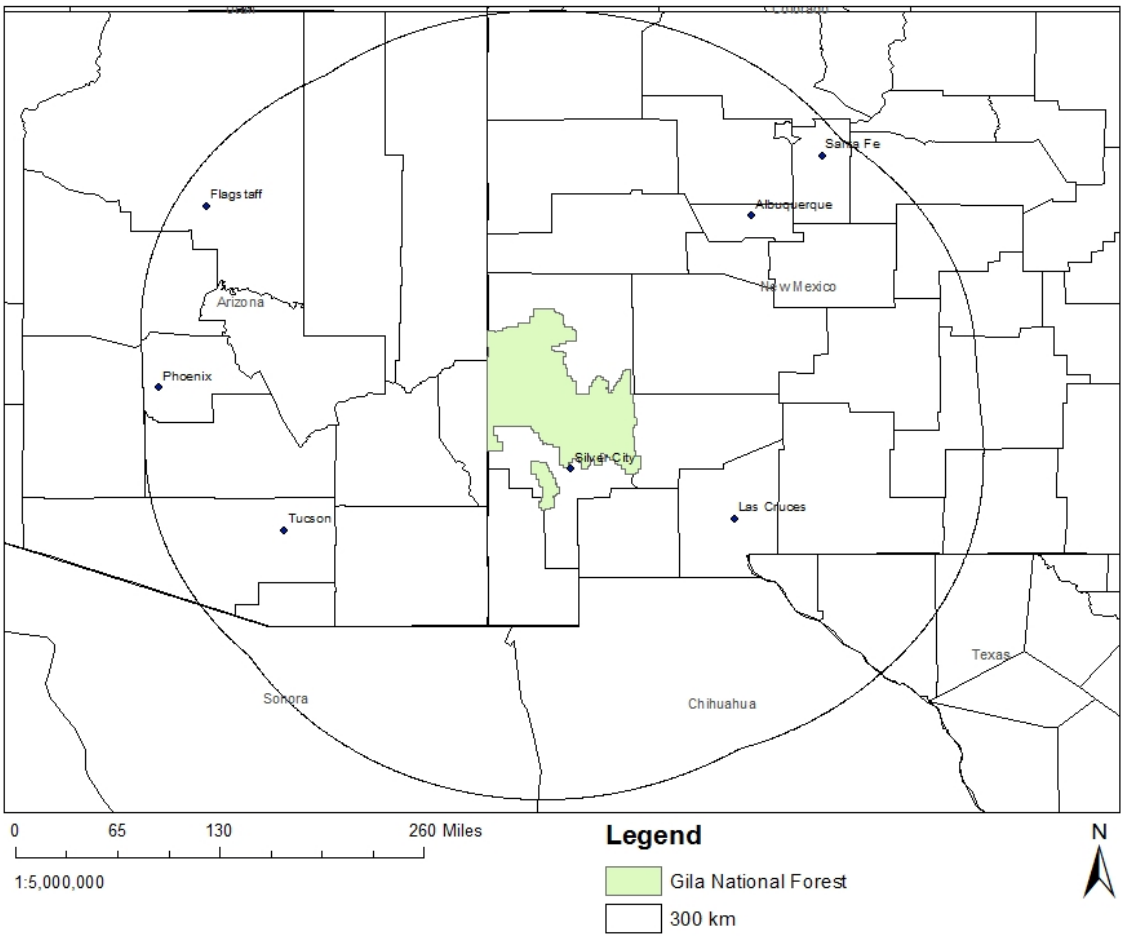


**Figure 89. Airsheds and Counties relevant for Gila National Forest**

## Sensitive Air Quality Areas

Sensitive air quality areas include Class I, Class II, non-attainment and maintenance areas. Class I areas are designated within the Clean Air Act as deserving the highest level of air quality protection. These areas include, but are not limited to wilderness areas over 5,000 acres. The Gila Wilderness is a Class I area. Class II areas are also designated within the Clean Air Act but are subject to somewhat less stringent protection. Class I and II areas within New Mexico and Arizona are displayed in Figure 90.

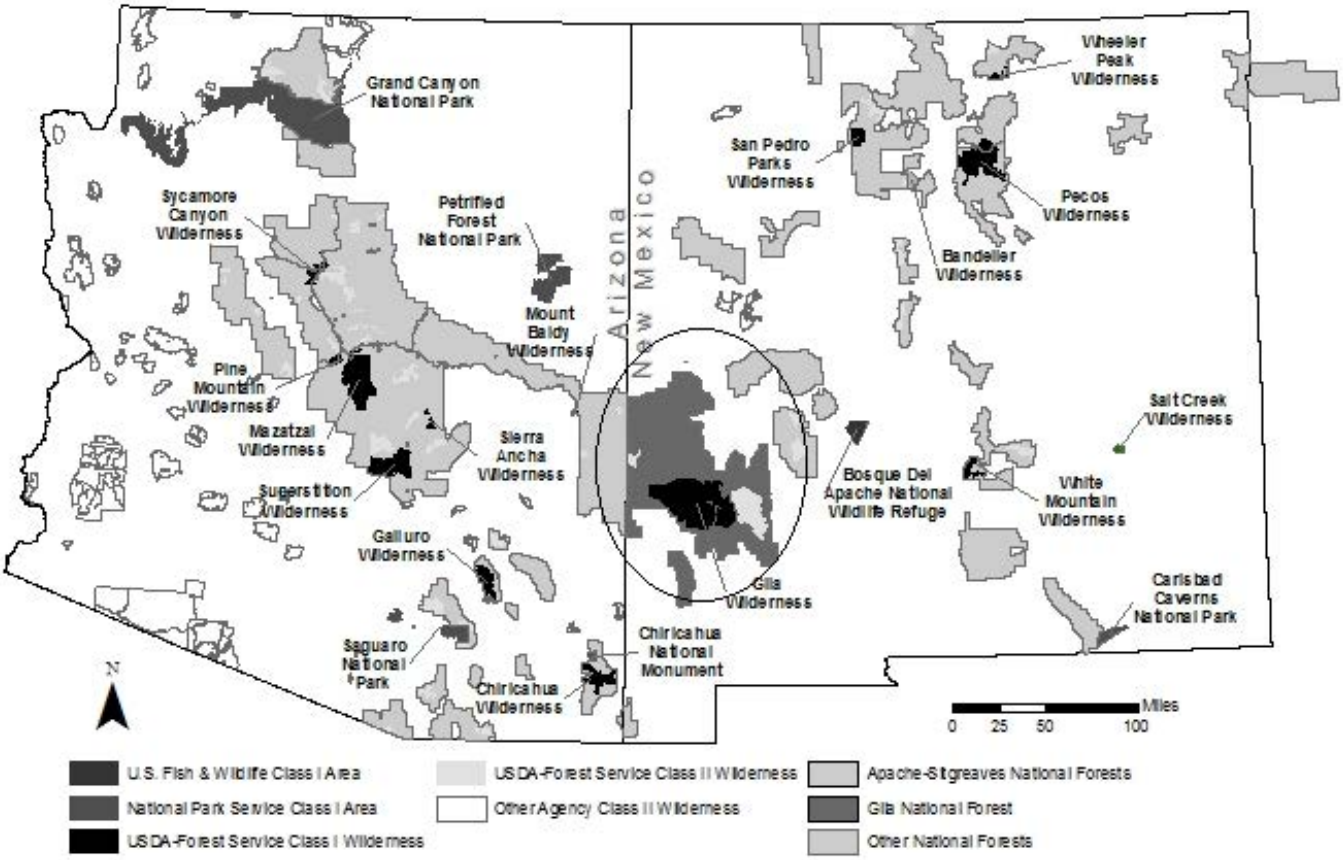


**Figure 90. Class I and II Areas in New Mexico and Arizona.**
**The circle indicates the location of the Gila NF**

Non-attainment areas are those areas that are not meeting the National Ambient Air Quality Standards (NAAQS) established by the EPA. The states are delegated the primary responsibility for air quality management except on tribal lands, on which the tribal government maintains primary responsibility. States may develop their own air quality standards, provided that they are at least as restrictive as the national standards. New Mexico Ambient Air Quality Standards (NMAAQS) include standards for total suspended particulate matter (TSP), hydrogen sulfide and total reduced sulfur for which there are no national standards. The NAAQS and NMAAQS are included as Appendix C. Maintenance areas are former non-attainment areas that are now meeting air quality standards. At the present time, there are no non-attainment or maintenance areas within the plan area.

## Federal, State, and Tribal State Implementation Plans

The federal Clean Air Act provides the basic framework for controlling air pollution, but as stated previously, the states or tribes are delegated the primary implementation and enforcement responsibility. Typically, air pollution generated outside National Forest System lands is the primary concern for impacts within the national forests and grasslands. The framework of the Clean Air Act provides tools relevant to protecting air quality in pristine areas from both new and existing sources of pollution.

The Prevention of Significant Deterioration (PSD) permitting program was established in 1977 to preserve the clean air usually found in pristine areas while allowing for economic growth. Its purpose is to prevent violations of NAAQS and protect air quality and visibility in pristine areas. Under this program, new major sources of air pollution or modifications to existing major sources of pollution may be required to assess

the impacts of pollution on soil, water, vegetation and visibility of lands managed by the Forest Service. Unless specific issues arise, individual national forests and grasslands are not generally responsible for conducting PSD reviews. Forest Service involvement and environmental analysis are provided for at the regional level. Ultimately, the Forest Service can dispute the terms of a permit if analyses demonstrate unacceptable impacts could occur in Class I and II areas.

For existing sources of air pollution, the 1999 federal Regional Haze Rule (RHR) requires states to develop programs to assure reasonable progress toward meeting the national goal of preventing any future visibility impairment in Class I areas, and remedying any existing impairments. The RHR includes requirements for State Implementation Plans (SIPs) and revisions thereof, as well as period progress reviews. It also includes a provision for New Mexico, and other western states, to incorporate recommendations for emission reduction strategies developed by the Grand Canyon Visibility Transport Commission (GCVTC) designed to improve visibility in the 16 Class I areas on the Colorado Plateau.

The GCVTC was established in a 1990 amendment to the Clean Air Act. The commission released its final report in 1996 and initiated the Western Regional Air Partnership (WRAP), a partnership of state, tribal and federal land management agencies. The WRAP was created to help coordinate implementation of the GCVTC recommendations related to: air pollution prevention, clean air corridors, stationary and mobile sources, road dust, emissions from Mexico, fire and areas in and near parks and wilderness areas.

Since the RHR was established, the New Mexico Environment Department (NMED) has been working to establish a SIP consistent with the RHR, and GCVTC and WRAP recommendations. This process has included multiple EPA reviews, litigation and revisions. In 2012, the EPA approved NMED SIP submittals with the exception of one component. This SIP component relates to San Juan Generating Station77 and is what resulted in the litigation. The approved SIP components included Forest emissions estimates as appropriate.

The Gila NF complies with Clean Air Act, RHR and New Mexico State Smoke Management Program, as required under the approved SIP. This program includes requirements for burn registration, notification of local communities and the state of the burn date(s), visual tracking and post-fire reports for all prescribed fire or managed wildfires greater than 10 acres (NMED 2011).

## Emissions

This section presents current and historical data related to emissions in the Gila airshed. Emissions information is important because adverse air quality impacts on the Forest can usually be traced back to emissions. Emissions inventories are created by quantifying the amount of pollution that comes from point and area sources. Point sources include power plants and factories. Area sources include automobile emissions and wildfires. Pollutants originating from area sources may be related to human activities, or be biogenic in nature. Biogenic sources include those originating from the natural biological processes of vegetation and soil microbes. Many pollutants emitted to the atmosphere are involved in chemical reactions following their release. Many of the compounds that are produced from these reactions are also pollutants. The original pollutants can therefore be thought of as precursor pollutants and are useful in projecting future trends. In fact, emissions data are the basis upon which air quality trends are determined in this assessment.

Baseline emissions from 2011 and projected emissions for 2020 were summarized for the following pollutants: carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds (VOCs), and particulate matter. All of these pollutants except VOCs have health based standards. VOCs are included because VOCs and nitrogen oxides are precursors to the formation of ozone, which effects both human and ecosystem health. VOCs are carbon based chemical compounds that evaporate easily, like acetone or

gasoline. Because health related impacts of particulate matter depend on particle size, particulate matter is described in terms of coarse (CPM) and fine (FPM). FPM represents particulate matter emissions at or below 2.5 microns in diameter and has greater health related impacts as it is more easily inhaled into the lungs. CPM represents particulate matter emissions greater than 2.5 but not more than 10 microns. Figure 91 through Figure 96 compare the emissions summaries for the Gila airshed by source for the identified pollutants between the 2011 baseline period and 2020 projections.

**Figure 91. Baseline and projected carbon monoxide emissions**

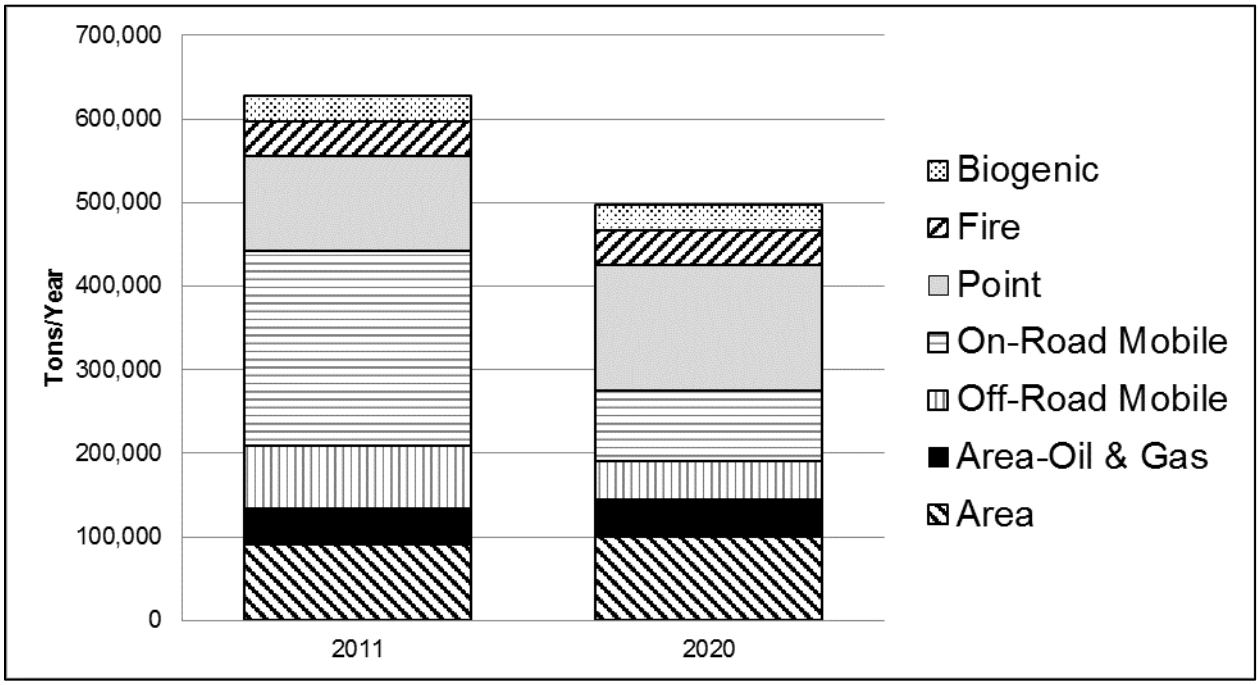


**Figure 92. Baseline and projected emissions of nitrogen oxides**

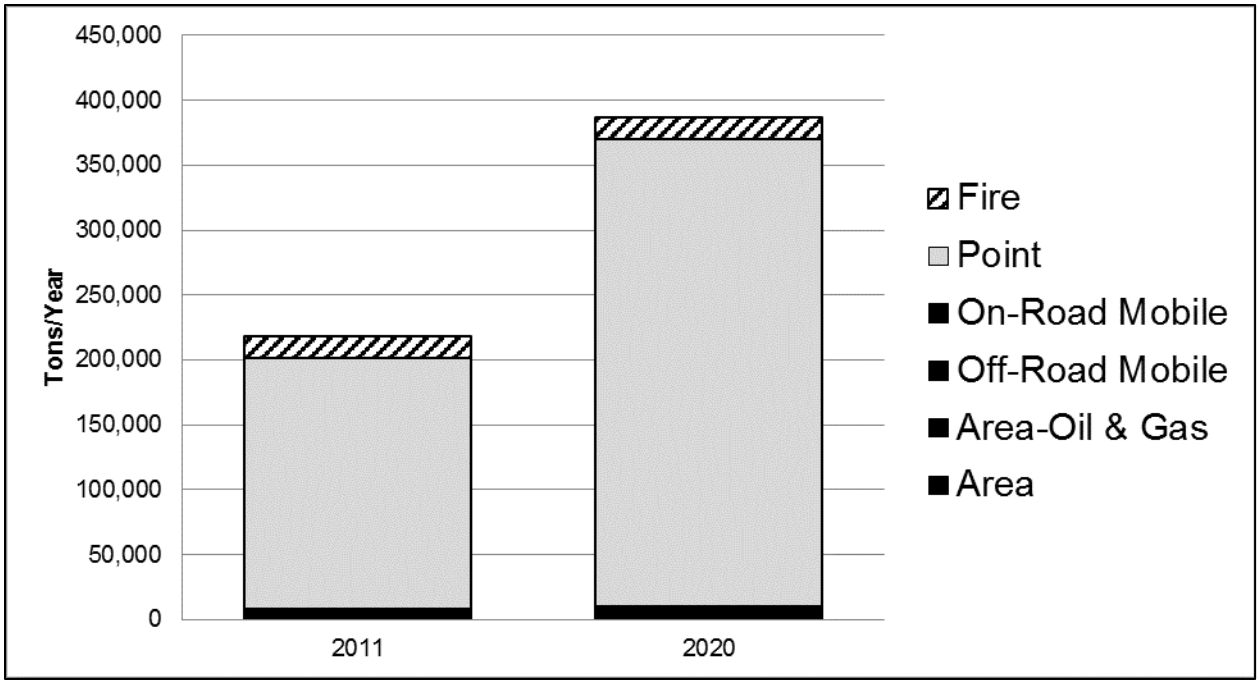


**Figure 93. Baseline and projected sulfur dioxide emissions**

Note: On and off road mobile, area-oil and gas and area categories are combined because they represent a proportion too small to be differentiated in the graph.

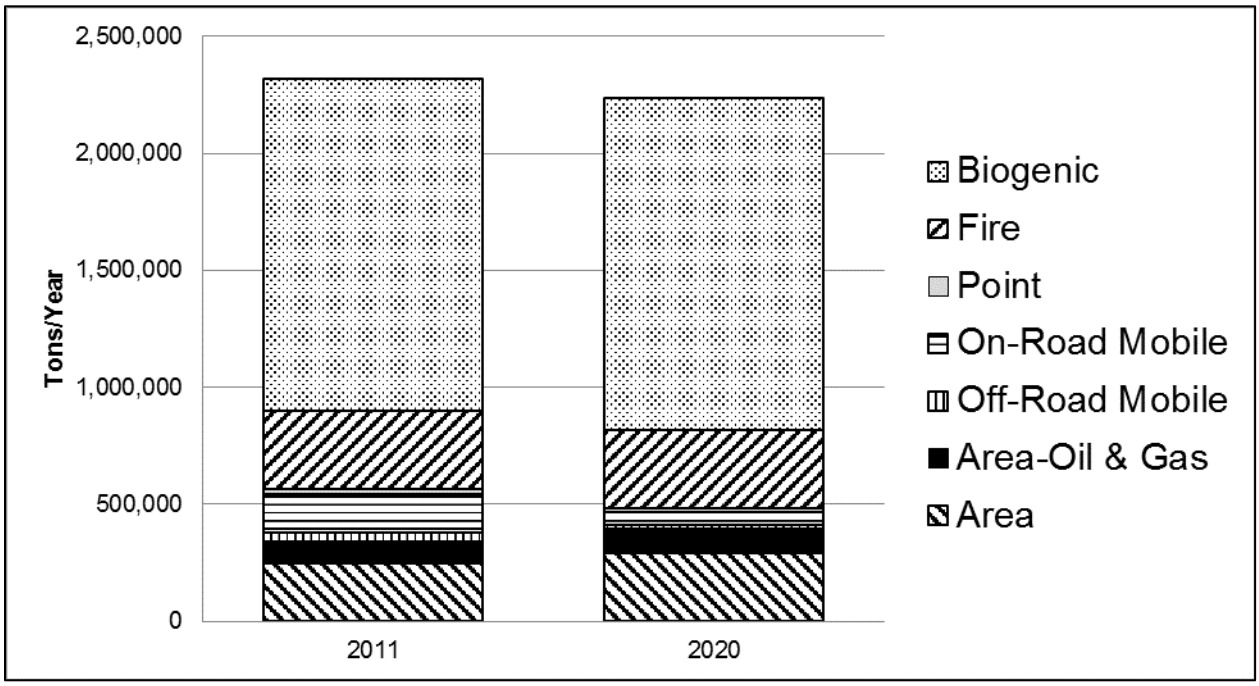


**Figure 94. Baseline and projected VOC emissions**

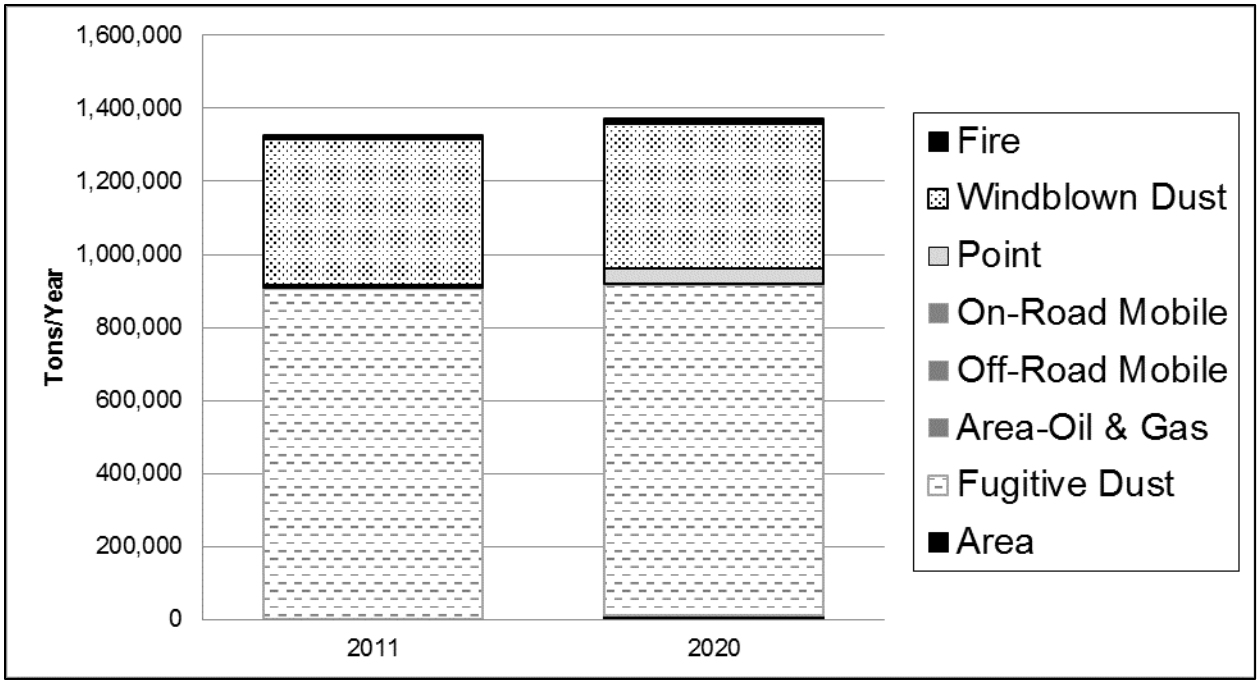


**Figure 95. Baseline and projected coarse particulate matter emissions**

Note: Fire is the black at the top of the column. Area is the black at the bottom of the column. On and off road mobile and area-oil and gas are combined with the same symbol because they make up a proportion of the total too small to differentiate between them.

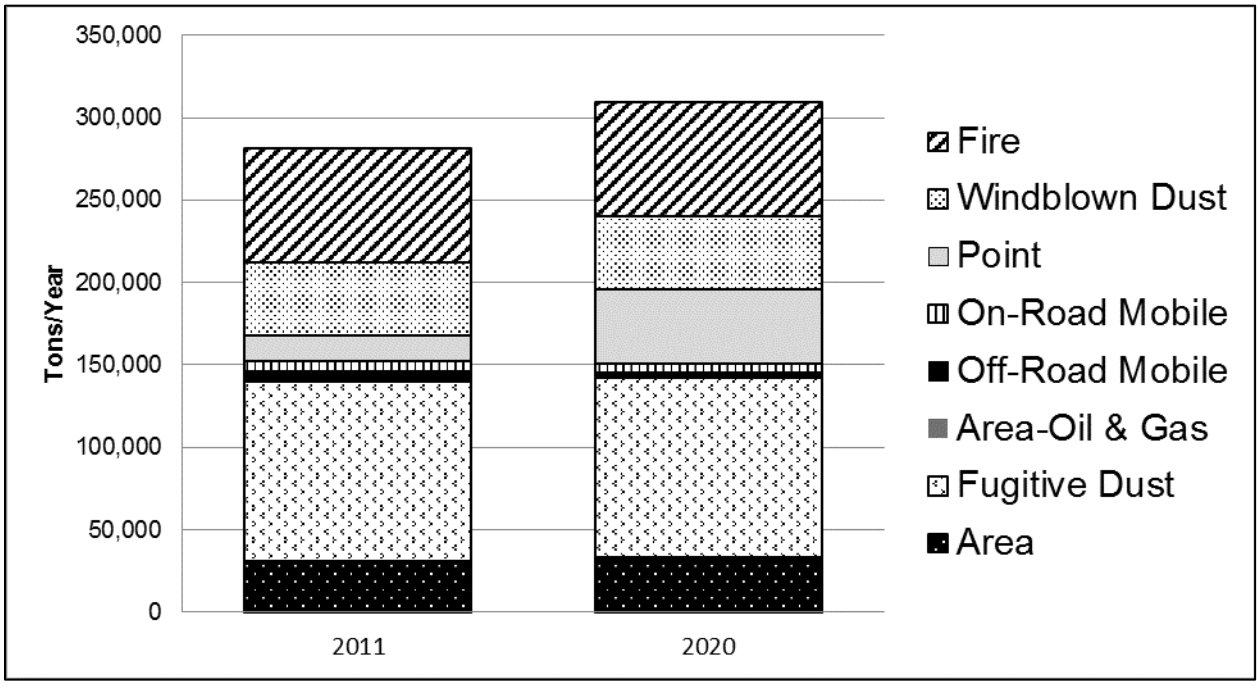


**Figure 96. Baseline and projected fine particulate matter emissions**

The data demonstrates that the majority of nitrogen oxides, sulfur dioxide and VOCs in the Gila airshed originate from the urban counties containing Phoenix, Tucson, Albuquerque, Las Cruces, El Paso and Ciudad Juarez, or industrial counties with significant oil and gas development or coal-fired power plants

(i.e. San Juan County, NM). Particulate emissions are dominated by fire and dust across the entire Gila airshed. There is some uncertainty in the data from Mexico, in that it is only indicated for area, point and on-road mobile sources, while the U.S. data is more finely distinguished.

There is a projected decrease in carbon monoxide and nitrogen oxides emissions through 2020. Most of the reductions come from fewer mobile sources associated with the introduction of lower emissions vehicles over time, cleaner fuels and improved gas mileage. The overall decrease would be greater if it were not partially offset by increases in both point and area sources of emissions from Mexico.

Sulfur dioxide emissions are projected to increase in the Gila airshed, also due to increases in emissions from Mexico. In 2011, point source sulfur dioxide emissions from Mexico accounted for 60 percent of the total emissions and are expected to increase to 75 percent in 2020. Over this same time period, U.S. emissions of sulfur dioxide are expected to decrease by 10 percent.

VOC emissions in the Gila airshed are dominated by biogenic emission sources and are projected to remain fairly stable through 2020. Particulate emissions, both CPM and FPM, are expected to increase slightly. These emissions come from wildfires, prescribed fires, agricultural fires and dust. There is a degree of uncertainty associated with estimating these emissions from year to year, and therefore in the interpretation of any trend. Higher temperatures and persistent drought conditions, such as those predicted to accompany climate change, could lead to an increasing trend (Prospero and Lamb 2003).

## Ambient Air Quality

While emissions, or volume of pollutants entering the atmosphere, play an important role in determining overall air quality for a given area, air quality evaluations also consider ambient concentrations of pollutants in the air. The Forest Service uses these concentrations to determine how pollutants, such as particulate matter, nitrogen and sulfur dioxides, and ozone impact Forest resources. The NAAQS and NMAAQs described previously form the basis for the regulatory reference condition used to assess air quality. Where regulatory standards are met, there is no significant departure in terms of air quality.

### *Ozone Concentrations*

Ozone is one of the major components of smog. It is not emitted into the atmosphere, rather it is formed in reactions involving nitrogen oxides and VOCs. Elevated ozone levels can cause breathing problems, trigger asthma, reduce lung function and increase the occurrence of lung disease. It also has potentially harmful effects on vegetation, which is usually the principal threat to wilderness areas. Vegetation may demonstrate elevated ozone levels through yellowing, reduced growth or premature death, although these symptoms are not unique to elevated ozone and may also be responses to insect infestations or disease.

Ozone data have been collected at the Chino Copper Smelter in Hurley, NM near the Gila NF. While this is an industrial site, data likely represent conditions worse than would be expected on the Forest but was chosen because of its close proximity. There is no significant departure from the regulatory reference related to ozone as concentrations have been consistently below the non-attainment thresholds at this site. The smelter was demolished in 2007 and smelting operations are no longer occurring at Chino.

### *Particulate Matter*

Particulate matter measurements in or near the Gila NF are very limited. No FPM data are available as the single monitor set up in Silver City, NM by the EPA was taken down because the values were so consistently low it did not warrant the cost of operating the equipment. CPM data are limited to the station at the Chino Copper Smelter in Hurley, NM with a period of record beginning in 2009. The data show concentrations comply with the NAAQS. There is no significant departure from the regulatory reference in terms of particulate matter.

### *Nitrogen and Sulfur*

Nitrogen oxides and sulfur dioxides occur as the result of fuel combustion, either from industrial or commercial sources such as power generation facilities, aircraft and automobiles. Nitrogen dioxide is the regulated form of nitrogen oxide emissions. Health effects from exposure to elevated concentrations of nitrogen dioxide include inflammation of the airways, and chronic bronchitis in children and other sensitive individuals. No data has been collected on nitrogen dioxide in or near the Gila NF.

Sulfur dioxide emissions are linked to the quality of sulfur in the fuels that are combusted and may also result from smelting and refining of copper ores. Exposure to sulfur dioxide causes changes in pulmonary function, increases in respiratory infections and irritation of the eyes. Monitoring data from the Chino Copper Smelter exists for a period of record beginning in 2000. This monitoring site was influenced, at times, from the emissions of the copper smelter showing elevated levels of sulfur dioxide when the smelter was in operation. Since the smelter was demolished in 2007, concentrations have declined significantly. There is no significant departure from the regulatory reference in terms of nitrogen and sulfur compounds.

Nitrogen oxides and sulfur dioxide are linked to the formation of nitrate and sulfate aerosols, which can have adverse effects on visibility. They are also linked to increases in acid precipitation and acid deposition. Both of these subjects are discussed further following sections.

## Visibility

Visibility refers to the conditions that allow the appreciation of the landscape in terms of form, contrast, detail and color of near and distant features. It has been valued going back to the 1977 Clean Air Act amendments, which recognized it as an important value for most wilderness areas by creating the Class I designation. Particulate and gaseous air pollutants may interfere with the observer's ability to see and distinguish these features.

The Interagency Monitoring of Protected Environments (IMPROVE) data for the Gila NF were summarized for the 20 percent haziest and 20 percent clearest days on an annual and monthly basis using a 1995-2014 period of record. The visibility condition that represents the "natural background" goal for Class I areas is based on the emissions summary data provided by the IWDW (2015). These results are displayed in Figure 97 and Figure 98.

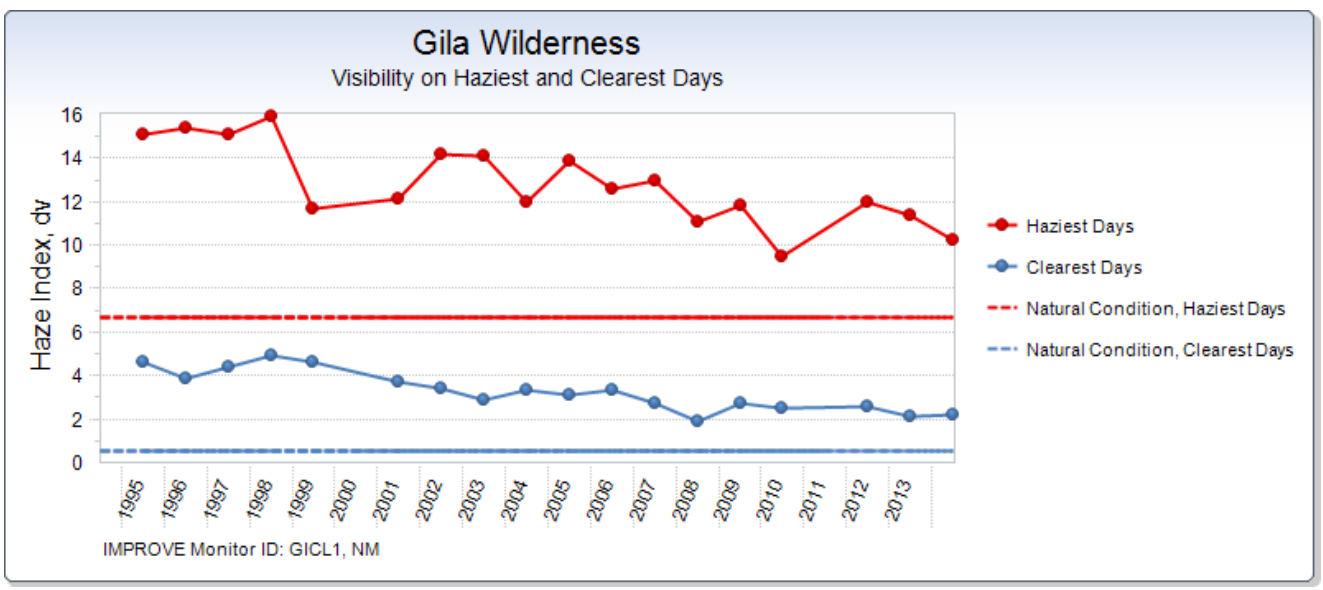


**Figure 97. Summary of IMPROVE visibility monitoring data**

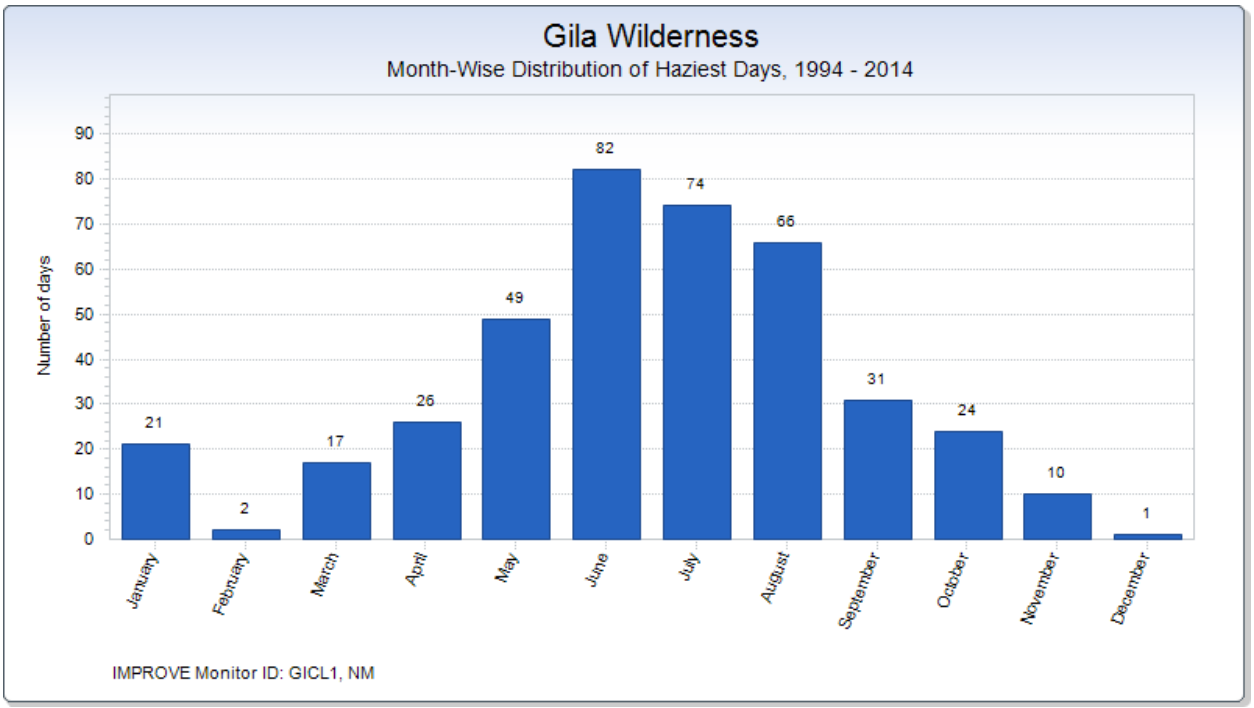


**Figure 98. Distribution of haziest days by month**

In general, the data show relatively good visibility conditions (13 dv or better), except on the haziest 20 percent of days; however, there is still significant departure in the Gila airshed in terms of visibility. The general trend has been toward moderate improvement. Analysis of the pollutant types and the monthly distribution of their concentrations indicate that the haziest days are the result of wildfire smoke impacting visibility on the Gila NF. There are ongoing discussions between federal land managers, the states, and the EPA regarding how visibility impairments related to wildfire are quantified in relation to human produced pollutants like sulfate and nitrate aerosols.

## Atmospheric Deposition

### Nitrogen and Sulfur

Air emissions of nitrogen oxides and sulfur dioxide can lead to atmospheric transformation of these pollutants into acidic compounds, such as nitric and sulfuric acids. These acids are deposited onto land and into waterbodies either wet or dry. Wet deposition occurs as acid rain, snow or fog. Dry deposition is a more complex process, but basically occurs as these acidic compounds become associated particulate matter and settle out of the air.

Nitrogen can also be deposited as nitrate or ammonium. These are the forms of nitrogen that are plant nutrients. Increases in nitrogen deposition can “over-fertilize” non-agricultural ecosystems, thereby artificially enhancing the productivity of native and non-native species, increasing system vulnerability to invasive species, and altering species composition and long term patterns of nutrient cycling. Excessive nitrogen deposition also brings with it the potential for nitrate leaching into surface and groundwater. In surface water, this can lead to eutrophication. Nitrate is also toxic to humans at certain concentrations and infants are most vulnerable. Nitrate contamination in groundwater causes “blue-baby syndrome.”

Deposition of nitrogen and sulfur can lead to acidification of lakes, streams and soils, injury to high elevation forests, and changes in terrestrial and aquatic species composition and abundance. High

elevation forests are at greater risk because precipitation, and therefore wet deposition, increases with elevation.

Direct measurements of wet nitrogen and sulfur deposition in precipitation were collected between 1985 and 2012 at a monitoring station at the Gila Cliff Dwellings National Monument near the Gila Wilderness. Funding to operate this station was discontinued in 2012. Figure 99 and Figure 100 display the measurements collected at this station. Units are in kilograms per hectare, which is equivalent to approximately 0.9 pounds per acre.

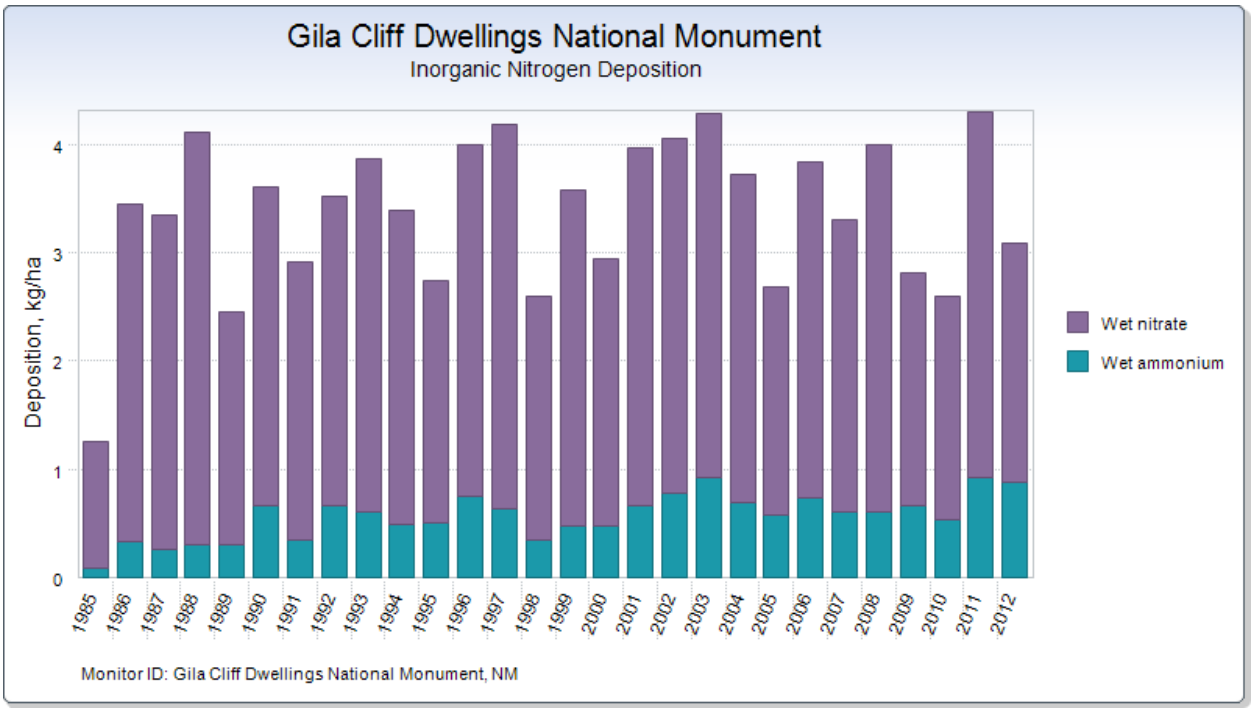


**Figure 99. Inorganic nitrogen deposition (Gila Cliff Dwellings National Monument, 1985-2012)**

(Data obtained from http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=NM07&net=NTN)

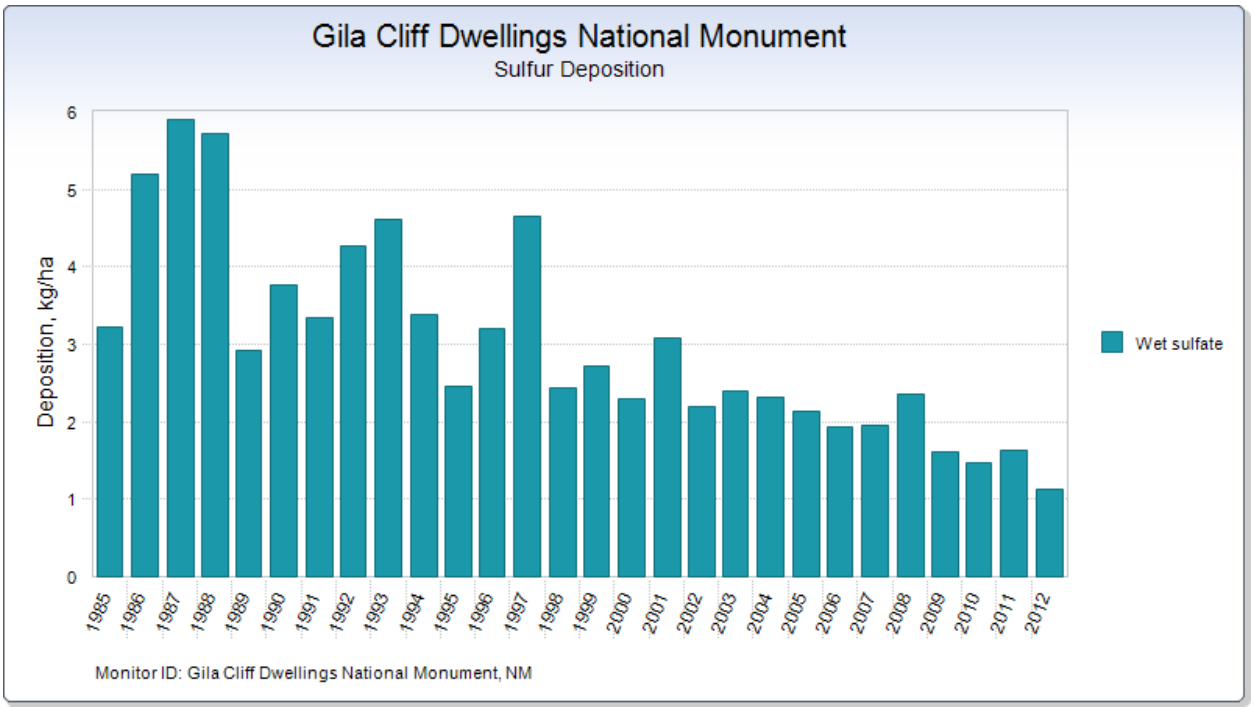


**Figure 100. Sulfur deposition (Gila Cliff Dwellings National Monument, 1985-2012)**

Over the period of record, wet deposition of nitrogen in the forms of nitrate and ammonium, has remained fairly constant. Sulfur deposition has declined significantly and corresponds with the closure of copper smelting operations at mines adjacent the Gila NF. However, wet deposition does not account for all deposition. While there are no monitoring stations on the Forest to measure dry deposition, such stations exist at the Chiricahua National Monument and Petrified Forest National Park. Data from these stations provide the ability to estimate the proportion of nitrogen and sulfur deposition attributable to dry deposition on the Forest. Figure 101 and Figure 102 display the five year average total wet and/or dry deposition at Oliver Knoll (wet only), Petrified Forest National Park, Chiricahua, and the Gila Cliff Dwelling National Monuments. The variability and range of potential deposition across the Forest is better illustrated by including multiple monitoring locations in and near the Gila National Forest.

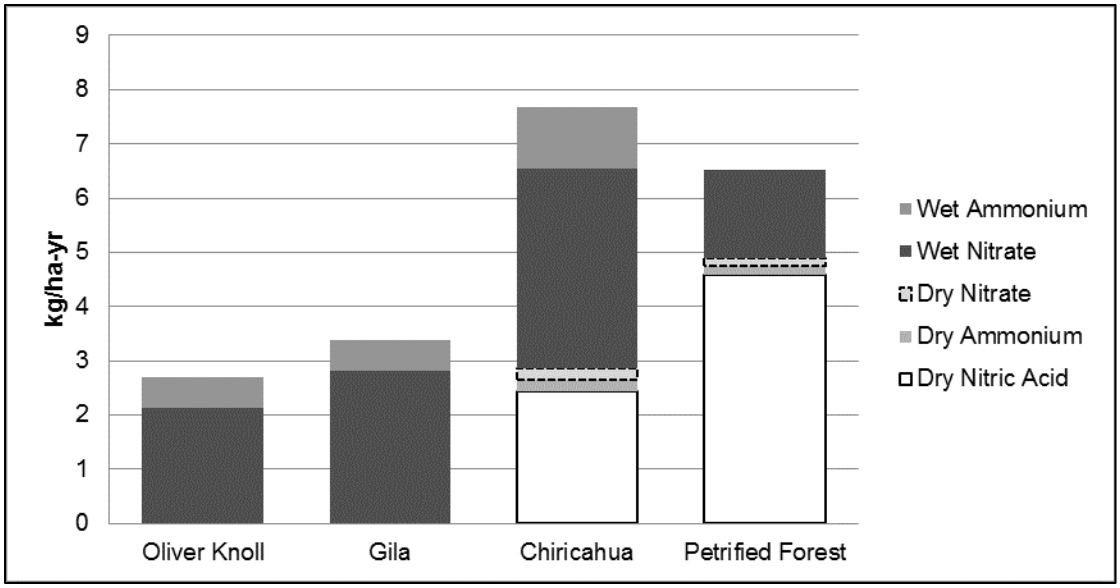


**Figure 101. Five year average of total nitrogen deposition at selected sites**

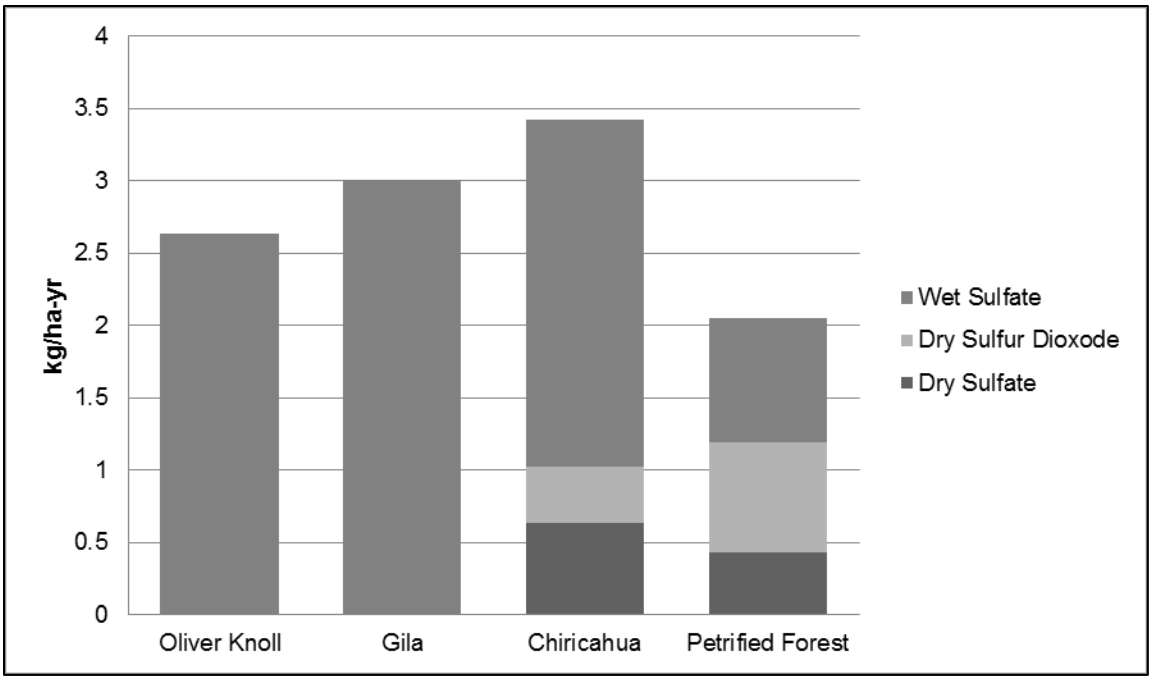


**Figure 102. Five year average of total sulfur deposition at selected sites**

Examination of the sum of dry and wet deposition at the Petrified National Forest Park and Chiricahua National Monument suggests that 40 to 75 percent of the nitrogen deposition and 30 to 60 percent of the sulfur deposition on the Gila NF likely comes from dry deposition. Considering nitrogen emissions are expected to decrease in the Gila airshed, it is reasonable to expect nitrogen deposition will decrease. Similarly, sulfur deposition can be expected in increase as increases in sulfur emissions from Mexico offset decreases in U.S. emissions.

## Mercury

Mercury deposition is an additional concern as it is a persistent toxin which can stay in the environment for long periods of time, cycling between air, water and soil. It is emitted primarily by coal-fired power plants and may be carried thousands of miles before deposition occurs. Similar to nitrogen and sulfur, mercury deposition may be wet or dry. Mercury is transformed by bacteria in aquatic sediments into a neurotoxin that is found in fish. It has detrimental health effects to humans, and behavioral and reproductive impacts to wildlife. However, each person's exposure depends on the amount of this neurotoxin found in the fish they eat, how much fish they eat, and how often. Mercury is subject to bioaccumulation, which means predator fish tend to have higher concentrations than prey fish.

Almost every state, New Mexico included, has consumption advisories for lakes and streams with water quality impairments due to mercury concentrations in fish tissue. These impaired water bodies in and near the Gila NF are identified in the Water Chapter. As a result of coal-fired utilities in the Southwest and the limited mercury pollution controls at those sites, the total concentration of mercury in the air is fairly high relative to elsewhere in the U.S. However, wet deposition is relatively low, except at high elevation, because of lower precipitation (MDN 2013).

While it is difficult to assess the current effects that mercury deposition is having on the Gila, since there are no mercury deposition monitors currently operating in the area (the Caballo Mercury Deposition Network monitoring site has not been operational since 2005), there are conflicting trends that suggest overall mercury effects will be stable. New regulatory controls at a few regional coal-fired power plants should reduce the total mercury emissions over the next several years. However, as previously stated, sulfur emissions and deposition are projected to increase. Since the bacteria that transform mercury into a neurotoxin require sulfur, mercury related impacts could foreseeably increase.

## Ozone

Ground-level ozone, while not atmospheric deposition in the strictest sense of the word, interferes with the ability of plants to produce and store food and makes them more susceptible to insects, disease, other pollutants, drought and high temperatures. Some plants have been identified as particularly sensitive to the effects of ozone and are reliable indicators of toxic ozone levels. Elevated levels of ozone have not been directly measured on the Gila NF, nor has an assessment of those species sensitive to ozone been conducted.

## Critical Loads

Critical loads describe the threshold amount of a pollutant below which no significant harmful effects on specified ecosystem components, such as plants and plant communities, lichens, fungi, soils, etc. Above the critical load, harmful effects attributable to the deposition of pollutants begin to occur. They are based on scientific information about expected ecosystem responses to a given level of atmospheric deposition. For ecosystems damaged by air pollution, critical loads help determine how much improvement in air quality would be needed to provide for recovery. Where they have not been exceeded, critical loads can identify levels of air quality needed to maintain and protect ecosystems into the future.

U.S. scientists, air regulators, and natural resource managers have developed critical loads for areas across the United States. This development includes collaboration with scientists in Europe and Canada. Currently, there are no critical loads specific to the Gila NF. Critical load information is limited to research conducted by Pardo et al. (2011a, 2011b) within the Temperate Sierras and North American Desert ecoregions (CEC 1997). This information pertains to nitrogen and acid deposition.

### *Nitrogen*

Lichens add significantly to the biodiversity of ecosystems and are some of the most sensitive species to nitrogen deposition. Critical loads nitrogen deposition have been developed for lichens in the Temperature Sierras ecoregion and are based on expert judgement (Pardo 2011; Pardo et al. 2011). In 2013 and 2014, The Forest Service and researchers have collected lichen tissue for laboratory analysis at five locations in the Gila Wilderness and six locations in the Aldo Leopold Wilderness. Seven of the nine species analyzed had elevated levels of nitrogen (St. Clair 2014). Based on the available critical load information and the Gila NF lichen analysis results, one percent exceeded the critical load. The minimum amount that the Gila NF exceeded the critical load was 0.03 kilograms per hectare and the maximum was 0.27 kilograms per hectare. Analysis is being conducted on additional samples collected after 2014, as well as on archived samples collected in 1996.

Herbaceous plants and shrubs comprise the majority of the vascular plants in North America (USDA NRCS 2016). They are less sensitive to nitrogen deposition than lichens, but more sensitive than trees due to relatively faster growth rates, shallower roots and shorter life span (Pardo et al. 2011a, 2011b). The shorter lifespan of these species can result in a rapid response to nitrogen deposition and rapid shifts (1-10 years) in community composition. Where invasive species are present, these shifts often favor those species over native species (Pardo et al. 2011a, 2011b). Critical loads from the Temperate Sierras ecoregion for herbaceous plants and shrubs are not available for the Gila NF. However, based on critical loads from the North American Deserts ecoregion, deposition in the range of three to 8.4 kilograms per hectare per year increased biomass of invasive grasses, decreased native forbs and change community composition.

Mycorrhizal fungi reside below the soil surface and have a symbiotic relationship with plants, which means that they occur within and/or closely associated with plant roots. This relationship benefits both the fungi and the plant. Atmospheric deposition of nitrogen in exceedance of the critical loads has been shown to alter community structure and composition, root colonization and decrease species richness (Pardo et al. 2011a, 2011b). There are no critical loads for mycorrhizal fungi and nitrogen deposition on the Gila NF, nor are there literature values to refer to. There is also no critical load for nitrogen deposition and nitrate leaching.

### *Acid*

The potential for impacts related to acid deposition has been recognized in the United States for more than 30 years. Research has shown nitrogen and sulfur deposition can have acidifying effects on soil and water resulting in negative impacts to aquatic resources, forest sustainability, biodiversity and ecosystem health (Driscoll et al 2001; McNulty et al. 2007). The physical and chemical properties of soils that determine its capacity to resist changes in pH are the primary controls on whether or not critical loads are exceeded. Also important is the rate of acid deposition, which is related to the types and amounts of pollutants being emitted. Coniferous forests are generally at higher risk because needles are naturally acidic. Higher elevation also increases risk as more precipitation tends to occur in these areas. Critical loads for acid deposition and an analysis of exceedances have been developed for soils at a national level by McNulty et al. (2007). Critical loads have not been exceeded on the Gila NF (McNulty et al. 2007).

Surface water acidification reduces the abundance and diversity of aquatic species. Many of the same factors discussed in the previous paragraph related to soils influence the susceptibility of aquatic ecosystems to acid deposition. Acidification begins in adjacent terrestrial areas (Pidwirny 2006) and depends on the system's ability to neutralize the acid before it leaches into surface water. Water quality data from NMED indicates there are no waters impaired for pH on the Gila NF (NMED 2014a).

## Stakeholder Input

Air quality is important to the Gila NF and the public. Smoke impacts to air quality were the primary topic about which the public raised concerns. The negative effects of smoke on human health were the focus for some who expressed their desire for no burning to occur on the Forest, whether as prescribed fire or wildfire. Others would like to see the Forest approach the state legislature to relax rules for prescribed burns as they tend to generate less smoke and have lower potential for overall ecological damage. In general, the perception of those who provided air quality related input is that air quality is good overall and is potentially improving, except during large, high severity wildfires.

## Risk

The ecosystem services provided by air are generally stable and not at risk. Air quality on the Gila NF is within national and state ambient air quality standards. Based on current and projected emissions inventories, the trend appears to be stable or improving for most pollutants with the exception of sulfur dioxide. This is also true regarding visibility conditions from a regulatory perspective because the State is operating under an approved SIP and is on an acceptable trajectory to the goals outlined in the Clean Air Act. The primary challenge could be with regard particulate matter, which can affect both ambient air quality and visibility on the Forest. Land-use, both on and off Forest, climate change and drought can contribute to particulate matter. Wildfires can also be a significant source of particulate matter for short periods of time, but can have significant public health impacts during these episodes.

There are many factors that contribute to the reliability and confidence of an assessment. Typically, a sufficient amount of direct measurements taken over time provide the greatest level of confidence regarding the current state and trends of forest health as it applies to air quality impacts. In the absence of direct measurements, modeled data can be used to assess relative risk of ecological systems to the impact of air pollution. However, this creates a greater degree of uncertainty in the interpretation. Understanding the assumptions in the modeled data and how well they perform on the ground determines the degree of confidence in the interpretation.

There are direct measurements, taken over time, for ambient air quality and visibility, therefore reliability of the assessment is high with regard to these characteristics. However, there is a fair amount of uncertainty associated with the risk that air quality might pose to ecosystem integrity and sustainability due to the very limited data on which to develop Gila NF specific critical loads. Research is weak with regards to assessing critical loads on the Forest and there is significant uncertainty in the assessment regarding the magnitude of impacts from nitrogen deposition. The primary results in the assessment were based on modeled critical loads and have not been verified on the Forest. Lichen studies represent the only direct measure of air pollution impacts. Additionally, the difficulty associated with quantifying dry deposition on complex mountainous terrain in arid climates with very little data (Pardo et al. 2011a, 2011b) contribute to the uncertainty of critical load estimates.

Modeled results also indicate that the levels of acid gases are not at levels significant enough to result in impacts to either soils or surface water. There are no direct measurements on the Forest that indicate otherwise. There is some indication that mercury deposition at higher elevations on the Forest may be significant, however, atmospheric mercury, based on regional emissions, is also expected to decrease. Table 98 provides a summary of air quality related conditions, trends and reliability of those determinations.

**Table 98. Summary of conditions, trends, and reliability of assessment**

| Air Quality Measure | Current Conditions | Trend | Reliability |
|---|---|---|---|
| **NAAQS**[1] | | | |
| Carbon Monoxide | Good | Improving | High |
| Nitrogen Dioxide | Good | Improving | High |
| Sulfur Dioxide | Good | Declining | High |
| Lead | Good | Stable | High |
| Ozone | Good | Stable | High |
| FPM | Good | Stable to Declining | High |
| CPM | Good | Stable to Declining | High |
| **Visibility** | | | |
| Visibility[2] | Departed | Stable to Improving | High |
| | **Critical Loads- Deposition**[3] | | |
| **Nitrogen Eutrophication** | | | |
| Lichens | Low risk | Improving | Low |
| Herbaceous Plants and Shrubs | Low risk | Improving | Low |
| Mycorrhizal Fungi | Unknown | Improving | Low |
| Forests | Unknown | Improving | Low |
| Nitrate Leaching | Unknown | Improving | Low |
| **Acid Deposition** | | | |
| Soils | Good | Improving | Low |
| Surface Water | Low risk | Stable to Improving | Moderate |
| **Deposition (other)** | | | |
| Mercury | Low risk | Improving | Low |
| Ozone | Unknown | Unknown | N/A |

[1]Relative to NAAQS

[2]Relative to 2064 Regional Haze Goal

[3]Level of risk, is based on the extent of potential impact on the Forest. For example, if models indicate that 98% of the Forest area exceeds nitrogen critical loads for lichens, that would be high risk. While approximately 50% of the forest area exceeds nitrogen critical loads for Mycorrhizal fungi or Forests, this is moderate risk. Break points are 0-33%- Low risk; 34-66%- Moderate risk; and 67-100%- High risk. In some cases, where there is conflicting data, the data is sparse, or has considerable uncertainty, best professional judgement was used to assign risk level.

## Summary

Air quality and the values dependent on air quality on the Gila NF are generally in good condition or are improving as most pollutants are decreasing; however, visibility and ambient air quality conditions associated with particulate matter are expected to continue to have episodic periods of very high levels —as a result of wildfires and increases in fugitive dust due to the effects of climate change. Also, impacts from emissions along the US-Mexico border are a significant concern and also an area of significant uncertainty in terms of the magnitude and subsequent impacts. Lastly, modeled critical loads from nitrogen deposition are insufficient to assess the full range of possible impacts to the ecosystems potentially affected.

# Chapter 6. Water

## Introduction

Water is necessary for the existence of all life. Water exists in soil and groundwater, streams, springs and seeps, wetlands and waterbodies, all of which occur in watersheds. This chapter describes reference and current conditions, and projects future conditions and trends related to key ecosystem characteristics of water within and surrounding the Gila NF. These characteristics include the dominant ecological characteristics that describe the composition, structure, function and connectivity of ecosystems as they relate to water resources. Table 99 lists the characteristics analyzed for this assessment and the metric, or standard of measurement by which it is analyzed.

**Table 99. Key water resource characteristics for assessment**

| Water Resource Characteristic | Metric |
|---|---|
| Watersheds | Condition |
| Perennial and Intermittent Streams | Extent and Distribution |
| Streamflow | Mean and Median Annual Flow<br>High and Low Flow Days<br>Mean Monthly Flow |
| Surface Water Quality | Regulatory Water Quality Status |
| Aquatic Biota | Native and Non-Native Fish Species Richness<br>Distribution of Native and Non-Native Fishes |
| Groundwater | Quantity<br>Extent and Distribution of Springs, Seeps and Wetlands<br>Quality |

Each water resource feature is a main heading in this chapter. Under each main heading is a discussion of current and reference conditions, trends, system drivers and stressors, and risk related to each characteristic. Waterbodies are not analyzed as a key ecosystem characteristic because most are constructed features not naturally occurring features on the Forest. Regardless, this chapter does include a main heading and discussion regarding waterbodies because they do have ecological significance. Similarly, groundwater wells are not analyzed as a key ecosystem characteristic, but are briefly discussed because of their socioeconomic and ecological importance. The chapter concludes with stakeholder input received during the assessment concerning water resources, and a summary. This chapter does not include a full treatment of aquatic species (see portions of Chapter 8: At-Risk Species) or riparian resources (see Chapter 7: Riparian) but includes supporting information from those analyses.

## Ecosystem Services of Water Resources

Water resources on the Gila NF provide many ecosystem services from which society derives enjoyment or benefit. It provides supporting ecosystem services as primary production, soil formation and nutrient cycling cannot happen without it. Water resource features contribute to provisioning and regulating services by contributing to erosion control, flood regulation, water purification, the production of forage, livestock, and game animals taken for meat, and other products. They also provide many cultural

ecosystem services to society as they provide opportunities for recreation, personal enrichment, education and research.

## Scales of Analysis

This analysis is based on three watershed scales. Watersheds are defined by the topographic extent of an area that drains to a single point in a stream or river system. Watersheds are cataloged using a uniform hierarchical system developed by the United States Geological Society (USGS). The United States is divided and subdivided into successively smaller hydrologic units. There are six levels of hydrologic units: region (1st level), subregion (2nd level), basin (3rd level), subbasin (4th level), watershed (5th level) and subwatershed (6th level) (USGS 1999). The word "watershed" is therefore both a general term, and a specific categorical term depending on the context it is used in.

Regions can encompass several states. Subwatersheds, the smallest unit, are typically 16,000 to 32,000 acres (25-50 square miles). This analysis uses subbasins for the broadest scale of assessment and watersheds and subwatersheds for the finest scale. The purpose of the broadest scale is to understand the environmental context beyond the Forest to determine the opportunities or limitations for the Gila NF may have to contribute to the sustainability of the larger ecological systems, as well as the impacts of the broader landscape on the sustainability of resources on the Forest. The broad scale is referred to as the context area. The context area includes all subbasins containing at least one subwatershed intersecting the Forest boundary. The fine scale is the referred to as the plan area. The plan area includes all watersheds with at least one subwatershed intersecting the Forest boundary.

Forty nine watersheds compose the plan area totaling approximately 8.4 million acres, of which the Gila NF constitutes 39 percent. Within the plan area watersheds, 202 subwatersheds intersect the Gila NF boundary. These subwatersheds are used to describe plan area watershed conditions on the Gila NF. The context area consists 11 subbasins totaling approximately 19.1 million acres, of which the Gila NF constitutes 17 percent. Table D1 in Appendix D displays subbasin, watershed and subwatershed names, hydrologic unit codes, total acres, Gila NF acres and percent within Forest boundaries. Figure 103 and Figure 104 display the context and plan area respectively relative to the Forest. The local units introduced in Chapter 1: Ecological Integrity and Sustainability are used to explore patterns of risk within the Forest, at a scale common to all ecological analyses.

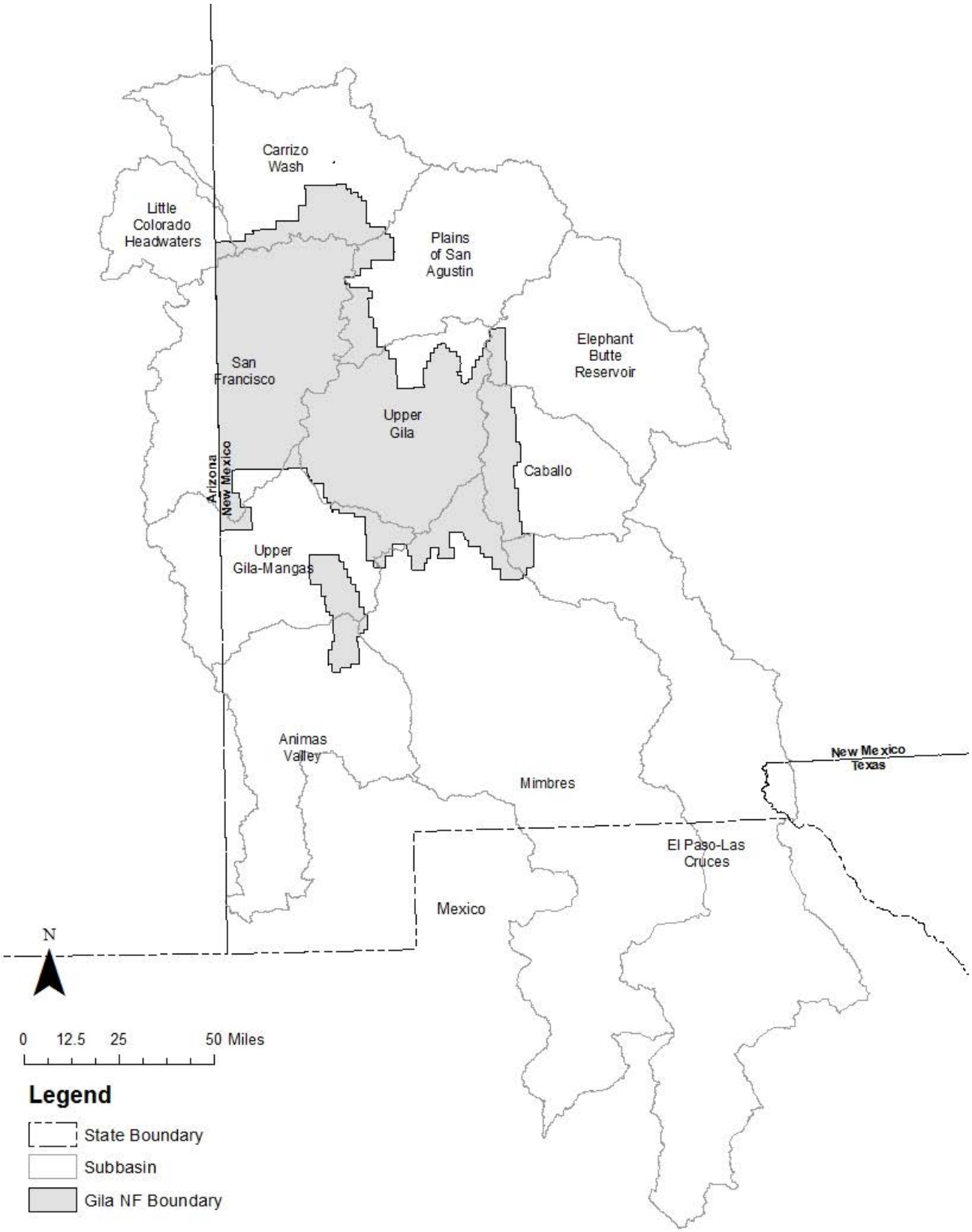


**Figure 103. Context area subbasins**

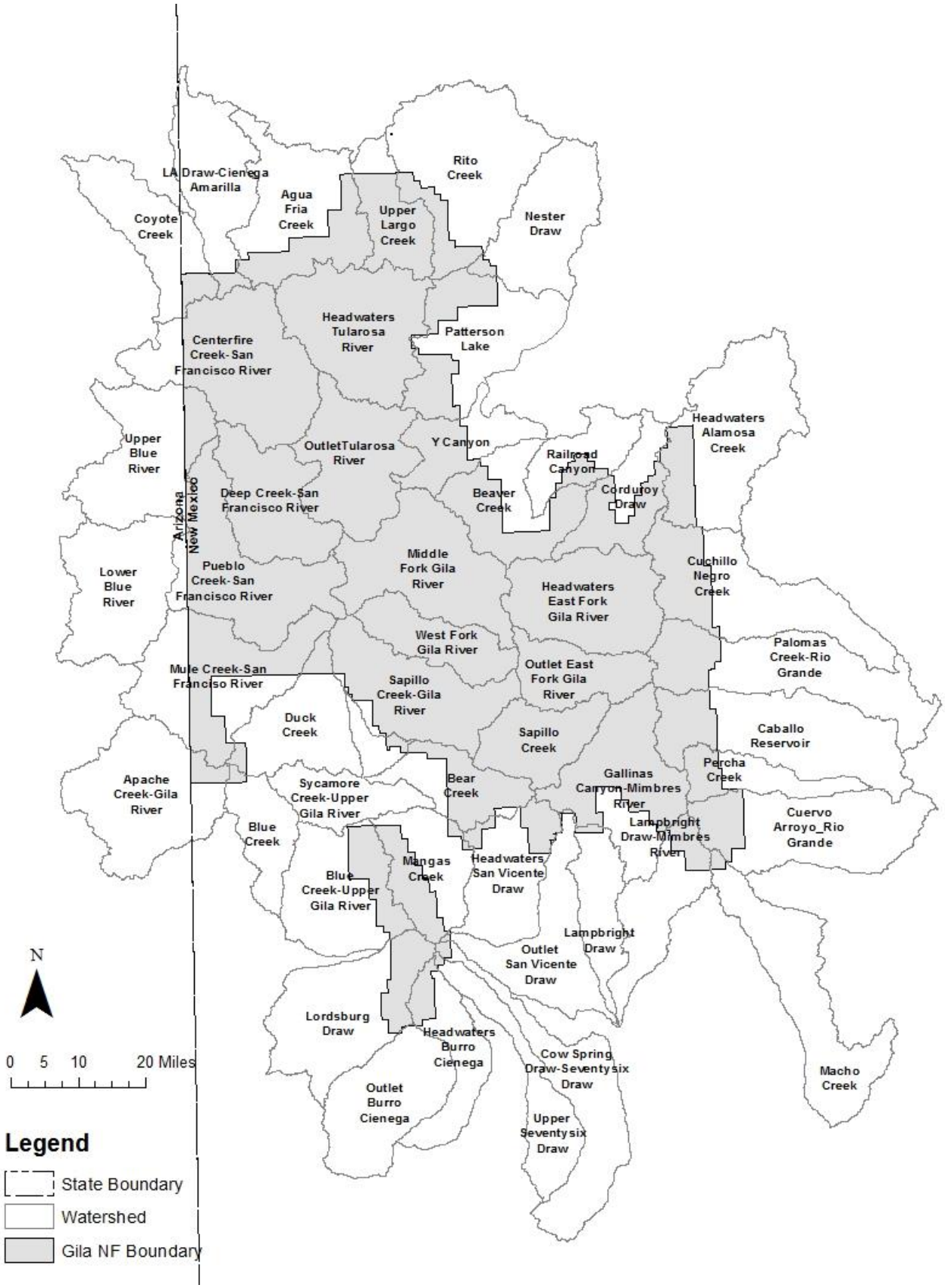


**Figure 104. Plan area watersheds**

## Data

United States Geological Survey (USGS) Watershed Boundary Dataset (WBD) and National Hydrography Dataset (NHD) provide information about the location and extent of watersheds, streams, waterbodies and springs and seeps. USGS streamflow data is also used. Wetland data is provided by United States Fish and Wildlife Service's National Wetlands Inventory. Climate data is provided by the Western Regional Climate Center. The New Mexico Environment Department's Surface Water Quality Bureau (NMED SWQB) is the primary source of water quality information, with the equivalent agencies in Arizona and Texas providing information about water quality for the context scale. Similarly, information about wells was obtained from the New Mexico, Arizona and Texas Offices of the State Engineer. The Gila NF Fire History and Monitoring Trends in Burn Severity (MTBS) datasets provide data related to prescribed fire and wildfire. The watershed condition classification information for the Gila, Apache-Sitgreaves and Cibola National Forests are used throughout this assessment. Fish distribution data was compiled from a variety of sources including Gila NF survey records, NM Department of Game and Fish records, NM Natural Heritage Database, FISHNET database (a global database of fish collections from a multitude of universities, museums, and other organizations), and "The Fishes of New Mexico" (Sublette et al. 1990) which contained information on the historic distributions of New Mexico fish. Additional information was used as indicated by citations throughout this chapter.

## Watersheds

Watershed condition describes the status of the physical and biological characteristics and processes within a watershed that affect hydrologic and soil functions supporting aquatic ecosystems. Watersheds that are functioning properly have the following characteristics (Potyondy and Geier 2011).

- They provide for high biotic integrity, which includes habitats that support adaptive animal and plant communities that reflect natural processes.
- •They are resilient and recover rapidly from natural and human disturbances.
- They exhibit a high degree of connectivity longitudinally along the stream, laterally across the floodplain and valley bottom, and vertically between surface and subsurface flows.
- They provide important ecosystem services, such as high quality water, the recharge of streams and aquifers, the maintenance of riparian communities, and the moderation of climate variability and change.
- They maintain long-term soil productivity.

### Analysis Methods

The Watershed Condition Classification is an interdisciplinary evaluation of watershed condition employed across all National Forest System lands. It offers a systematic, flexible means of classifying watersheds based on a core set of national watershed condition indicators. The classification system utilizes existing data, local knowledge, professional judgment, written rule sets and criteria. Each of the 12 indicators is composed of one or more attributes. The attributes are scored, summed, and averaged to produce indicator scores, which are averaged within four process categories. The overall watershed condition score is then computed as a weighted average of the process category scores. The final score for each subwatershed results in an overall rating of Functioning Properly, Functioning at Risk, or Impaired Function (Potyondy and Geier 2011). The classification is available to the public online at http://apps.fs.fed.us/nfs/nrm/wcatt/WCFMapviewer/; the hydrologic unit codes provided in Appendix D may be useful for navigating the map viewer. Table 100 provides a detailed outline of the model.

**Table 100. Watershed Condition Classification model**

| |
|---|
| **Aquatic Physical Process Category: 30 percent of weighted average** |
| *Water Quality Indicator*: addresses the alteration of the physical, chemical and biological components of water quality including 303(d) listings and other water quality issues not resulting in a 303(d) listing |
| *Water Quantity Indicator*: addresses changes to the natural streamflow regime with respect to magnitude, duration and timing |
| *Aquatic Habitat Indicator*: addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function |
| **Aquatic Biological Process Category: 30 percent of weighted average** |
| *Aquatic Biota Indicator*: addresses distribution, structure and density of native and introduced aquatic fauna |
| *Riparian/Wetland Vegetation Indicator*: addresses function and condition of native riparian vegetation along streams, waterbodies and wetlands |
| **Terrestrial Physical Process Category: 30 percent of weighted average** |
| *Roads and Trails Indicator*: addresses changes to the hydrologic and sediment regimes due to density, location, distribution and maintenance of the road and trail network |
| *Soil Condition Indicator*: addresses alteration to natural soil condition, including productivity, erosion and chemical contamination |
| **Terrestrial Biological Process Category: 10 percent of weighted average** |
| *Fire Regime/Wildfire Effects Indicator*: addresses potential for altered hydrologic and sediment regimes because of departures from natural range of variability in vegetation, fuel composition, fire frequency, fire severity and fire pattern; |
| *Forest Cover Indicator*: addresses the potential for altered hydrologic and sediment regimes because of the loss of forest cover on Forest lands; |
| *Forest Health Indicator*: addresses forest mortality impacts to hydrologic and soil function due to major invasive and native forest pests, insect and disease outbreaks and air pollution; |
| *Terrestrial Invasive Species Indicator*: addresses potential impacts to soil, vegetation and water resources due to terrestrial invasive species including vertebrates, invertebrates, and plants; |
| *Rangeland Vegetation Indicator*: addresses impacts to soil and water relative to the vegetative health of rangelands. |

There are 202 subwatersheds within the plan area. Watershed condition classifications are available for 189. These classifications describe 46 of the 49 plan area watersheds and more than 99 percent of the Forest. No condition classification data are available for Outlet San Vincente Draw, Upper Seventysix Draw, or Outlet Burro Cienega.[31] The initial watershed condition classification was conducted in 2011. This classification was updated in 2016 to reflect changed conditions as a result of the significant wildfires the plan area has experienced since that time. The 2016 classification is used for this assessment.[32]

It is assumed that most watersheds would have been within their functional limits prior to European settlement. Therefore, the reference condition for watershed condition is defined as Functioning Properly with Functioning at Risk and Impaired Function classifications representing a departure from the reference. Subwatershed condition classifications are area weighted to the watershed level to describe

[31] A five percent area within the Gila NF threshold was used to determine which subwatersheds would be classified based on the assumption that below this percentage, the effects of Gila NF land management on overall condition were not significant. The Gila NF contains five percent or more of 181 of these subwatersheds and classified all but one. This subwatershed was classified by the Cibola National Forest (Cibola NF) because a larger percentage occurs within Cibola NF boundaries. The remaining eight subwatersheds were classified by the Apache-Sitgreaves National Forests (Apache-Sitgreaves NFs) for the same reason, and although less than five percent of those subwatersheds occurs on the Gila NF, collaborative management by both Forests does represent a significant contribution to overall watershed condition. The 13 subwatersheds with no condition classification represent less than one percent of the Forest.

[32] The Gila NF updated its initial classification in 2016. All subwatersheds that experienced fire of any severity across 1000 acres or more of its area were re-classified, including those impacted by the 2012 Whitewawter Baldy Complex, 2013 Silver Fire, and 2014 Signal Fire. The Apache-Sitgreaves NFs updated their classification following 2011 Wallow Fire. Those subwatersheds classified by the Cibola NF have not been updated, but have not experienced a large scale disturbance that might warrant re-classification.

the variability in conditions within plan area watersheds. The condition classification representing the largest proportion of the watershed area is then used to assign a single condition class to that watershed. This same procedure is repeated at the subbasin scale, using the subwatershed condition classification that represents the largest proportion of the subbasin area to describe the context area. Information suitable for assessing trend is not available. Risk is a direct interpretation of the watershed condition classification. Individual indicator and attribute scores are not assessed here in terms of departure, but are discussed in terms of explanatory value relative to overall watershed conditions, as they exist under current management.

## Plan Area

The variability in current watershed conditions across the plan area is displayed below in Table 101 .

**Table 101 . Current watershed conditions and departure across the plan area.**

| Watershed Name | Subwatershed Condition Class | | | Overall Watershed Condition Class |
|---|---|---|---|---|
| | Functioning Properly (% of Watershed Area) | Functioning At Risk (% of Watershed Area) | Impaired Function (% of Watershed Area) | |
| ***Plains of San Agustin Subbasin*** | | | | |
| Nester Draw | 100% | 0% | 0% | Functioning Properly |
| Patterson Lake | 100% | 0% | 0% | Functioning Properly |
| Y Canyon | 100% | 0% | 0% | Functioning Properly |
| ***Elephant Butte Reservoir Subbasin*** | | | | |
| Headwaters Alamosa Creek | 58% | 42% | 0% | Functioning Properly |
| ***Caballo Subbasin*** | | | | |
| Caballo Reservoir | 14% | 27% | 60% | Impaired Function |
| Cuchillo Negro Creek | 29% | 71% | 0% | Functioning at Risk |
| Palomas Creek-Rio Grande | 20% | 80% | 0% | Functioning at Risk |
| Percha Creek | 0% | 100% | 0% | Functioning at Risk |
| ***El Paso-Las Cruces Subbasin*** | | | | |
| Cuervo Arroyo_Rio Grande | 42% | 58% | 0% | Functioning at Risk |
| ***Mimbres Subbasin*** | | | | |
| Cow Spring Draw-Seventysix Draw | 0% | 100% | 0% | Functioning at Risk |
| Gallinas Canyon-Mimbres River | 8% | 69% | 23% | Functioning at Risk |
| Headwaters San Vicente Draw | 0% | 100% | 0% | Functioning at Risk |
| Lampbright Draw | 0% | 100% | 0% | Functioning at Risk |
| Lampbright Draw-Mimbres River | 40% | 60% | 0% | Functioning at Risk |
| Macho Creek | 100% | 0% | 0% | Functioning Properly |

| Watershed Name | Subwatershed Condition Class | | | Overall Watershed Condition Class |
|---|---|---|---|---|
| | Functioning Properly (% of Watershed Area) | Functioning At Risk (% of Watershed Area) | Impaired Function (% of Watershed Area) | |
| ***Little Colorado Headwaters Subbasin*** | | | | |
| Coyote Creek | 21% | 79% | 0% | Functioning at Risk |
| ***Carrizo Wash Subbasin*** | | | | |
| Agua Fria Creek | 100% | 0% | 0% | Functioning Properly |
| LA Draw-Cienega Amarilla | 0% | 100% | 0% | Functioning at Risk |
| Rito Creek | 100% | 0% | 0% | Functioning Properly |
| Upper Largo Creek | 45% | 55% | 0% | Functioning at Risk |
| ***Upper Gila Subbasin*** | | | | |
| Beaver Creek | 100% | 0% | 0% | Functioning Properly |
| Corduroy Draw | 100% | 0% | 0% | Functioning Properly |
| Headwaters East Fork Gila River | 51% | 49% | 0% | Functioning at Risk |
| Middle Fork Gila River | 10% | 76% | 14% | Functioning at Risk |
| Outlet East Fork Gila River | 28% | 72% | 0% | Functioning at Risk |
| Railroad Canyon | 100% | 0% | 0% | Functioning Properly |
| Sapillo Creek | 65% | 35% | 0% | Functioning Properly |
| Sapillo Creek-Gila River | 23% | 58% | 19% | Functioning at Risk |
| West Fork Gila River | 0% | 100% | 0% | Functioning at Risk |
| ***Upper Gila-Mangas Subbasin*** | | | | |
| Apache Creek-Gila River | 0% | 100% | 0% | Functioning at Risk |
| Bear Creek | 33% | 67% | 0% | Functioning at Risk |
| Blue Creek | 100% | 0% | 0% | Functioning Properly |
| Blue Creek-Upper Gila River | 18% | 82% | 0% | Functioning at Risk |
| Duck Creek | 33% | 67% | 0% | Functioning at Risk |
| Mangas Creek | 22% | 78% | 0% | Functioning at Risk |
| Sycamore Creek-Upper Gila River | 0% | 100% | 0% | Functioning at Risk |
| ***Animas Valley Subbasin*** | | | | |
| Headwaters Burro Cienega | 0% | 100% | 0% | Functioning at Risk |
| Lordsburg Draw | 0% | 100% | 0% | Functioning at Risk |
| ***San Francisco Subbasin*** | | | | |
| Centerfire Creek-San Francisco River | 0% | 91% | 9% | Functioning at Risk |
| Deep Creek-San Francisco River | 17% | 83% | 0% | Functioning at Risk |

| Watershed Name | Subwatershed Condition Class | | | Overall Watershed Condition Class |
|---|---|---|---|---|
| | Functioning Properly (% of Watershed Area) | Functioning At Risk (% of Watershed Area) | Impaired Function (% of Watershed Area) | |
| Headwaters Tularosa River | 22% | 78% | 0% | Functioning at Risk |
| Lower Blue River | 100% | 0% | 0% | Functioning Properly |
| Mule Creek-San Francisco River | 35% | 45% | 20% | Functioning at Risk |
| Outlet Tularosa River | 18% | 65% | 17% | Functioning at Risk |
| Pueblo Creek-San Francisco River | 7% | 35% | 58% | Impaired Function |
| Upper Blue River | 9% | 89% | 2% | Functioning at Risk |

Recall that not all indicators are given the same weight, which means a subwatershed may be considered Functioning Properly overall, but may have indicators that are rated Functioning at Risk or even Impaired Function. Likewise, subwatersheds that are considered Functioning at Risk or Impaired Function overall, may have indicators that are considered Functioning Properly. Figure 105 through Figure 116 display the indicator ratings and percentage of subwatersheds in each category, followed by a discussion of these ratings and their contributions to departure at the Forest and watershed scale.

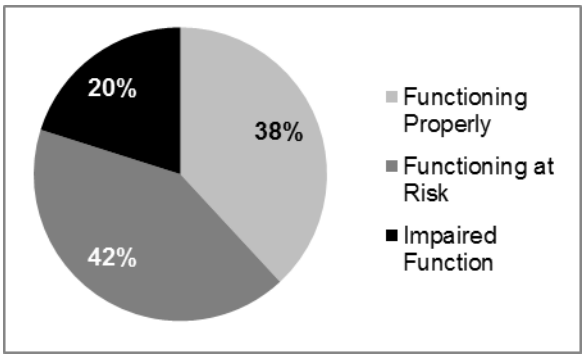


**Figure 105. Aquatic Biota Indicator**

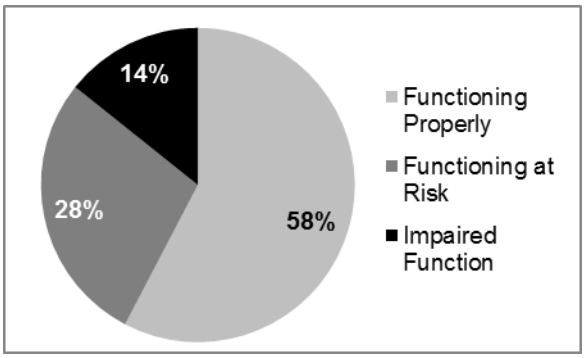


**Figure 107. Water Quantity Indicator**

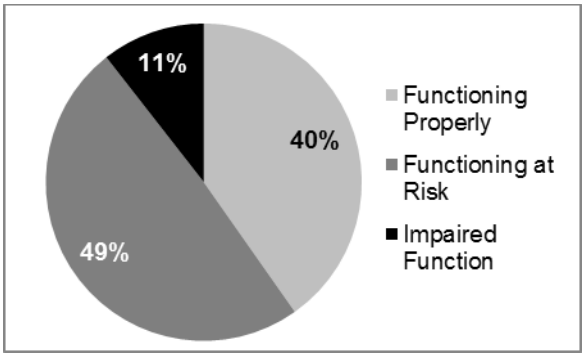


**Figure 106. Riparian/Wetland Vegetation Indicator**

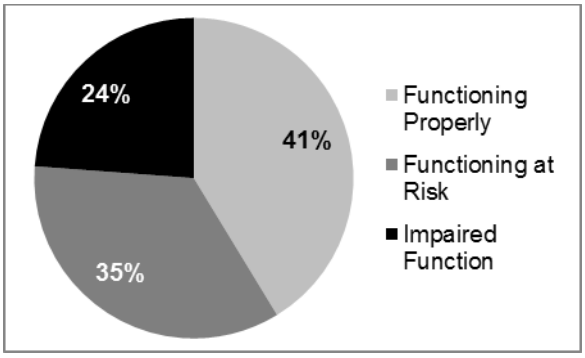


**Figure 108. Aquatic Habitat Indicator**

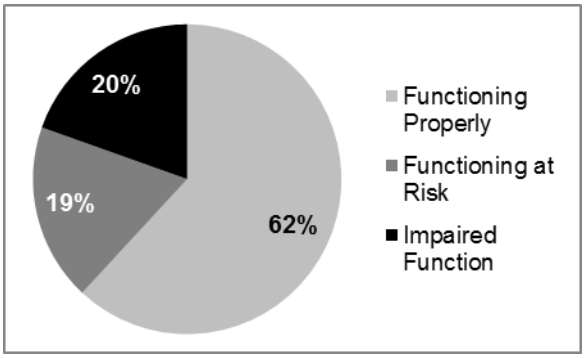


**Figure 109. Water Quality Indicator**

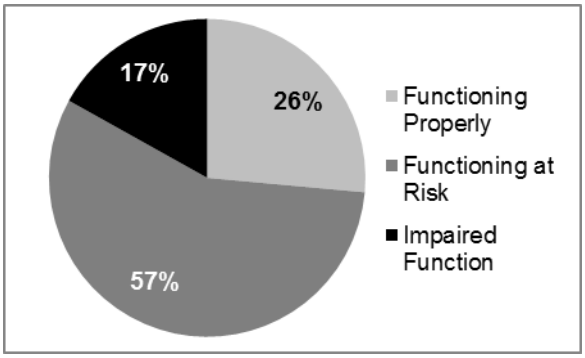


**Figure 113. Roads and Trails Indicator**

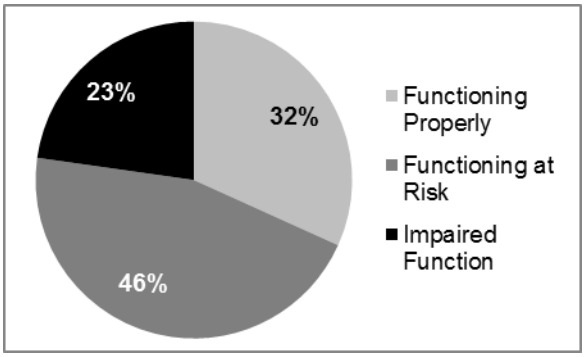


**Figure 110. Soil Condition Indicator**

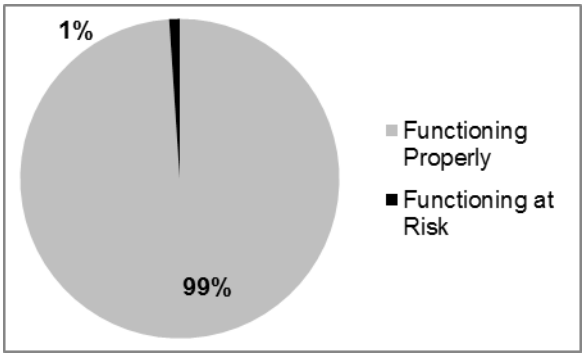


**Figure 114. Forest Health Indicator**

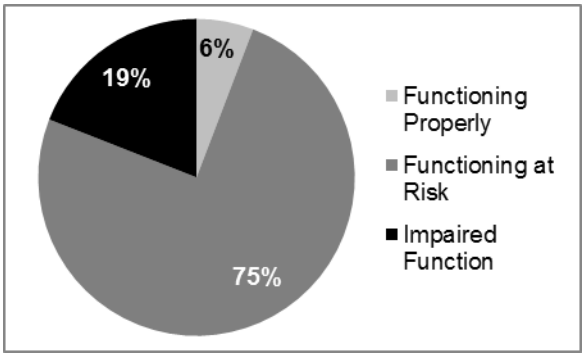


**Figure 111. Fire Regime/Wildfire Effects Indicator**

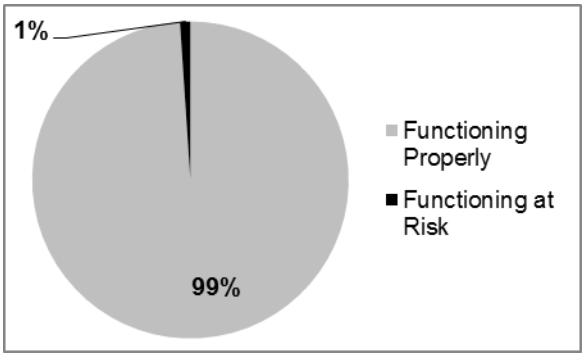


**Figure 115. Terrestrial Invasive Species Indicator**

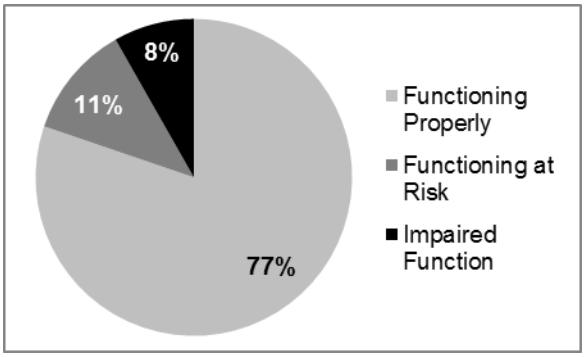


**Figure 112. Forest Cover Indicator**

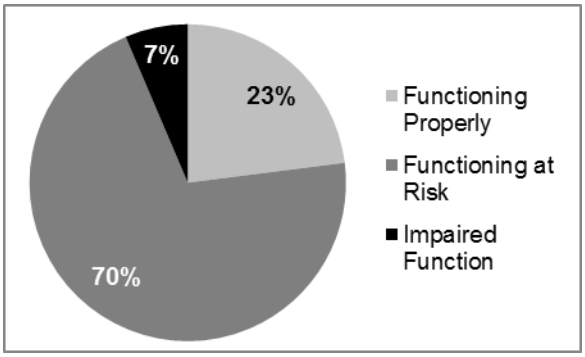


**Figure 116. Rangeland Vegetation Indicator**

Looking at the subwatershed indicator ratings and the rationales behind them allows for the interpretation of the causes behind departure in watershed condition at the Forest level. The rationale for these indicator ratings are documented at http://apps.fs.fed.us/nfs/nrm/wcatt/WCFMapviewer/. The indicators given the most weight in the 12 indicator model, and therefore largely responsible for the overall subwatershed classification are: aquatic biota, aquatic habitat, riparian/wetland vegetation, water quality, water quantity, soil condition and roads and trails. Less than half of the Forest's subwatersheds are Functioning Properly in terms of aquatic biota (Figure 105), aquatic habitat (Figure 108) and riparian/wetland vegetation (Figure 106).

The riparian/wetland vegetation indicator is considered Functioning Properly if "native mid to late seral vegetation appropriate to the site's potential dominates the plant communities and is vigorous, healthy, and diverse in age, structure, cover and composition on more than 80 percent of the riparian/wetland areas in the watershed…" and reproduction of native species is occurring such that sustainability is ensured and the vegetation is supported by the properly functioning hydrologic characteristics of the particular stream or wetland system (Potoyndy and Geier 2011). Functioning at Risk ratings reflect a moderate loss of these characteristics with limited areas displaying significant impacts. An indicator rating of Impaired Function indicates 25 percent or less of the riparian/wetland areas in the watershed display the characteristics described as Functioning Properly.

According to the rationale documented in the Gila NF classification, 23 of the 113 subwatersheds rated Functioning at Risk or Impaired Function in terms of riparian/wetland vegetation (Figure 106) are limited in their ability to support these vegetation communities due to the lack of perennial or intermittent surface or subsurface water. Approximately 67 of the 76 subwatersheds that are Functioning Properly (Figure 106) are also limited in their ability to support riparian/wetland vegetation, leaving approximately 98 subwatersheds across the Forest that were not considered as limited by water in their ability to support these vegetation communities. This indicator score was given a lower weight (less than two percent) in all subwatersheds limited by available water so that the overall classification is not significantly influenced. However, this means that just nine percent of the Forest's subwatersheds that currently have the water to support riparian/wetland communities are Functioning Properly, 29 percent are Functioning at Risk or Impaired Function due to fire and/or post-fire effects, and 10 percent are rated Functioning at Risk or Impaired Function due to the cumulative effects of relatively small irrigation diversions that lead to drying of the system. The remaining 52 percent are Functioning at Risk or Impaired Function due to the effects of drought, rising temperatures, roads and motorized trails, and/or herbivory by wildlife and livestock. More than 10,600 acres of riparian are currently excluded from livestock grazing (see System Drivers and Stressors Chapter for more information).

Patterns in the aquatic habitat indicator closely mirror those found in the riparian/wetland vegetation indicator, as available water and its distribution affect habitat quality and connectivity. An aquatic habitat rating of Functioning Properly means that "the watershed supports large continuous blocks of high-quality aquatic habitat and high-quality stream channel conditions" (Potoyndy and Geier 2011). Ratings of Functioning at Risk indicate "the watershed supports medium to small blocks of contiguous habitat. Some high-quality aquatic habitat is available, but stream channel condition show signs of being degraded" (Potoyndy and Geier 2011). Impaired Function ratings meant that "the watershed supports small amounts of continuous high-quality habitat. Most stream channel conditions show evidence of being degraded by disturbance" (Potoyndy and Geier 2011). There is a higher percentage of subwatersheds that are Functioning at Risk or Impaired Function (Figure 106 and Figure 108) because the aquatic habitat indicator considers stream channel shape and function, which the watershed condition classification model does not directly consider for riparian/wetland vegetation (Table 100). Large woody debris remains important to aquatic habitat, but is less of a contributing factor to departure in most subwatersheds. This indicator was also given a lower weight where there is not enough water to support aquatic habitat.

Available water limits the potential for riparian/wetland vegetation and aquatic habitat, but represents an even greater limitation to the aquatic biota indicator. Approximately 30 percent of subwatersheds rated Functioning at Risk or Impaired Function lack sufficient water to support aquatic biota, as opposed to the 20 percent that are water limited with respect to riparian/wetland vegetation. An additional factor contributing to departure in the aquatic biota indicator is that non-native species are present in approximately 70 percent of subwatersheds that support aquatic biota and are out-competing natives in approximately 38 percent of these. Aquatic biota are analyzed as an ecosystem characteristic later in this chapter.

The water quantity indicator is intended to capture significant changes in streamflow due to water diversions, water controls or wildfire. Water controls (e.g. dams and berms in drainages), or cumulative effects of relatively small irrigation diversions or controls are responsible for just over a quarter of the 42 percent of all subwatersheds rated as Functioning at Risk or Impaired Function with respect to this indicator (Figure 107) with wildfire effects responsible for the remainder.

Of subwatersheds rated Functioning at Risk or Impaired Function with respect to the water quality indicator (Figure 109), 23 contain streams that are not meeting State water quality standards for one or more reasons (i.e. 303(d) listed). Other water quality issues not resulting in 303(d) listings are primarily sediment and temperature related. Wildfire effects resulted in negative changes to this indicator score in 42 subwatersheds between the Gila NF's initial 2011 classification and 2016 update.

The roads and trails indicator scores reflect the attributes of road density, maintenance and proximity to water of all motorized linear transportation features. All of these attributes were identified issues in subwatersheds rated Functioning at Risk or Impaired Function. Lack of road maintenance is the largest concern across the Forest in terms of these attributes, followed by proximity to water and road density. Of the 26 percent of subwatersheds that are rated Functioning Properly (Figure 113), most are located primarily or entirely within wilderness areas.

Of the 69 percent of subwatersheds with soil condition indicator ratings of Functioning at Risk or Impaired Function (Figure 110), all are experiencing some degree of accelerated erosion and decreased productivity. This is due to fire effects in 38 subwatersheds. Soil condition, soil loss and productivity are discussed in further detail in Chapter 4 Soil. Soil contamination risk has been identified as an issue in approximately 38 percent subwatersheds with the risk of atmospheric deposition of nutrient nitrogen and/or acidic compounds being cited as the reason in most cases. Atmospheric deposition and contamination are discussed in further detail in both the Soil and Air Chapters. The contamination risk due to atmospheric deposition was rated for the Gila NF by the USDA Forest Service Washington Office. Old mines are the second most common risk factor (8 percent), with leaky underground fuel tanks and old landfills account for one percent each.

The fire regime/wildfire effects indicator scores (Figure 111) are affected by the Fire Regime Condition Class (FRCC) and or wildfire effects, not both (Potyondy and Geier 2011). FRCC is a departure rating from the historic range of variability in fuel composition, fire frequency, severity and pattern with low, moderate and high categories. Subwatersheds that are Functioning Properly with respect to this indicator (Figure 111) have a predominantly low departure from the natural fire regime or wildfire effects such that they are expected to recover in one to two years. Subwatersheds that are rated Functioning at Risk (Figure 111) with respect to this indicator are considered moderately departed from the historic fire regime or wildfire effects such that some increase in erosion and runoff are a concern, but long-term watershed integrity is not at risk. Recovery from wildfire effects is expected in two to five years. Subwatersheds that are considered Impaired Function (Figure 111) are highly departed from the natural fire regime or post-fire effects persist longer than five years and are a threat to long-term watershed integrity. All Impaired

Function ratings are due to wildfire effects. Of the Functioning at Risk ratings, approximately half are due to wildfire effects with the remainder being due to departures in the historic fire regime.

The forest cover indicator scores are affected by stand replacement fire or any other management activity that reduces forest cover. The 19 percent of subwatersheds that are Functioning at Risk or Impaired Function with respect to this indicator correspond directly to those subwatersheds rated as Impaired Function for the fire regime/wildfire effects indicator (Figure 112).

Although 99 percent of subwatersheds are rated Functioning Properly with respect to the forest health indicator (Figure 114), instances of insects and disease do occur on the Forest (see Upland Vegetation and System Drivers and Stressors Chapters for more information). The indicator rating reflects the degree of tree mortality expected or occurring due to insects, disease or air pollution. The Functioning Properly rating was assigned if these issues were present in less than 20 percent of the subwatershed. A rating of Functioning at Risk indicates problems in 20 to 40 percent of the subwatershed and Impaired Function indicates problems in more than 40 percent. No subwatersheds are rated Impaired Function for forest health and only two were rated Functioning at Risk. Some known issues, such as dwarf mistletoe infestation were not reflected in the ratings due to insufficient data. While this watershed scale assessment of insects and disease is not directly comparable to the Ecological Response Unit (ERU) scale analysis in the Upland Vegetation Chapter, at the Forest scale, the results validate each other.

In general, terrestrial invasive species are not well established on the Gila NF as compared to other forests in the Southwest. However, formal survey data is limited. This indicator relied primarily on local knowledge of existing populations. Ninety nine percent of subwatersheds are currently considered Functioning Properly with respect to this indicator (Figure 115). In the one percent rated Functioning at Risk, populations of bull thistle are identified the cause. While other invasive species may exist across the Forest, their populations are not known to meet the criteria that would move a subwatershed into a Functioning at Risk or Impaired Function rating. Invasive species are discussed further in the Upland Vegetation, Riparian and System Drivers and Stressors Chapters.

The rangeland vegetation indicator was scored by District range specialists referencing available data collected at permanent range monitoring sites, the national ruleset provided in the technical guide (Potyondy and Geier 2011) and professional judgement to rate this indicator. According to this data, 23 percent of subwatersheds are Functioning Properly, 70 percent are considered Functioning at Risk and 6 percent are Impaired Function (Figure 116). Range condition is discussed further in the Multiple Use Chapter.

Two watersheds are Impaired Function overall: Pueblo Creek-San Francisco River and Caballo Reservoir (Table 101). In Pueblo Creek-San Francisco River, part of this departure is due to changes in most indicator ratings in three subwatersheds as a result of the 2012 Whitewater Baldy Complex Fire. However, there are issues in this watershed that predate the Whitewater Baldy Complex Fire and analysis methods would still have shown a high departure in watershed condition. Pre-Whitewater Baldy, roads and trails, soil condition and rangeland vegetation indicator ratings were Functioning at Risk or Impaired Function in most subwatersheds and aquatic habitat fragmentation and nonnative aquatic species were identified issues as well. Pre-fire, all subwatersheds were associated with a moderate departure from the historic fire regime (Functioning at Risk). Post-fire, this remains the case where this indicator isn't rated Impaired Function because of the Whitewater Baldy Complex Fire. The 2013 Silver Fire had similar effects to indicator ratings in Caballo Reservoir. Prior to the Silver Fire, analysis methods would have depicted low departure in this watershed.

## Context Area

In terms of watershed condition, opportunities and limitations are determined by the percentage of subbasin area located within the Gila NF. Table 102 displays the subbasin extent and percentage occurring on Forest for the 11 context area subbasins.

**Table 102. Context area subbasin extent and Gila NF percent**

| | Subbasin Area | | |
|---|---|---|---|
| **Subbasin Name** | **Total (acres)** | **Gila NF (acres)** | **% On Gila NF** |
| Plains of San Agustin | 1,275,453 | 135,981 | 11 |
| Elephant Butte Reservoir | 1,403,516 | 40,451 | 3 |
| Caballo | 795,153 | 211,635 | 27 |
| El Paso-Las Cruces | 3,542,482 | 37,572 | 1 |
| Mimbres | 4,283,488 | 210,291 | 5 |
| Little Colorado Headwaters | 515,246 | 13,510 | 3 |
| Carrizo Wash | 1,446,531 | 197,142 | 14 |
| Upper Gila | 1,269,561 | 1,069,298 | 84 |
| Upper Gila-Mangas | 1,311,302 | 198,660 | 15 |
| Animas Valley | 1,449,526 | 59,574 | 4 |
| San Francisco | 1,793,569 | 1,097,383 | 61 |
| **Totals** | **19,085,827** | **3,271,497** | **17** |

Continuing with the five percent area threshold to determine which subwatersheds were classified, the Gila NF's ability to contribute to sustainability is limited to those subbasins with five percent or more occurring on National Forest System lands. The Gila NF alone constitutes five percent or more of Plains of San Agustin, Caballo, Mimbres, Carrizo Wash, Upper Gila, Upper Gila-Mangas and San Francisco subbasins. When including Apache-Sitgreaves and Cibola NFs, National Forest System lands constitute more than five percent of the Little Colorado Headwaters and Elephant Butte Reservoir subbasins. Figure 117 summarizes current conditions at the subbasin scale.

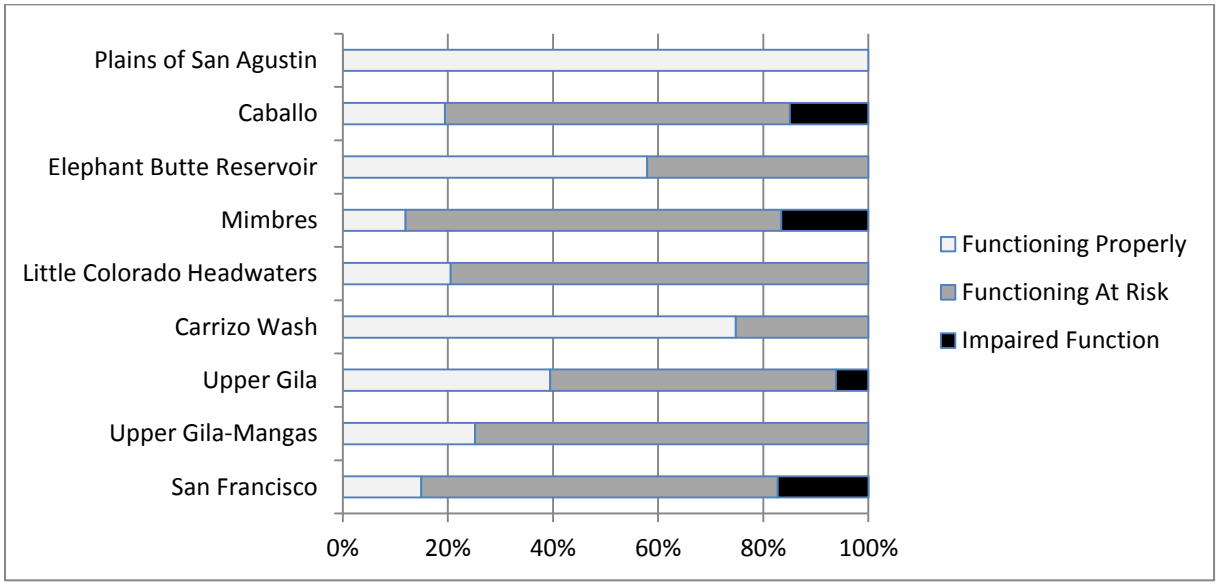


**Figure 117. Subbasin watershed conditions on the Gila NF**

In the Plains of San Agustin subbasin, all Gila NF acres are Functioning Properly, as are 75 percent of Forest acres in Carrizo Wash and 58 percent of Elephant Butte Reservoir. In other subbasins, watershed condition is Functioning at Risk overall with less than half of the area is Functioning Properly. Areas of Impaired Function occur in San Francisco, Upper Gila, Mimbres and Caballo subbasins.

Opportunities to contribute to sustainability by maintaining or improving subbasin watershed conditions exist in all nine of these subbasins. These opportunities increase with the percentage of the total area located on the Forest. Off-forest watershed conditions currently have little direct impact on overall watershed conditions within most subbasins because the majority of off-Forest area is located downhill and downstream. Severe watershed degradation would have to occur in order for impacts to be realized uphill and upstream. This is true to a lesser extent in the San Francisco subbasin and Upper Gila-Mangas where off-forest watershed conditions could potential have greater impact on watershed condition within Gila NF. This is due to topographic factors, as well as patterns of landownership and use.

### Risk

As stated in the discussion of analysis methods, risk is a direct interpretation of the watershed classification. Risk is assessed using the risk matrix below based on the departure classifications in Table 101. The results of the risk assessment for plan area watersheds follows Table 103 as Figure 118.

**Table 103. Risk matrix for watershed condition**

| Departure Classification | Risk Assessment |
|---|---|
| Functioning Properly | Low Risk |
| Functioning at Risk | Moderate Risk |
| Impaired Function | High Risk |

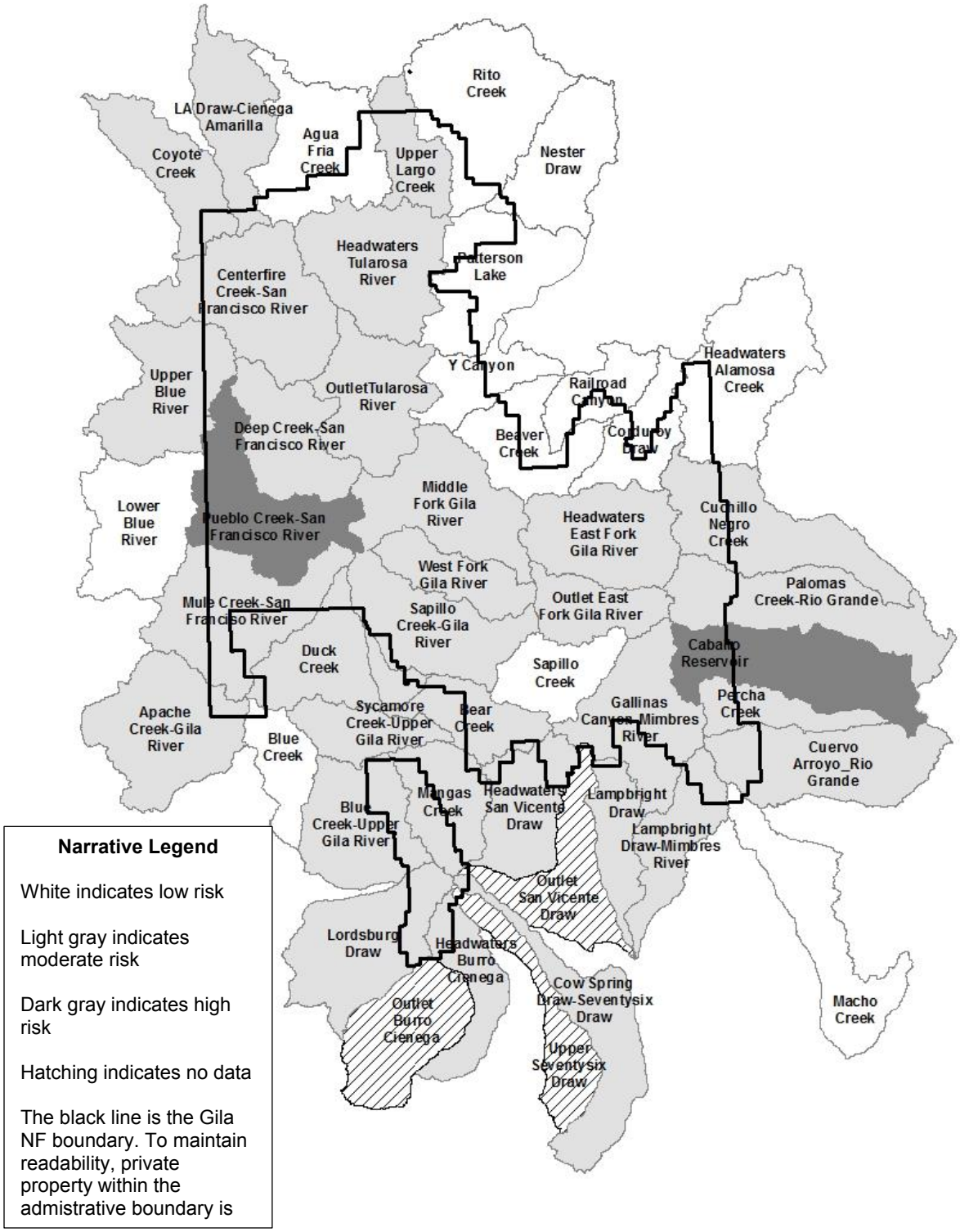


**Figure 118. Risk to watershed condition across the plan area**

Fourteen of the 49 plan area watersheds are associated with a low risk to overall watershed condition under current management, 30 watersheds are associated with moderate risk and two watersheds with high risk. Recall that three watersheds do not have classifications because no subwatershed within those watersheds has one percent of its total area located on National Forest System lands. The largest percentage of the Forest is associated with a moderate risk to watershed condition based on the same approach as was used at the watershed level. Subwatershed indicator ratings identify factors contributing to risk. Table 104 displays the percent of indicator scores within the low, moderate and high risk categories that are not Functioning Properly.

**Table 104. Subwatershed indicators contributing to watershed risk**

| | Percent of Subwatershed Indicator Ratings not Functioning Properly | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Watershed Risk Rating | Aquatic Biota | Riparian/Wetland Vegetation | Water Quality | Water Quantity | Aquatic Habitat | Roads and Trails | Soil Condition | Fire Regime or Wildfire Effects | Forest Cover | Forest Health | Terrestrial Invasive Species | Rangeland Vegetation Condition |
| Low | 19 | 14 | 5 | 17 | 14 | 18 | 45 | 86 | 2 | 0 | 0 | 81 |
| Moderate | 73 | 72 | 48 | 49 | 70 | 79 | 74 | 97 | 23 | <1 | <1 | 75 |
| High | 85 | 85 | 46 | 54 | 77 | 69 | 92 | 92 | 30 | 8 | 0 | 69 |

Local unit risk was determined by calculating the percentage of the local unit area represented by each watershed risk rating. The risk rating representing the largest percentage was assigned to the local unit. All local units are associated with a moderate risk to watershed condition under current management except Little Colorado-San Agustin Fringe in which there is a low potential risk. The following table provides the same information for watersheds presented in Table 105 above for each local unit.

**Table 105. Subwatershed indicators contributing to local unit risk**

| | Percent of Subwatershed Indicator Ratings not Functioning Properly | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local Unit | Aquatic Biota | Riparian/Wetland Vegetation | Water Quality | Water Quantity | Aquatic Habitat | Roads and Trails | Soil Condition | Fire Regime or Wildfire Effects | Forest Cover | Forest Health | Terrestrial Invasive Species | Rangeland Vegetation Condition |
| Apache | 85 | 81 | 44 | 67 | 78 | 89 | 63 | 96 | 11 | 0 | 0 | 100 |
| Black Range | 44 | 51 | 32 | 39 | 51 | 80 | 61 | 90 | 24 | 10 | 0 | 68 |
| Little Colorado – San Agustin Fringe | 36 | 40 | 23 | 30 | 36 | 62 | 62 | 94 | 2 | 0 | 2 | 89 |
| Mogollon Front | 68 | 71 | 32 | 38 | 74 | 79 | 88 | 94 | 24 | 0 | 3 | 82 |
| Upper Gila | 79 | 74 | 84 | 21 | 79 | 53 | 74 | 0 | 68 | 5 | 0 | 37 |
| Lower Gila | 91 | 67 | 45 | 39 | 27 | 82 | 70 | 97 | 6 | 0 | 0 | 76 |

Most low risk watersheds have relatively few perennial or intermittent stream miles on the Forest, with the exception of Sapillo Creek, therefore there is less risk associated with aquatic biota, aquatic habitat, and riparian/wetland vegetation. The risk in most low risk watersheds is the result of moderate departure in the historic fire regime and rangeland vegetation indicators that are Functioning at Risk. Low severity fire mitigates risk of large extents of high and moderate burn severity, and therefore risk to watershed condition. In most of these watersheds, restoration of the historic fire regime and herbivory by livestock and wildlife compete for the same resource; that is to say forage available to support wildlife and livestock is also the fine fuels necessary to carry fire. Almost half of these low risk watersheds also have soil conditions (i.e. productivity and erosion) that are Functioning at Risk, and in a few instances, Impaired Function. This risk is due in large part to reduction in soil functions related to historic livestock grazing practices that are no longer practiced. However it is also influenced by current livestock grazing management and in most of these low risk watersheds, herbivory by elk. While current livestock management has allowed for improvements in soil condition and range condition trends across the Forest are generally stable to slightly upward (Multiple Uses Chapter), current management slows natural recovery of soil functions that were altered by historic practices.

These dynamics are also at work to varying degrees in moderate and high risk watersheds and all local units, as reflected in the percentages of indicator scores not Functioning Properly (Table 104 and Table 105). On the other hand, wildfire effects due to large areas of high and moderate burn severity contribute to risk in both high risk watersheds and some moderate risk watersheds. This is not a risk factor in low risk watersheds. Wildfire effects pose risk to aquatic habitat, riparian/wetland vegetation, water quantity, water quality, soil condition and forest cover indicators, but in some cases have favored native aquatic species (see Aquatic Biota subsection of this chapter).

Roads and trails are also a significant contributor to risk to soil condition, aquatic habitat, water quality and therefore aquatic biota. Roads and trails, herbivory and fire represent the primary system drivers and stressors to overall watershed condition on the Gila NF that are within the ability and authority of the Forest to manage. The System Drivers and Stressors Chapter also contains greater detail concerning all watershed condition drivers and stressors and their historic and current status on the Forest.

While not within the ability or authority of the Forest to control or influence, climate change is major stressor that elevates the risk to watershed condition. Climate change, its potential effects to watershed condition and watershed vulnerability to climate change are discussed in detail in the System Drivers and Stressors Chapter. On the basis of a moderate or greater vulnerability to climate change, which is the case for all Gila NF watersheds, local units and the Forest as a whole, all low risk ratings are elevated to moderate, and moderate is elevated to high risk. Although climate change is outside the ability or authority of the Forest to control or influence, Forest management has opportunities to mitigate associated risk by maintaining, improving or restoring watershed processes.

## Perennial and Intermittent Streams

Streams can be classified as perennial, intermittent or ephemeral by seasonal variations of flow. Ephemeral streams experience relatively short duration flow only in direct response to surface runoff from precipitation or snow melt. Perennial streams typically flow year round as they receive contributions from both surface runoff and groundwater. Intermittent streams fall between perennial and ephemeral types as groundwater contributions are seasonal. Along the full length of any one stream, there may be stretches that could be classified differently. Elevation, bedrock type and topography; bank, floodplain and channel bed materials; channel geometry; and the valley size and shape are a few of the factors that can influence these flow regimes.

Streams, especially perennial and intermittent streams, are important water sources that support terrestrial, riparian and aquatic ecosystems, as well as human uses. This section is an assessment of where, and at what densities these streams exist across the landscape.

### Analysis Methods

Limited information is available to describe a reference condition for the extent and distribution of these water resource features; therefore, an alternative methodology is required. Representativeness and redundancy analysis is used instead of departure and trend analysis to facilitate risk assessment.

Representativeness is descriptive of current conditions, and substitutes for a departure rating. It is based on three assumptions:

1) There is a “representative” range of specific water feature conditions associated with a characteristic across the landscape.

2) A wide range of hydrologic feature conditions will sustain the highest degree of biodiversity.

3) A higher representativeness, leading to a wider range of conditions, creates a more sustainable ecosystem.

Representativeness is evaluated by calculating the proportional occurrence of a characteristic on the Forest at a given scale (e.g. watershed) compared to that found at the next larger scale (e.g. subbasin). The resulting value is a stream density ratio. A rating of proportional, overrepresented, or underrepresented is assigned based on how close the resulting value is to one. A value of one indicates that the stream density on the Gila NF is similar to the stream density outside the Forest. Values between 0.9 and 1.1 are considered proportionally represented. The majority of subwatersheds have values in this range which was the basis for establishing these thresholds. Values below this range are underrepresented and indicate lower stream densities on the Forest as compared to lands off Forest. Values above this range are overrepresented and indicate higher stream densities on the Forest as compared to lands off Forest.

Redundancy describes the distribution of a characteristic across the landscape. It is based on the assumption that finding a characteristic in multiple, evenly distributed places increases the likelihood of maintaining representativeness and decreases the risk of losing that characteristic, or a specific condition of that characteristic, through a single disturbance event. Either a characteristic is redundant, or it is not. This is evaluated by answering the question: does the characteristic occur in every subunit on the Forest within the larger area? For example, the Outlet East Fork Gila River watershed contains five subwatersheds. Perennial streams are present in four of these watersheds, and are absent in one subwatershed; therefore, perennial streams are not considered redundant in the Outlet East Fork Gila River watershed.

What is known about the current and historic distribution of native fishes, analyzed as a key characteristic in the following subsection, also provides an important perspective relative to perennial streams. That information is used as a “stop-check” to validate or refine the assessment of risk to perennial streams.

Limitations of the representativeness and redundancy approach include the fact that the assumptions it is based on may or may not hold true in the environment. Additionally, it is a purely mathematical analysis approach and does not incorporate consideration of system drivers and stressors as do other methodologies used in the ecological assessment.

## Plan Area

Table 106 lists each of the 49 plan area watersheds and displays total watershed area, watershed area located on Forest, total perennial and intermittent stream miles and percentage occurring on and off-Forest. Appendix D contains a table displaying similar information, but also includes subwatersheds with the addition of subwatersheds.

**Table 106. Extent and distribution of perennial and intermittent stream miles for plan area watersheds and the Gila NF**

| | Watershed Area | | | Perennial Stream Miles | | | Intermittent Stream Miles | | |
|---|---|---|---|---|---|---|---|---|---|
| Watershed Name | Total (acres) | Gila NF (acres) | % Gila NF | Total | On Gila NF | % On Gila NF | Total | On Gila NF | % on Gila NF |
| *Plains of San Agustin Subbasin* | | | | | | | | | |
| Nester Draw | 169,190 | 5,328 | 3 | 0.2 | 0 | 0 | 3.8 | 0.4 | 10 |
| Patterson Lake | 207,398 | 78,514 | 38 | 0.5 | 0.5 | 100 | 18.5 | 10.3 | 56 |
| Y Canyon | 97,476 | 52,140 | 38 | 0 | 0 | -- | 0 | 0 | -- |
| *Elephant Butte Reservoir Subbasin* | | | | | | | | | |
| Headwaters Alamosa Creek | 257,399 | 40,451 | 16 | 1.4 | 0 | 0 | 80.3 | 17.2 | 21 |
| *Caballo Subbasin* | | | | | | | | | |
| Caballo Reservoir | 247,026 | 52,993 | 21 | 47.8 | 26.1 | 55 | 58.6 | 21.0 | 36 |

| Watershed Name | Watershed Area Total (acres) | Watershed Area Gila NF (acres) | Watershed Area % Gila NF | Perennial Stream Miles Total | Perennial Stream Miles On Gila NF | Perennial Stream Miles % On Gila NF | Intermittent Stream Miles Total | Intermittent Stream Miles On Gila NF | Intermittent Stream Miles % on Gila NF |
|---|---|---|---|---|---|---|---|---|---|
| Cuchillo Negro Creek | 236,142 | 76,046 | 32 | 29.7 | 18.3 | 62 | 86.2 | 44.6 | 52 |
| Palomas Creek-Rio Grande | 234,606 | 57,833 | 25 | 49.0 | 19.5 | 40 | 41.6 | 24.4 | 59 |
| Percha Creek | 77,379 | 24,763 | 32 | 34.3 | 9.9 | 29 | 16.5 | 9.1 | 55 |
| *El Paso-Las Cruces Subbasin* | | | | | | | | | |
| Cuervo Arroyo-Rio Grande | 226,938 | 37,572 | 17 | 21.2 | 6.6 | 31 | 52.2 | 6.1 | 12 |
| *Mimbres Subbasin* | | | | | | | | | |
| Cow Spring Draw-Seventysix Draw | 184,549 | 3,070 | 2 | 0 | 0 | -- | 0 | 0 | -- |
| Gallinas Canyon-Mimbres River | 205,881 | 151,448 | 74 | 83.1 | 74.3 | 89 | 73.0 | 23.2 | 32 |
| Headwaters San Vicente Draw | 144,197 | 26,072 | 18 | 4.1 | 3.6 | 89 | 46.5 | 7.3 | 16 |
| Lampbright Draw | 92,105 | 2,351 | 3 | 0 | 0 | -- | 0 | 0 | -- |
| Lampbright Draw-Mimbres River | 124,477 | 20,713 | 17 | 1.5 | 0.1 | 5 | 50.1 | 6.2 | 12 |
| Macho Creek | 213,735 | 3,641 | 2 | 0 | 0 | -- | 0 | 0 | -- |
| Outlet San Vicente Draw | 160,634 | 1,684 | 1 | 0 | 0 | -- | 0 | 0 | -- |
| Upper Seventysix Draw | 114,409 | 1,313 | 1 | 0 | 0 | -- | 0.5 | 0.5 | 100 |
| *Little Colorado Headwaters Subbasin* | | | | | | | | | |
| Coyote Creek | 147,501 | 13,510 | 9 | 32.6 | 0.7 | 2 | 32.4 | 0.3 | 1 |
| *Carrizo Wash Subbasin* | | | | | | | | | |
| Agua Fria Creek | 218,968 | 76,850 | 35 | 19.3 | 6.7 | 35 | 2.2 | 2.0 | 89 |
| LA Draw-Cienega Amarilla | 160,256 | 7,918 | 5 | 7.4 | 0.4 | 6 | 0 | 0 | -- |
| Rito Creek | 279,878 | 37,218 | 13 | 6.3 | 3.7 | 59 | 10.5 | 3.9 | 37 |
| Upper Largo Creek | 98,300 | 75,156 | 76 | 19.3 | 6.7 | 35 | 8.2 | 2.8 | 34 |
| *Upper Gila Subbasin* | | | | | | | | | |
| Beaver Creek | 147,638 | 79,799 | 54 | 0 | 0 | -- | 5.0 | 5.0 | 100 |
| Corduroy Draw | 111,118 | 68,279 | 61 | 11.9 | 6.7 | 56 | 11.4 | 10.6 | 93 |
| Headwaters East Fork Gila River | 193,943 | 192,473 | 99 | 68.6 | 60.2 | 88 | 41.1 | 39.3 | 96 |
| Middle Fork Gila River | 218,844 | 218,128 | >99 | 96.6 | 94.1 | 97 | 18.5 | 18.5 | 100 |
| Outlet East Fork Gila River | 104,412 | 103,887 | 99 | 56.4 | 53.3 | 94 | 11.5 | 11.5 | 100 |
| Railroad Canyon | 89,105 | 14,046 | 16 | 0 | 0 | -- | 0 | 0 | -- |
| Sapillo Creek | 110,693 | 108,907 | 98 | 45.3 | 40.5 | 89 | 15.8 | 14.4 | 91 |

| Watershed Name | Watershed Area Total (acres) | Watershed Area Gila NF (acres) | Watershed Area % Gila NF | Perennial Stream Miles Total | Perennial Stream Miles On Gila NF | Perennial Stream Miles % On Gila NF | Intermittent Stream Miles Total | Intermittent Stream Miles On Gila NF | Intermittent Stream Miles % on Gila NF |
|---|---|---|---|---|---|---|---|---|---|
| Sapillo Creek-Gila River | 189,860 | 181,341 | 96 | 139.9 | 135.3 | 97 | 27.2 | 20.4 | 75 |
| West Fork Gila River | 103,948 | 102,439 | 99 | 86.3 | 81.0 | 94 | 11.9 | 11.9 | 100 |
| *Upper Gila-Mangas Subbasin* | | | | | | | | | |
| Apache Creek-Gila River | 237,306 | 12,270 | 5 | 1.4 | 0.7 | 49 | 125.0 | 4.9 | 4 |
| Bear Creek | 103,985 | 65,069 | 63 | 10.5 | 2.8 | 26 | 70.8 | 46.2 | 65 |
| Blue Creek | 88,931 | 3,428 | 4 | 20.6 | 0 | 0 | 0 | 0 | -- |
| Blue Creek-Upper Gila River | 186,504 | 46,732 | 25 | 33.5 | 11.7 | 35 | 42.1 | 11.2 | 26 |
| Duck Creek | 144,993 | 16,862 | 12 | 12.4 | 5.7 | 46 | 30.7 | 0 | 0 |
| Mangas Creek | 130,597 | 50,698 | 39 | 0.4 | 0.4 | 100 | 31.6 | 6.0 | 19 |
| Sycamore Creek-Upper Gila River | 121,829 | 3,601 | 3 | 17.1 | 1.1 | 6 | 0.5 | 0.4 | 94 |
| *Animas Valley Subbasin* | | | | | | | | | |
| Headwaters Burro Cienega | 109,203 | 17,666 | 16 | 0 | 0 | 0 | 8.2 | 0.1 | 1 |
| Lordsburg Draw | 221,184 | 41,617 | 19 | 4.2 | 2.2 | 53 | 0 | 0 | -- |
| Outlet Burro Cienega | 179,037 | 291 | <1 | <0.1 | 0 | 0 | 0 | 0 | -- |
| *San Francisco Subbasin* | | | | | | | | | |
| Centerfire Creek-San Francisco River | 267,108 | 207,266 | 78 | 145.9 | 64.0 | 44 | 119.8 | 41.1 | 34 |
| Deep Creek-San Francisco River | 153,321 | 149,537 | 98 | 60.6 | 49.2 | 81 | 20.1 | 19.3 | 96 |
| Headwaters Tularosa River | 225,391 | 211,838 | 94 | 39.3 | 10.5 | 27 | 25.3 | 18.4 | 73 |
| Lower Blue River | 198,105 | 277 | <1 | 90.0 | 0 | 0 | 410.0 | 0.5 | <1 |
| Mule Creek-San Francisco River | 244,422 | 121,064 | 50 | 82.7 | 51.3 | 62 | 161.1 | 15.4 | 10 |
| Outlet Tularosa River | 184,206 | 180,493 | 98 | 54.6 | 39.4 | 72 | 8.2 | 8.2 | 100 |
| Pueblo Creek-San Francisco River | 226,379 | 198,993 | 88 | 81.7 | 63.5 | 78 | 76.5 | 52.9 | 69 |
| Upper Blue River | 198,049 | 27,915 | 14 | 172.3 | 9.68 | 6 | 363.6 | 8.7 | 2 |
| **Total** | **8,388,553** | **3,271,497** | **39** | **1,688** | **956.7** | **57** | **2,227.4** | **545.9** | **25** |

Perennial stream density is generally higher on Forest largely because it occupies upper watershed areas where many streams originate (i.e. headwaters), and where precipitation is higher and temperatures are cooler. Cooler temperatures reduce transpiration and evaporative demand which aids in keeping water in streams for longer periods. As intermittent streams tend to occur at lower elevation and/or lower positions in the watershed, precipitation is generally lower and temperatures warmer. This makes bedrock type and topography, bank, floodplain and channel bed materials, channel geometry, and the valley size and shape

relatively stronger controls on flow regime. As these characteristics are highly variable from one watershed to another, intermittent stream density on the Gila NF is highly variable. The Forest's contribution to sustainability of perennial and intermittent stream miles increases with both percentage of miles and contributing watershed area on Forest.

The results of the representativeness and redundancy analysis for perennial stream miles, described under analysis methods, are displayed in Figure 119 and Figure 120 respectively, followed by the same information for intermittent stream miles in Figure 121 and Figure 122. Recall that watersheds that are proportionally representative have similar stream densities both on and off Forest. Those that are underrepresenative have lower stream densities on Forest compared to lands and those that are overrepresentative have higher stream densities on Forest as compared to other lands.

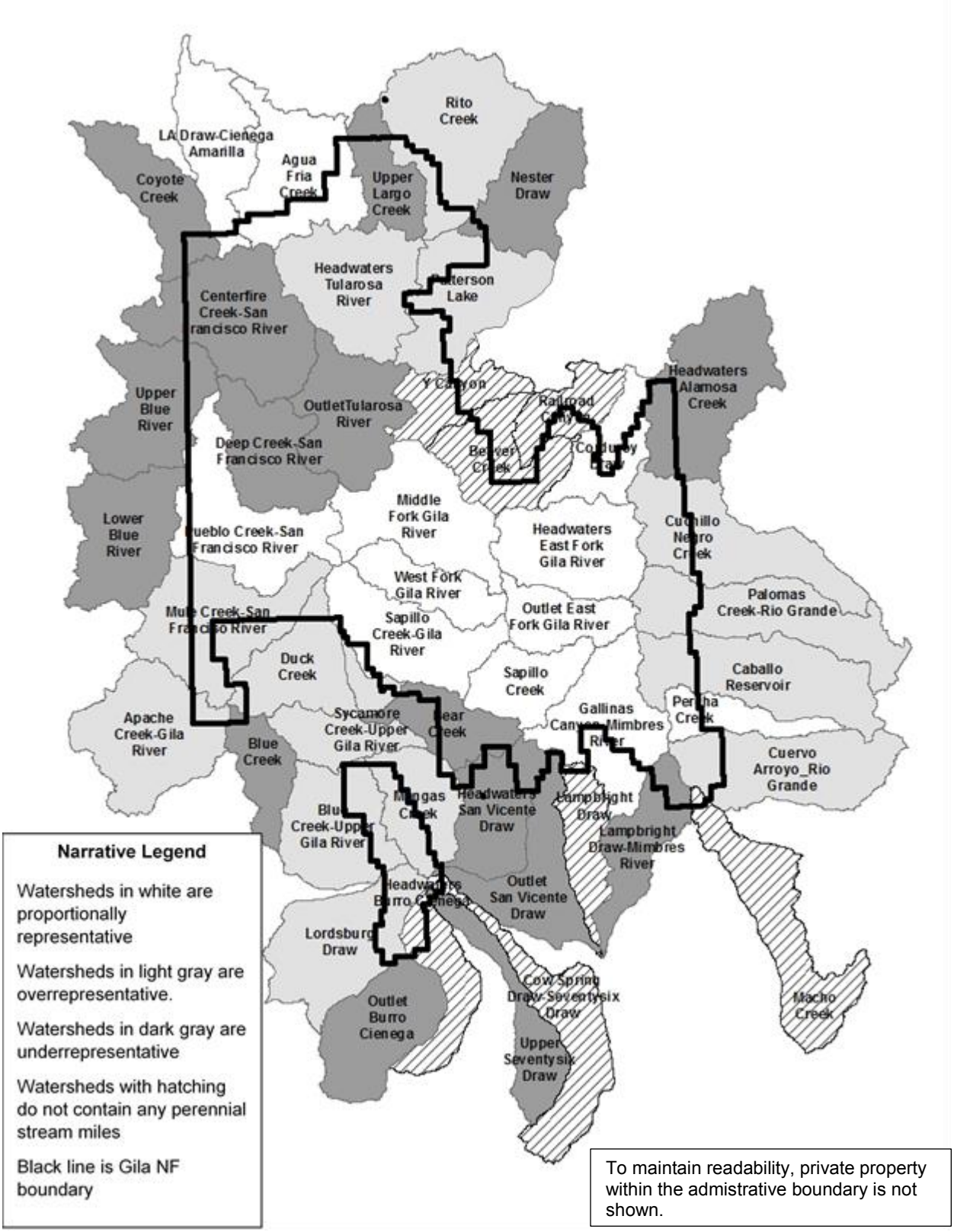


**Figure 119. Representativeness of perennial streams across the plan area**

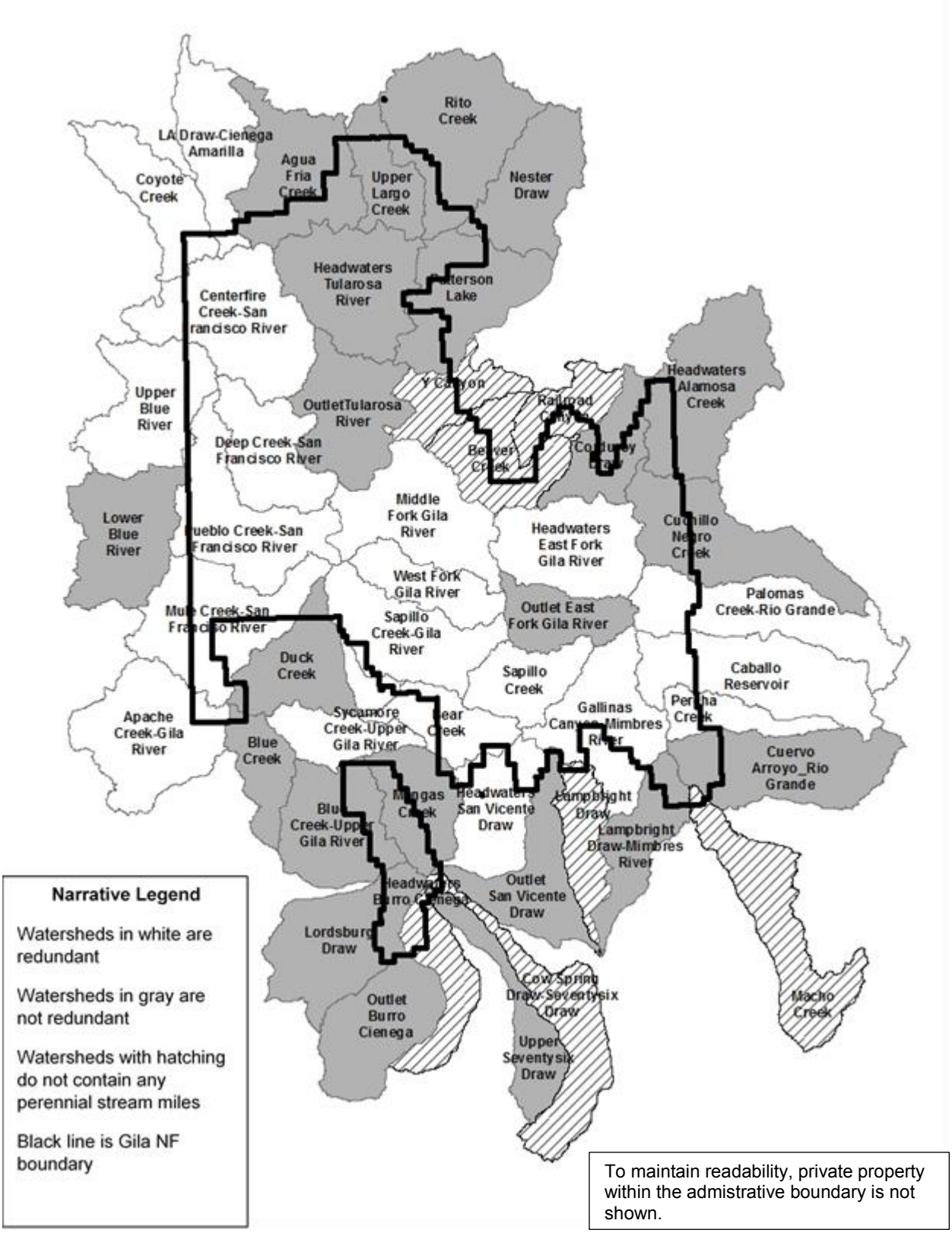


**Figure 120. Redundancy of perennial streams across the plan area**

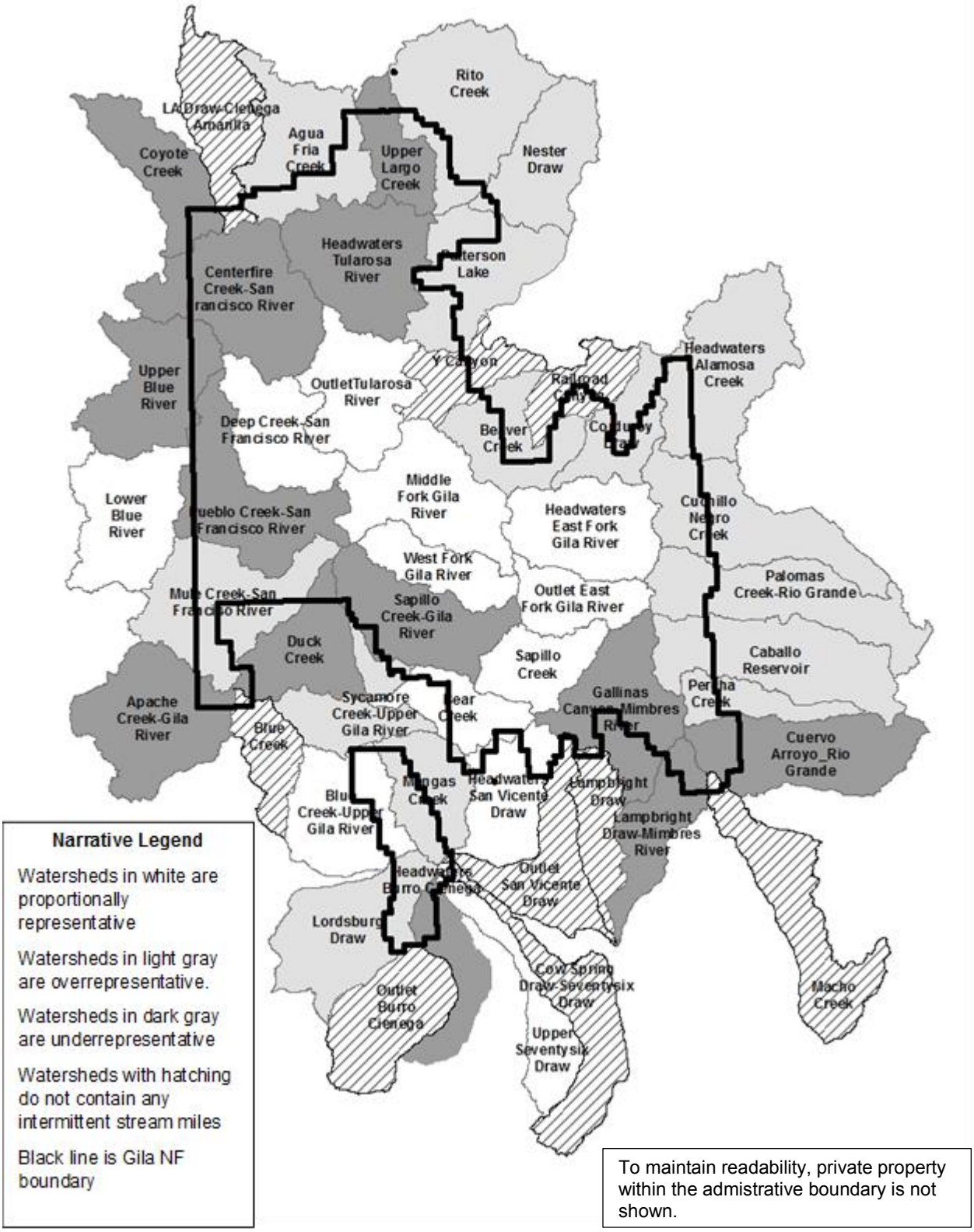


**Figure 121. Representativeness of intermittent streams across the plan area**

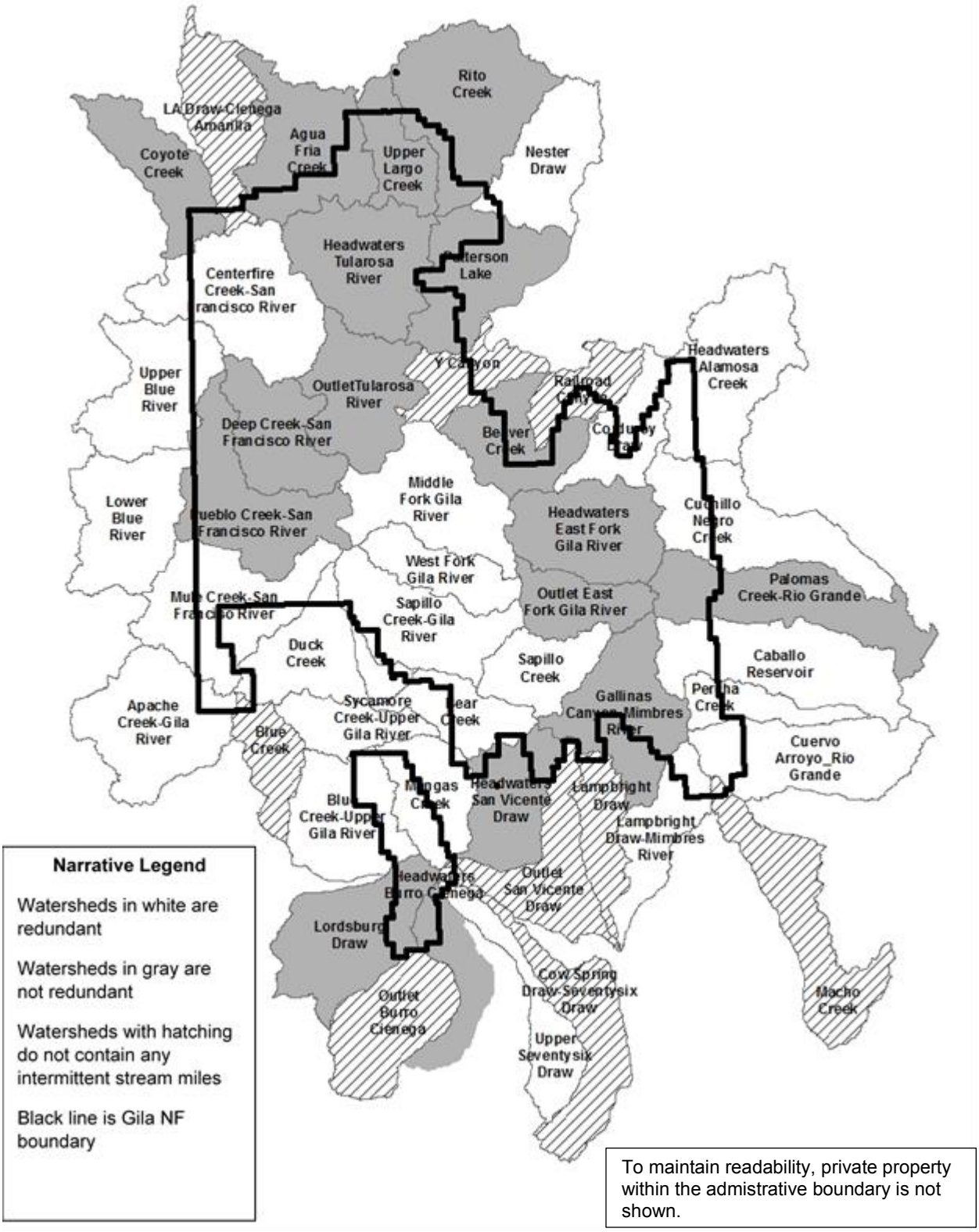


**Figure 122. Redundancy of intermittent streams across the plan area**

## Context Area

Table 107 displays perennial stream miles by subbasin, and the portion located within Forest. The Forests have been working with the USGS to improve the NHD. As part of this, the Forests have distinguished the difference between intermittent and ephemeral streams at the watershed scale. However, this has not been done for the context area outside of National Forest System lands. Therefore, similar data for intermittent streams at the subbasin level were not available.

**Table 107. Extent and distribution of perennial stream miles for subbasins within the context area and the Gila NF**

| | Subbasin Area | | | Perennial Stream Miles | | |
|---|---|---|---|---|---|---|
| **Subbasin Name** | **Total (acres)** | **Gila NF (acres)** | **Gila NF (%)** | **Total** | **On Gila NF** | **% on Gila NF** |
| Plains of San Agustin | 1,275,453 | 135,981 | 11 | 0.7 | 0.5 | 76 |
| Elephant Butte Reservoir | 1,403,516 | 40,451 | 3 | 74.3 | 0 | -- |
| Caballo | 795,153 | 211,635 | 27 | 160.8 | 73.8 | 46 |
| El Paso-Las Cruces | 3,542,482 | 37,572 | 1 | 116.0 | 6.6 | 6 |
| Mimbres | 4,283,488 | 210,291 | 5 | 98.6 | 78.0 | 79 |
| Little Colorado Headwaters | 515,246 | 13,510 | 3 | 268.5 | 0.7 | <1 |
| Carrizo Wash | 1,446,531 | 197,142 | 14 | 43.6 | 14.0 | 32 |
| Upper Gila | 1,269,561 | 1,069,298 | 84 | 504.9 | 471.0 | 93 |
| Upper Gila-Mangas | 1,311,302 | 198,660 | 15 | 100.9 | 22.3 | 22 |
| Animas Valley | 1,449,526 | 59,574 | 4 | 4.2 | 2.2 | 52 |
| San Francisco | 1,793,569 | 1,097,383 | 61 | 759.8 | 287.5 | 38 |
| **Totals** | **19,085,827** | **3,271,497** | **17** | **2,132.1** | **956.7** | **45** |

The Gila NF occupies 17 percent of the context area and contains 45 percent of perennial stream miles. The opportunities for the Forest to contribute to sustainability of perennial streams is proportional to the percentage of miles and contributing watershed area located on Forest. Opportunities are only indirect in the case of Elephant Butte, and relatively small in Little Colorado Headwaters and El Paso-Las Cruces subbasins. The Forest's contributions are greatest in Upper Gila because of the high proportion of both watershed area and perennial miles. The Forest is a significant contributor in San Francisco and in Upper Gila-Mangas, largely because the Upper Gila drains to it. Despite the relatively small percentage of subbasin area on Forest, it remains the primary contributor to sustainability of perennial streams in the Mimbres. Regardless of the low number of perennial miles in Animas Valley and Plains of San Agustin, these streams are no less important and the Forest is a significant contributor to sustainability. While equivalent data is not available to describe the Forest's opportunities and limitations for intermittent streams, they certainly exist in subbasin watersheds that contain intermittent streams on the Forest.

## Risk

The results of the representativeness and redundancy analysis are applied to the assessment of risk to the extent and distribution of perennial and intermittent stream miles using the matrix displayed as Table 108. In watersheds that do not contain any perennial or intermittent stream miles within subwatersheds that intersect the Forest boundary, there is no risk.

**Table 108. Risk matrix for representativeness and redundancy analysis results.**

| | Redundant | Not Redundant |
|---|---|---|
| Proportionally Represented | Low Risk | Moderate Risk |
| Not Proportionally Represented | Moderate Risk | High Risk |

The results of the watershed scale risk assessment are presented in Figure 123 (perennial) and Figure 124 (intermittent).

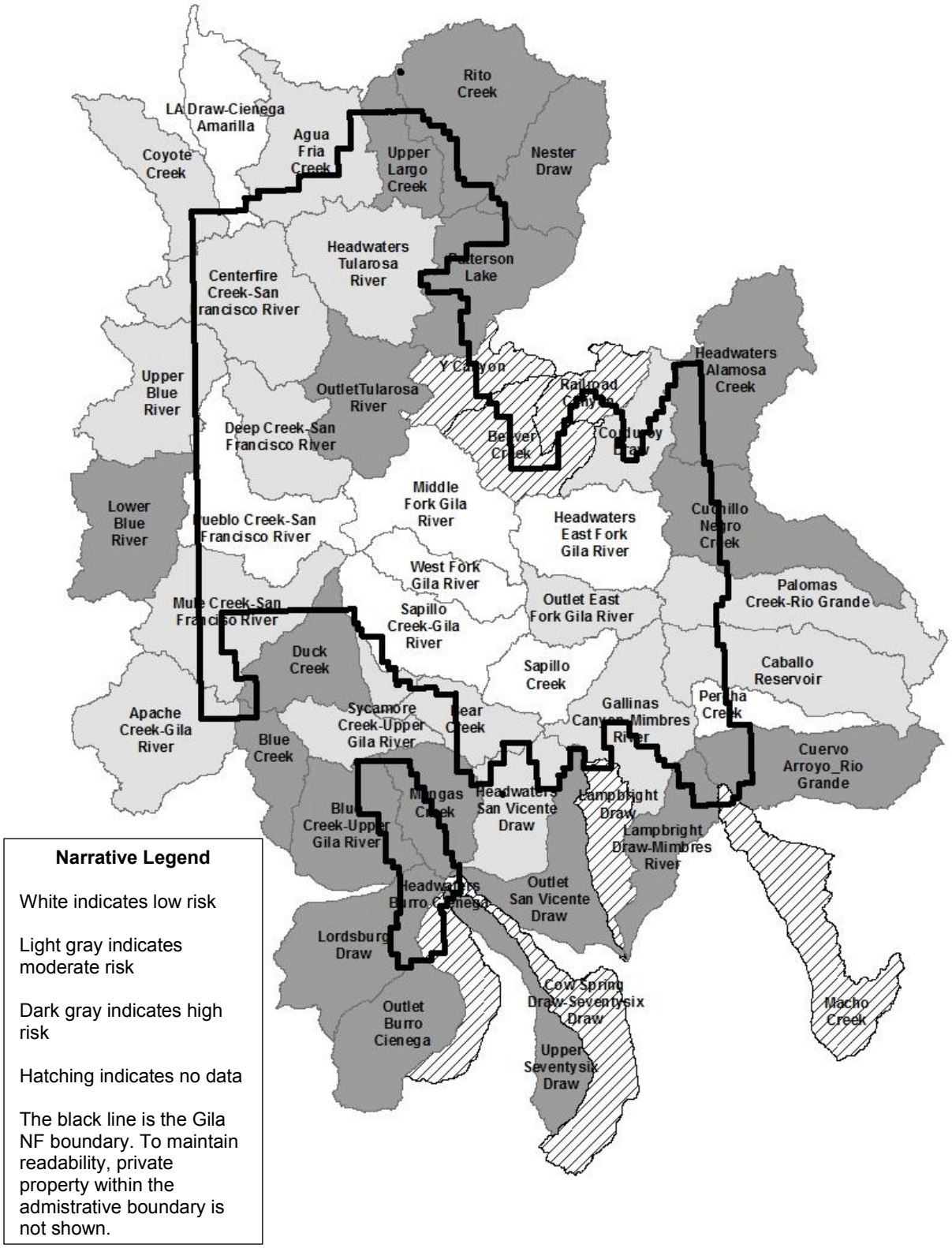


**Figure 123. Risk to perennial streams across the plan area.**

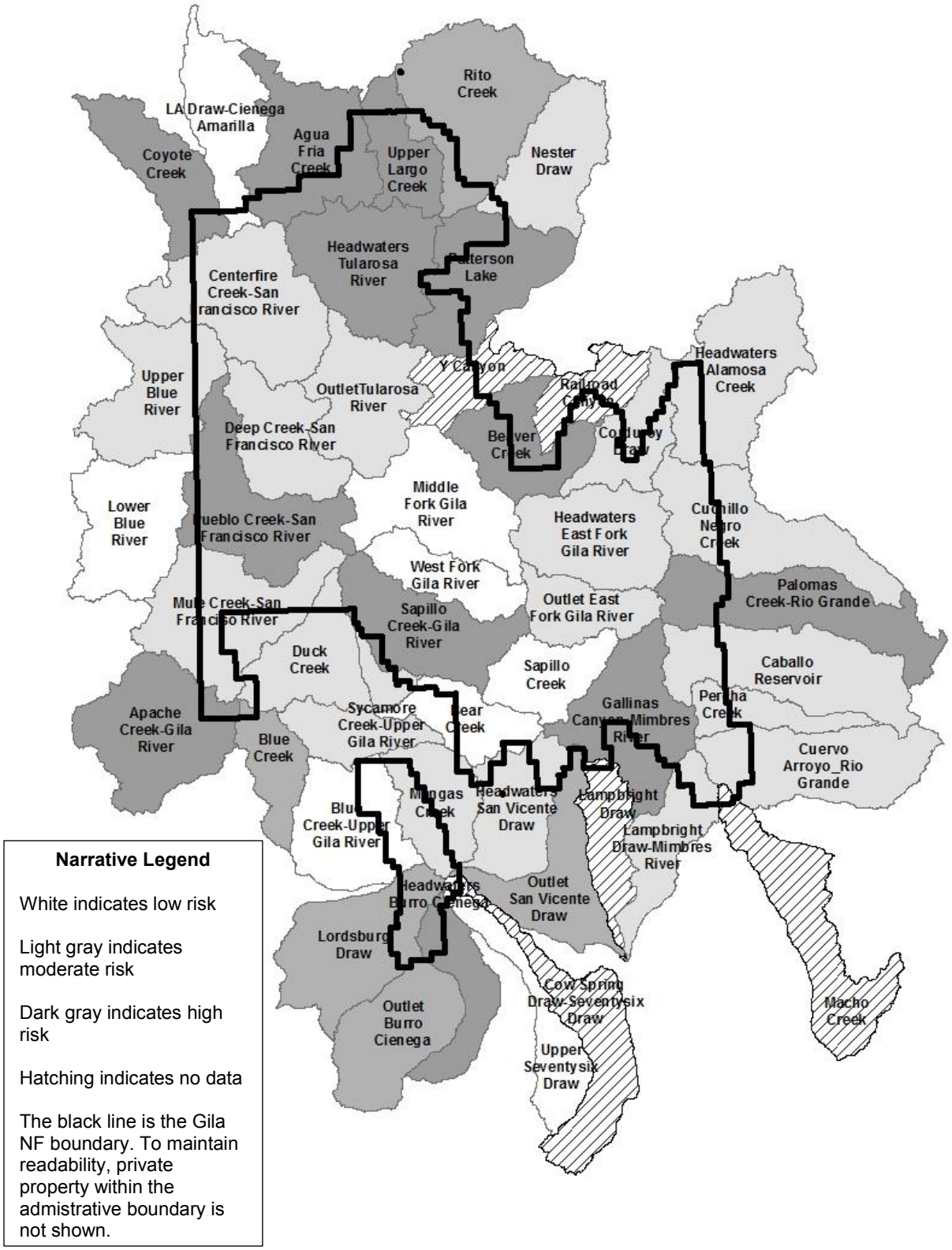


**Figure 124. Risk to intermittent streams across the plan area.**

There is no relationship between risk interpreted from the representativeness and redundancy analysis and the status of system drivers or stressors, including Gila NF management. Rather, it is mostly a reflection of climatic factors and patterns of land ownership. Private property within the Gila NF administrative boundary tends to be located near water sources, which leads to perennial and/or intermittent streams to be underrepresented on Forest in some cases where it might appear reasonable to expect proportional representation. While Forest management can contribute to the sustainability of water occurring as perennial an intermittent streams by maintaining and improving watershed condition, climate change and competition between ecological and socio-economic demands for water are the primary stressors contributing to risk as discussed in the System Drivers and Stressors Chapter.

Forest and local unit risk is assessed by assigning each local unit the risk category associated with the majority of its area. Based on this approach, the Forest as a whole is associated with a moderate risk, Upper Gila local unit is associated with a low risk to perennial streams and all other local units with a moderate risk. With respect to intermittent streams, Forest-wide risk is moderate, Upper and Lower Gila local units are associated with a low risk and all other local units with a moderate risk. The difference between perennial and intermittent stream risk in Lower Gila is a reflection both stream density and distribution, not the value these features provide. In general, intermittent streams densities on Forest are similar to other lands in this local unit and their distribution is more even than perennial streams.

## Streamflow

In general, streamflow has two primary components: base flow and surface runoff. Base flow comes from groundwater that flows from springs or directly from the bed and banks of stream channels. Base flow maintains streamflow in perennial streams throughout the year and is particularly important during dry periods. Surface runoff is the result of rainfall and snowmelt. Surface runoff varies with the total amount of rainfall and the intensity, duration and extent of rainfall events. The influence of temperature, watershed condition, evapotranspiration rates, as well as soil depth, texture, structure and moisture content before the rainfall event are also important factors in determining runoff responses.

### Analysis Methods

Streamflow can be characterized in terms of the timing, magnitude, frequency, duration, and the variability associated with each characteristic. This section focuses on data from the six USGS streamflow gages located within the plan area on Mogollon Creek and the San Francisco, Gila, and Mimbres rivers.[33] Figure 125 displays the location of the streamflow gages.

[33] All streamflow gages used in this analysis lie within the plan area. One additional streamflow gage occurs within the context area on the Gila River near Virden, New Mexico. This gage was not analyzed as the difference in contributing watershed area between the Virden and Redrock gages is relatively small.

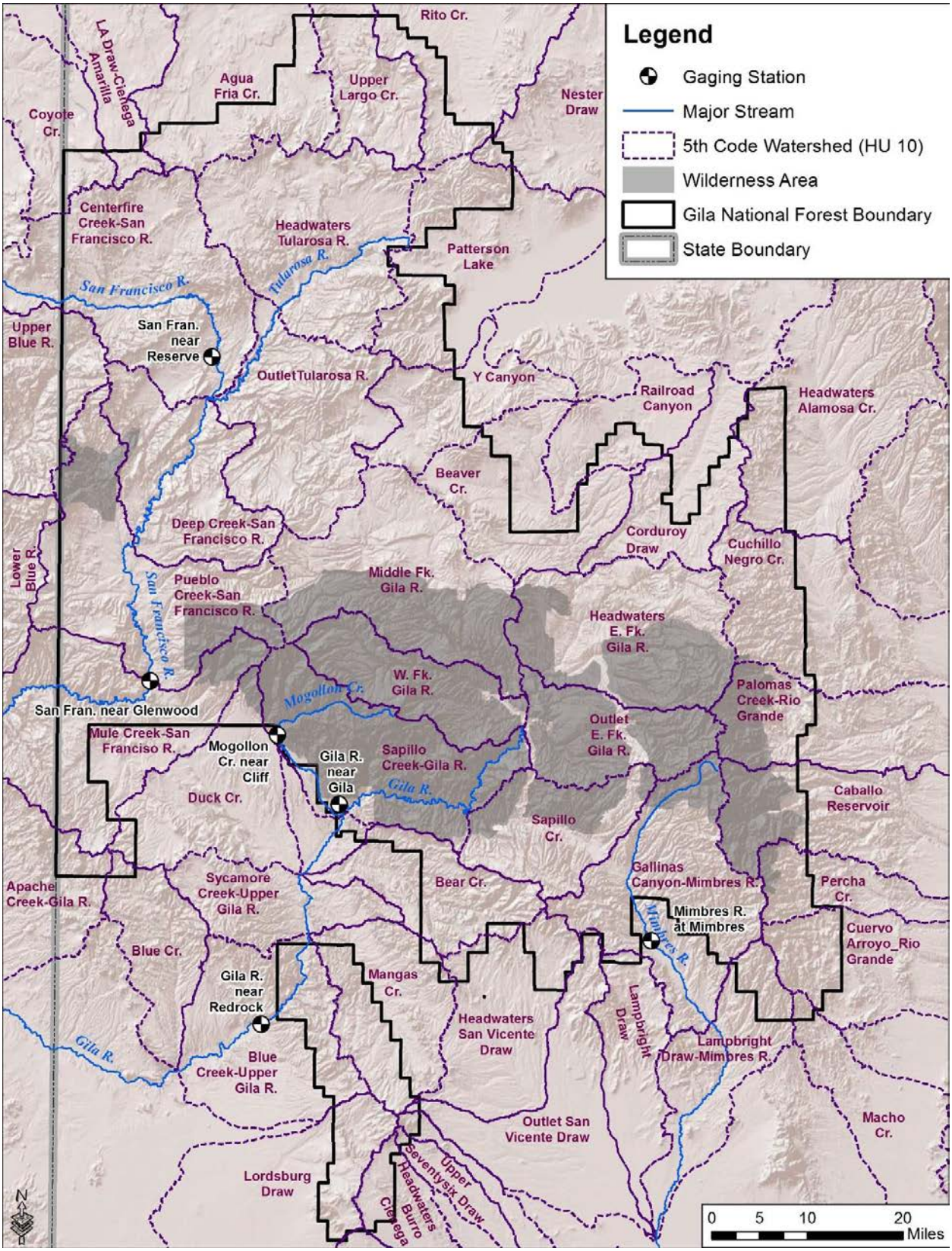


**Figure 125. Location of USGS gages used for streamflow analysis**

Quantitative streamflow records are not available for the time prior to European settlement, which necessitates establishing a reference period within the period of record. Since approximately 1990, a decreasing trend is observed in the precipitation record, accompanied by an increasing trend in temperature. As discussed under the climate change heading in the System Drivers and Stressors Chapter, mean annual temperature has not dipped below the period of record average since 1992. Based on these observations, the year 1990 was selected as the threshold year to define the reference time period for this assessment. This is also the threshold year used in developing the Climate Change Vulnerability Assessment (CCVA) for the Gila NF (Triepke 2015). The threshold is applied by using pre-1990 data to describe the reference period and post-1990 data to describe current conditions. Dividing the single period of record into reference and current time periods allows for a description of departure, but a third time period is needed to describe any trends. Trend is assessed using subset of the current time period beginning in the year 2000. The year 2000 has been used in other streamflow studies and was selected because it allows for the most direct comparison of these analysis results with the more rigorous Flood Frequency, Flow Duration, and Trends (England 2002) analysis in the Gila River Fluvial Geomorphology Study conducted by the Bureau of Reclamation (BOR). This study is discussed further later in this chapter.

However, using just six streamflow gages with relatively short periods of record to determine departure and trend in streamflow has limitations. A paleostreamflow reconstruction, extending back to the year 1663 and including the Gila and San Francisco Rivers gages, describes a high degree of natural variability in streamflow patterns as a defining characteristic and concluded that the reconstruction was best interpreted as a record of drought (Meko and Graybill 1995). Also, the instrumental record very likely represents higher than average precipitation period (Meko and Graybill 1995; Cook et al. 2011; Gori et al. 2014; also see the predominant climate regime discussion in the System Drivers and Stressors chapter, Chapter 9). The bottom line being that regardless of trends that may be interpreted in the gage data, area hydrology is the product of many natural and human caused changes over a much longer period of time than the instrumental record reflects. With such limited baseline data and high variability, change (i.e. departure) is very difficult to detect (McLean 1981).

Another consideration for all of gages except the San Francisco River near Reserve gage is that post-fire effects from recent uncharacteristic wildfires have altered watershed response and streamflow patterns. There is not yet a sufficient period of record to quantitatively describe the magnitude and duration of changes in flow, or to differentiate short and long term trends when considering annual and monthly values. In light of the limitations associated with the gage data analysis, the most accurate description of departure and trends in streamflow considers the gage data analysis, the BOR study (England 2002), historic and current distribution of native fishes, and the water quantity indicator from the watershed condition classification. Recall that the water quantity indicator provides qualitative documentation of altered streamflow resulting from water diversions, water controls and significant wildfire.

For watersheds with representation in the gage data, departure and trend is initially determined by the gage data and refined based on the water quantity indicator and aquatic biota data. If the water quantity indicator ratings capture wildfire effects or diversions that are not reflected in the gage data, departure is elevated to reflect the indicator rating that represents the largest percentage of the watershed if it is different from the gage data interpretation. Where native fish were present and are now completely absent, and there are no non-native fish, departure is elevated one category. For watersheds without representation in the gage data, the water quantity indicator and aquatic biota data are used to determine departure; again, with the departure category reflecting the indicator score that represents the largest percentage of the watershed. (i.e. Functioning Properly equates to low departure, Functioning at Risk equates to moderate departure and Impaired Function equates to high departure). The watershed condition classification is not suitable to assess trend. Therefore, trends are only defined where the gage data is applied.

## Plan Area

Average, or mean streamflow values are useful for describing the range of variability in flow characteristics. Median values are better for understanding the central tendency; in this case, how much water is typically in the stream at a given time and over what period of time.

At the San Francisco River gage near Reserve, mean annual flow has varied between a minimum of 4.8 cubic feet per second (cfs) in 2003 to 86.7 cfs in 1983. Median annual flow has varied between a minimum of 3.9 cfs (2009) and a maximum of 21 cfs (1983). Flows generally increase along the San Francisco River as it travels south and west from Reserve to the gage near Glenwood where the mean annual flow has ranged between 12 cfs (1986) and 374.9 cfs (1983). Median annual flows at this gage have varied from 11 cfs (1956) to 107 cfs (1941).

At the Mogollon Creek gage near Cliff, mean annual flow has varied between a minimum of 4.3 cfs (2000) and 85.2 cfs (1978). Median annual flows have varied between a minimum of 1.3 cfs (2000) and 29 cfs (1983). Just above the confluence with Mogollon Creek, mean annual flow at the Gila River gage near Gila has varied between 43 cfs (1956) and 413.7 cfs (1993). Median annual flow has varied between 44 cfs (1956) and 209 cfs (1941). As the Gila River continues west and south through the Burro Mountains, streamflow and variability increase. At the gage near Redrock, mean annual flow has ranged between 50.4 cfs (1951) and 635.6 cfs (1993) and median annual flows have ranged between 52 cfs (1953) and 318 cfs (1941). At the Mimbres River gage near Mimbres, mean annual flows have varied between a minimum of 3.1 cfs in 2003 and 41.7 cfs in 1992. Median flows have ranged between 3.1 cfs (2003) and 22 cfs (1991). Figure 126 illustrates annual variability in mean and median flows at the Mimbres gage across the period of record. Appendix D contains equivalent figures for all gages.

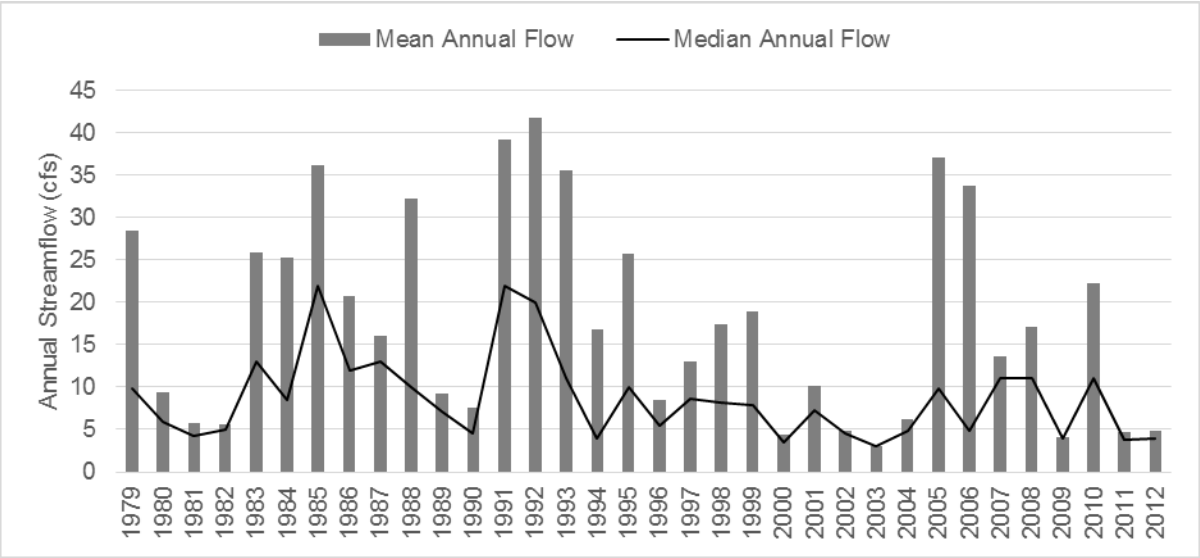


**Figure 126. Annual mean and median streamflow at the Mimbres River gage near Mimbres, period of record 1979-2012**

Seasonal variability in mean monthly flow is important as an indicator of the relative importance of baseflow, snowmelt and rainfall runoff contributions. Snowmelt contributions to mean monthly streamflow are most important from February through April, with the highest flows of the year occurring in March at all gages except the Mimbres River gage where snowmelt runoff peaks in February and the highest mean monthly flows occur in August (31.4 cfs) during the summer monsoon season. However, flows above 20 cfs are maintained at the Mimbres River gage between January and April, which demonstrates that snowmelt runoff remains an important streamflow component. Beginning in May, the

importance of snowmelt runoff begins to be replaced by baseflow contributions, which are most important in June prior to the onset of the summer monsoons when mean monthly flows are at their lowest at all gages.

Rainfall runoff contributions are most important from July through October, with the highest mean monthly flow during this period occurring in August for the Mimbres River gage, September for the Mogollon Creek and Gila River gages near Gila and Redrock, and October at the San Francisco River gages. November and December mean flows are a combination of surface runoff and baseflow at all gages. Figure 127 illustrates the monthly variability in mean flow for the Gila near Gila gage across the period of record. Appendix D contains a table displaying this information for all gages.

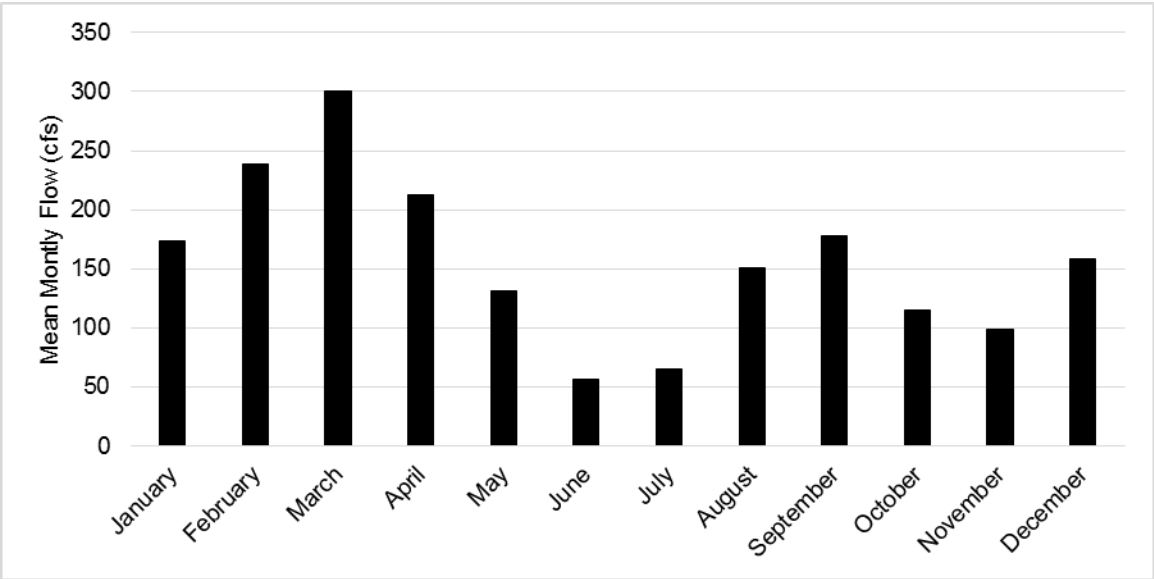


**Figure 127. Monthly flow at the Gila River gage near Gila, period of record 1928-2014**

High and low flows and the frequency at which they occur are important streamflow characteristics. For this assessment, high flow days are considered to be those days where mean flow is equal to or greater than the two-year flood return interval. Return intervals are discussed further in the Riparian Chapter where flood frequency is analyzed as a key characteristic.

Based on this definition of high flow days, less than one percent of days in the period of record for each gage have been high flow days. There have been 21 high flow days at the San Francisco River gage at Reserve, 51 at the gage near Glenwood, 3 at the Mogollon Creek gage, 135 at the Gila River gage near Gila, 44 at the gage near Redrock, and 15 at the Mimbres River gage.

Low flow days are defined as those days when mean flow is equal to or less than the fifth percentile of the period of record. Across the period of record, there have been 1,511 low flow days at the San Francisco River gage near Reserve (≤2.5 cfs), 2,035 days near Glenwood (≤13 cfs), 1,447 at the Mogollon Creek gage (0 cfs), 1,629 at the Gila River near Gila (≤30 cfs), 1,511 near Redrock (≤20 cfs), and 650 at the Mimbres River gage (≤1.7 cfs)

Table 109 summarizes the available data for mean and median annual flow, high and low flow days, and climatic variables for the Gila near Gila gage. Appendix D contains a table displaying the same information for all gages.

**Table 109. A comparison of annual streamflow characteristics and climatic variables at Gila near Gila between the reference and current time periods**

| | | Post-1990 | | Post-2000 | |
|---|---|---|---|---|---|
| Variable | Pre-1990 | | Change from pre-1990 (%) | | Change from pre-1990 (%) |
| ***Gila River near Gila, NM*** | | | | | |
| Mean Annual Flow (cfs) | 149.6 | 172.5 | +15% | 144.7 | -3% |
| Median Annual Flow(cfs) | 72 | 77 | +7% | 68 | -6% |
| High Flow Days (number of days/total days in period of record) | 77/22,645 | 58/9,130 | +87% | 28/5,478 | +50% |
| Low Flow Days (number of days/total days in period of record) | 1,040/22,645 | 589/9,130 | +40% | 455/5,478 | +81% |
| ***Southwestern Mountains Climate Division*** | | | | | |
| Mean Annual Precipitation (in) | 15.1 | 15.4 | +2% | 14.3 | -5% |
| Mean Annual Temperature (°F) | 48.6 | 49.8 | +1.2 | 50.1 | +1.5 |

At the San Francisco River near Reserve, mean and median flow have decreased substantially, which is consistent with England (2002). This indicates a decreasing trend in streamflow, and variability of flow. This is further supported by the dramatic decrease in high flow days and the increase in low flow days. Near Glenwood, the San Francisco River gage demonstrates an overall increase in high flow days and mean and median flow between the reference and current time period, with a decrease in low flow days. This is also consistent with the BOR study (England 2002). However, in the post-2000 time period, high flow days and mean and median flow decreased and low flow days increased suggesting a drying trend and a reduced variability of flow.

On Mogollon Creek, mean flow has not changed significantly overall, but has decreased since 2000. However, median flow is down 18 percent between reference and current time periods and 33 percent since 2000. High and low flow days have both increased. This is indicative of a drying trend and increasing variability in flow. At the Gila near Gila gage, mean and median flow have increased between reference and current time periods, consistent with the BOR study (England 2002). High and low flow days have also increased overall. However, in the 2000-2014 time period, mean and median flows have decreased slightly as high and low flow days continued to increase. This may signal the beginning of a drying trend and increasing variability in flow. Similar trends and interpretations are associated with the Gila River gage near Redrock. The Mimbres River data clearly shows a dramatic drying trend and decreasing variability in flow, with low flow days, mean and median flow decreasing between the reference and current time period.

Periods of record, precipitation and temperature all influence this analysis and the conclusions that may be drawn from it. According to the BOR study, which included all of the gages analyzed here except the Mimbres gage, precipitation patterns explained streamflow patterns at all gages except the San Francisco near Reserve (England 2002). On the other hand, there is some explanatory value in the period of record

at this gage (1968-2014) given that it includes the relatively wet 1980s but does not include the drought of the 1950s. This would inflate the reductions in streamflow and variability, but to what degree is uncertain. This is also a likely issue with the Mogollon Creek and Mimbres gage data. Regardless, general decreasing trends in precipitation and increasing trends in temperature over the last two decades have significantly impacted annual streamflow patterns.

Average monthly values are also be descriptive of departure and trends in streamflow. Figure 128 illustrates changes in average monthly streamflow for the San Francisco near Glenwood. Appendix D contains similar figures for all gages.

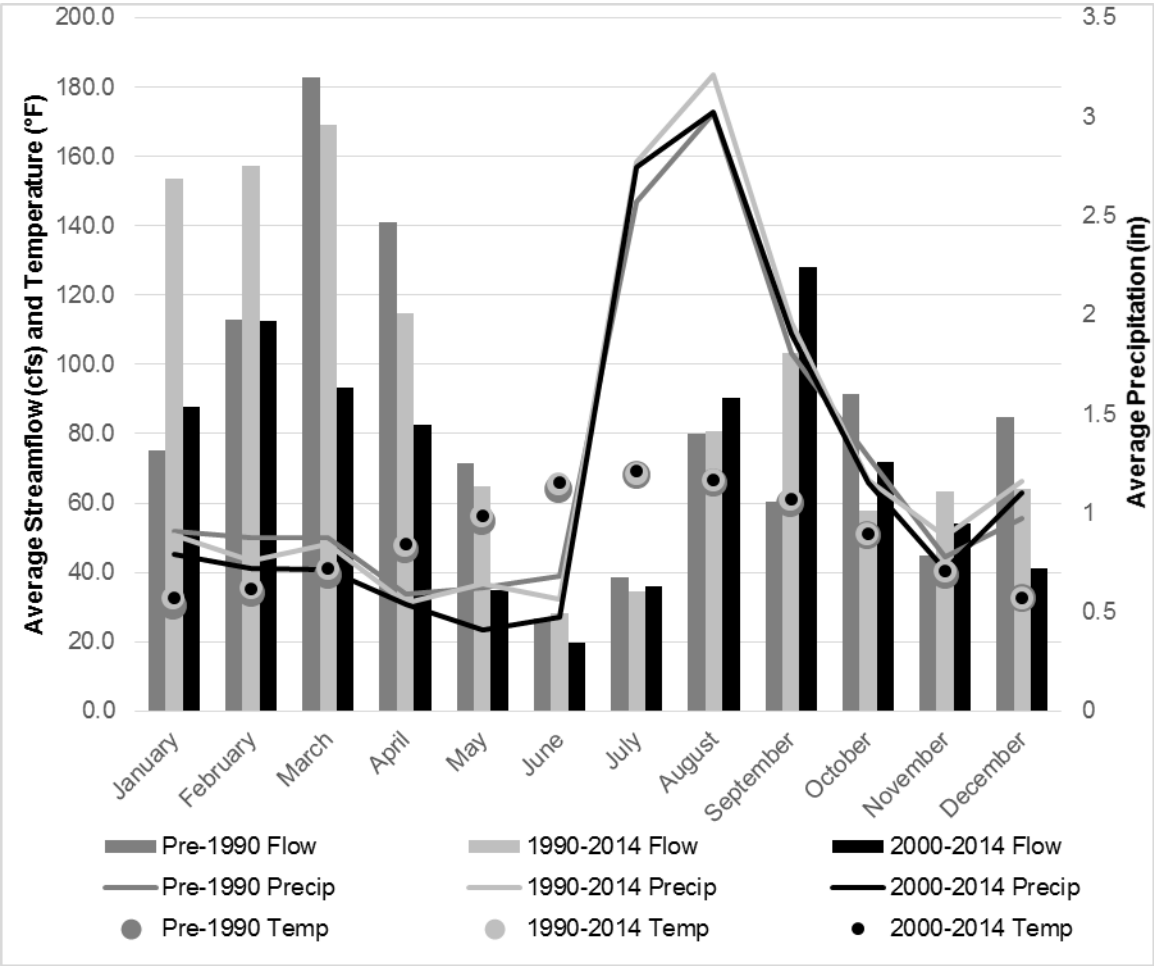


**Figure 128. Mean monthly streamflow at the San Francisco gage near Glenwood (period of record 1928-2014) and mean monthly precipitation and temperature Southwestern Mountains climate division (period of record 1895-2014)**

When comparing the post-2000 subset of the current time period to the reference period, several general trends are observed: average streamflow has decreased in the winter and spring months (December-May), peak snowmelt runoff is occurring earlier and the snowmelt runoff period is decreasing, and the duration of late spring-early summer low flow periods are increasing. These changes are consistent with climate change projections and have enormous ecological and socioeconomic implications. During monsoon months (July-September) streamflow variability reflects variability of monsoon patterns and may be increased, decreased or the same between all time periods.

As described under analysis methods, the gage data, the historic and current distribution of native fishes, and the water quantity indicator from the 2016 watershed condition classification are used describe departure and trend in streamflow. The results are discussed following Figure 129 which displays the results graphically.

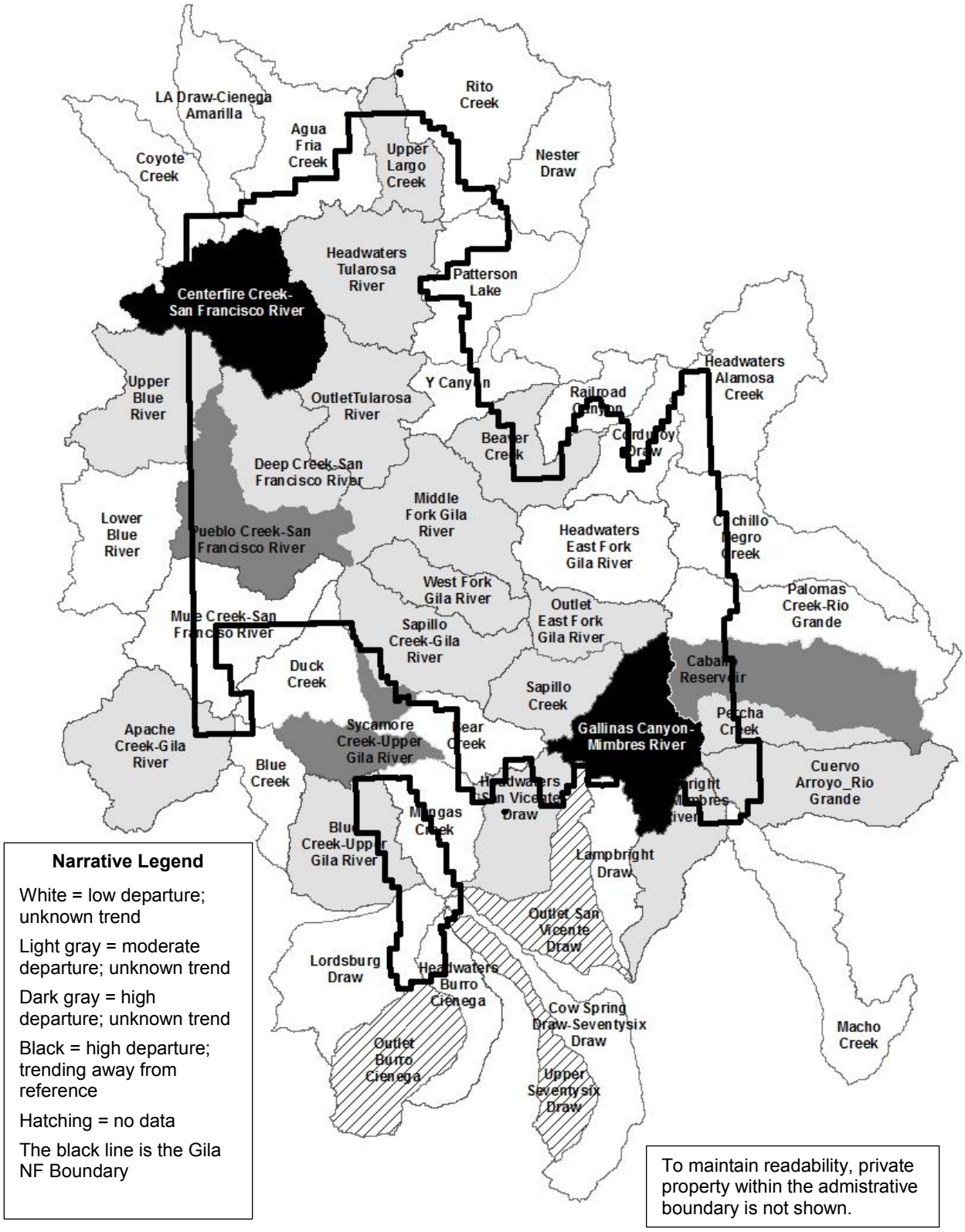


**Figure 129. Departure and trend in streamflow for plan area watersheds**

There is no gage data or watershed condition classification data to describe departure and trend in streamflow for Outlet Burro Cienega, Upper Seventysix Draw, or Outlet San Vincente Draw. Centerfire Creek-San Francisco River is the only watershed represented by the San Francisco River gage near Reserve. The Outlet Tularosa River watershed enters the San Francisco River just below the gage. Based on the gage data analysis and the conclusion drawn by England (2002) that this was the only gage in his study where trends could not be explained by precipitation patterns, Centerfire Creek-San Francisco River is in high departure and trending away from reference. This watershed contains water control structures in many of its drainages that alter streamflow, however, these structures were in place during the reference period. Therefore, like precipitation patterns, they cannot fully explain changes in streamflow. This watershed also experienced further alteration in some areas following the 2011 Wallow Fire. As mentioned previously under the Analysis Methods heading, not enough time has passed for changes due to recent wildfires to be reflected in annual and monthly values.

Departure and trend in the remaining watersheds in the San Francisco subbasin are based on the water quantity indicator. England concluded that the variability at the San Francisco River gage near Glenwood could be explained by precipitation patterns (2002), most or all of the water controls and diversions that occur, were already in place during the reference period and the only events that have happened in the current time period with the ability to create changes in streamflow at this scale are large extents of high and moderate burn severity, such as occurred in the 2012 Whitewater Baldy Complex Fire. While watersheds will regain function overtime, hydrologic response to precipitation may be never return to pre-fire conditions in some watersheds. This will depend on the extent and severity of soil erosion and changes to stream channel shape and function. Existing diversions in these watersheds are known to reduce flow and in some places, remove all of the surface flow in the San Francisco River during parts of the year. This usually occurs during low flow periods coinciding with the growing (irrigation) season.

A similar approach as was taken with watersheds represented by the San Francisco near Reserve gage was used for watersheds that had representation in the Gila River near Gila and Gila River near Redrock gage data for the same reasons. Of those watersheds represented by the Gila River near Gila gage, nearly all are in moderate departure due to post-fire effects of the Whitewater Baldy Complex Fire. In Beaver Creek, departure was elevated from low to moderate based on data previously documenting desert sucker, headwater chub, longfin dace and speckled dace. No native or non-native fish are currently known to occupy streams in this watershed. Of those watersheds represented by the Gila River near Redrock gage, Sycamore Creek-Gila River is the only watershed in high departure. This is due to water controls and diversions, the most significant of which is associated with Bill Evans Lake and ongoing mining activities at Tyrone, New Mexico. The dams constructed by the New Mexico Department of Game and Fish that create Quemado Lake, Snow Lake, Lake Roberts, and Bear Canyon Dam Reservoir also alter flow to varying extents in the Upper Largo, Middle Fork Gila River, Sapillo Creek and Gallinas Canyon-Mimbres River watersheds respectively.

Gallinas Canyon-Mimbres River is the only watershed represented by the Mimbres River gage. Since this gage was not part of the BOR study (England 2002), it is considered to be in high departure and trending away from reference based on this gage data analysis. There are small diversions in this watershed and the 2013 Silver Fire has contributed to alteration of streamflow in this watershed. The Silver Fire has also altered flow in Lampbright Draw-Mimbres River, Caballo Reservoir, Percha Creek and Cuervo Arroyo-Rio Grande watersheds. Tailings piles from historic mining activity in the Cold Springs drainage of Lampbright Draw-Mimbres River also contribute to departure in streamflow.

### Context Area

Current streamflow conditions for the San Francisco, Upper Gila and Upper Gila-Mangas subbasins are represented by the gage data analysis. Based on the watershed departure rating representing the largest

percentage of these subbasins, the San Francisco and Upper Gila are in moderate departure with an unknown trend and Upper Gila-Mangas is in low departure with an unknown trend. In the Little Colorado Headwaters, departure in streamflow is likely greater outside the Gila NF than within it (low departure) due to more stream miles, water controls and diversions and greater extents affected by the 2011 Wallow Fire. In Carrizo Wash, Plains of San Agustin, Elephant Butte Reservoir, Caballo, El Paso-Las Cruces Animas Valley subbasins, there is no stream gage data, watershed condition classification or aquatic biota information sufficient to describe current conditions. Some assumptions could be made regarding water controls and diversions, which are likely to occur at higher densities off Forest. Likewise, some assumptions could be made about large extents of high and moderate burn severity which are more likely to occur on Forest than on other lands. However, current conditions at the subbasin scale are not quantifiable based on existing information. Opportunities and limitations regarding the Gila NF's ability to contribute to ecological integrity and sustainability are the same factors discussed previously in the watershed condition and perennial and intermittent streams.

## Risk

Risk to streamflow integrity and its ability to continue providing current levels of ecosystem services is assessed at the watershed scale using the matrix displayed as Table 110.

**Table 110. Streamflow risk matrix.**

| Departure | Trend Toward Reference | Trend Unknown or Static | Trend Away from Reference |
|---|---|---|---|
| High | Risk Addressed | High Risk | Very High Risk |
| Moderate | Risk Addressed | Moderate Risk | High Risk |
| Low | Low Risk | Low Risk | Moderate Risk |

The results of the risk assessment can be interpreted graphically from Figure 129 above, with the watersheds in white at low risk, light gray at moderate risk, dark gray at high risk and black at very high risk. This risk is can be attributed primarily to current climate, existing water controls and diversions. Changes to the distribution and length of time snow stays on the ground at the higher elevations resulting from large, contiguous extents of stand replacement fire (high and moderate burn severities) contributes to risk. Current management is also a risk factor in the sense that the large extents of high and moderate burn severity that occurred as the result of recent wildfires were due to the legacy of past fire suppression and drought conditions. Wildfire risk can be reduced through managed, low severity fire, whether prescribed or allowing wildfires to burn under favorable conditions, which reduces the risk of large extents of high and moderate burn severity. Risk to streamflow due to post-fire effects lessens with years, but recovery of stream channel shape and function may require decades. Departure in stream channel shape and function alters the connections between groundwater and surface water. Stream bed elevations raised by sediment deposition (aggradation) or lowered by erosion (degradation) have the potential to lead to drying of the system.

There is always a degree of risk associated with natural cycles of drought. However, this risk does not incorporate climate change which is predicted to increase the frequency, severity and duration of droughts (IPCC 2007; Seager et al. 2007), alter precipitation patterns, and thereby timing, quantity, duration and distribution of available water. A moderate or greater vulnerability to climate change at the watershed scale (see System Drivers and Stressors Chapter) elevates risk one category. This is the case for all Gila NF watersheds. Table 111 displays the percentage of the Forest and each local unit in each risk category,

without the consideration of climate change. Again, a moderate or greater vulnerability to climate change elevates risk one category which is the case for all local units and the Forest as a whole.

**Table 111. Percentage of local unit and Forest area in each streamflow risk category.**

| Local Unit | Low Risk | Moderate Risk | High Risk | Very High Risk |
|---|---|---|---|---|
| Apache | 35 | 36 | 0 | 29 |
| Little Colorado-San Agustin Fringe | 56 | 19 | 0 | 25 |
| Mogollon Front | 27 | 36 | 38 | 0 |
| Black Range | 49 | 11 | 14 | 26 |
| Upper Gila | 0 | 100 | 0 | 0 |
| Lower Gila | 44 | 55 | 1 | 0 |
| Gila NF Total | 34 | 50 | 8 | 11 |

Recall that high and very high risk are differentiated by whether or not there is a trend away from reference (Table 110). All watersheds in high departure that contribute area to the Apache and Little Colorado-San Agustin Fringe local units are trending away from reference.

## Waterbodies

Waterbodies on the Gila NF are nearly all constructed features, although a few natural depressions do occur that may hold water seasonally. Because these are constructed features and did not exist prior to European settlement, waterbodies are not analyzed as a key characteristic; their very existence represents a departure from the reference period. However, they are important ecological features. Most waterbodies are earthen tanks built to provide livestock water (i.e. stock tanks), with a secondary benefit of providing water to wildlife. Not all stock tanks hold water year round. Some are poorly located or designed, and many are in need of maintenance. The most reliable livestock tanks are associated with areas of groundwater discharge, such as springs. A few have been stocked with non-native fish for recreational purposes by the New Mexico Department of Game and Fish (NMDGF). NMDGF also constructed, and has the management responsibility for dams that create the three lakes or reservoirs located, entirely or in part, on the Forest for recreational fisheries purposes. These lakes are Quemado Lake, Snow Lake and Lake Roberts.

While constructed waterbodies provide the benefit of storage, making surface water available to livestock, wildlife and for recreational purposes over a longer period of time, they alter natural patterns of water flow. Constructed waterbodies reduce the amount of water flowing downstream, which can be both positive and negative. These features may serve to attenuate floodwaters and potentially reduce negative flooding impacts to human life and property downstream. On the other hand, these features negatively impact natural streamflow patterns, hydrologic connectivity of stream systems, aquatic habitat connectivity, and tend to increase evaporative losses and reduce groundwater recharge. The most significant instances of these negative ecological impacts occurring on the Forest are captured by the water quantity indicator of the watershed condition classification.

The Forest does not have an inventory of storage capacity and condition related to all stock tanks located within its boundaries, but is currently conducting an inventory in the Gila-San Francisco River basin. According to NHD, 18 percent of context area waterbodies occur on the Gila NF which is roughly proportional to the 17 percent (Table 102) of the context area the Forest occupies. Appendix D contains tables displaying information from the NHD about the number of waterbodies within the context and plan areas, both on and off-Forest.

## Surface Water Quality

The primary source of water pollution on National Forest System lands are nonpoint source pollutants. Nonpoint source pollutants are those which cannot be traced back to a single point, such as pipes or ditches from industrial or sewage treatment sources. Nonpoint source pollution is caused by water moving over and through the ground and carrying natural and human-made pollutants into streams and waterbodies, and remains the nation's largest source of water quality problems. Common nonpoint source pollutants include temperature (too warm), sediment, metals, bacteria and nutrients. Activities potentially generating nonpoint source pollutants on the Forest include: mining activities, fire, grazing, roads, timber and fuelwood harvesting, recreational uses and ground disturbance generated by off-highway vehicle use.

The Federal Clean Water Act is administered by the Environmental Protection Agency (EPA) although the EPA delegates many functions to the Army Corps of Engineers and State governments. The New Mexico Water Quality Control Commission sets standards which define water quality goals by designating uses (e.g. domestic water supply, irrigation, livestock watering, wildlife habitat, and aquatic life), setting criteria to protect those uses, and establishing provisions to preserve water quality. Use Attainability Studies are conducted on a three year rotating basis to examine water quality standards for changes to reflect new technology, data or scientific understanding. The current standards were established in 2013.

Every two years, the New Mexico Environment Department's Surface Water Quality Bureau prepares an assessment of the quality of the state's surface waters, which includes a list of impaired waters. Impaired waters are those waters determined to be in non-attainment of standards for one or more of their designated uses. Limitations associated with budget and personnel mean that not all waters are assessed in any given two year cycle. The state water quality assessment is released in a document called the State of New Mexico Clean Water Act 303(d)/305(b) Integrated List and Report. The most current 303(d)/305(b) Integrated List and Report (2014-2016) is available at https://www.env.nm.gov/swqb/303d-305b/2014-2016/index.html.

### Analysis Methods

There is no information regarding surface water quality sufficient to describe a reference condition; therefore the regulatory standard is used to describe reference and current conditions. The same thresholds used in the vegetation analysis are applied here to define low, moderate and high departure for watersheds based on the percentage of subwatersheds that intersect the Forest boundary and contain impaired streams:

- 0-33% of subwatersheds contain impaired streams=low departure
- 34-66% of subwatersheds contain impaired streams=moderate departure
- >66% of subwatersheds contain impaired streams=high departure

However, departure from the regulatory reference condition does not necessarily imply trend. Changes in the water quality standards and methods of measurement have resulted in streams being added and removed from the 303(d) list without any actual changes in biological, chemical, or physical water quality parameters (NMED 2014b). In fact, 67 percent of the roughly 168 miles of impairments in Upper Gila and San Francisco subbasins removed from the 303(d) in 2014 were de-listed due to changes in standards and measurement methods.

The watershed condition classification's water quality indicator allows Forests to document water quality concerns that have not resulted in a 303(d) listing (Potyondy and Geier 2011). In watersheds without any 303(d) listings, if more than 33 percent of subwatersheds intersecting the Forest boundary have water

quality concerns documented by the Gila NF's water quality indicator, departure is considered moderate. Otherwise, departure in these watersheds without 303(d) listings is low as described above.

## Plan Area

Of the nearly 1,546 total miles of assessed streams in plan area watersheds, 42 percent occur on the Gila NF. Of the assessed stream miles located on the Gila NF, approximately 286 miles, or 44 percent are meeting all water quality standards. Approximately 364 miles, or 56 percent are listed as impaired for one or more reasons. The Middle Fork Gila River, West Fork Gila River, Outlet East Fork Gila River and Sapillo Creek-Gila River watersheds account for nearly 59 percent of the total impaired miles on the Forest, most of which occur in the Gila and Aldo Leopold Wilderness areas. Water quality conditions for stream miles not assessed is unknown because no data has been collected on miles not assessed. Miles of assessed streams, those that are meeting all State water quality standards and impaired miles for plan area watersheds are displayed in Table 112. Appendix D contains a similar table that includes subwatersheds.

**Table 112. Miles of assessed streams, those that are meeting all State water quality standards and impaired miles for plan area watersheds.**

| Watershed Name | Gila NF % of Watershed | Assessed Stream Miles | | Miles Meeting All Water Quality Standards | | Impaired Miles [303(d) listed] | |
|---|---|---|---|---|---|---|---|
| | | Total | Gila NF | Total | Gila NF | Total | Gila NF |
| ***Plains of San Agustin Subbasin*** | | | | | | | |
| Nester Draw | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Y Canyon | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Patterson Lake | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Elephant Butte Reservoir Subbasin*** | | | | | | | |
| Headwaters Alamosa Creek | 16 | 0.1 | 0 | 0.1 | 0 | 0 | 0 |
| ***Caballo Subbasin*** | | | | | | | |
| Cuchillo Negro Creek | 32 | 1.2 | 0 | 1.2 | 0 | 0 | 0 |
| Palomas Creek-Rio Grande | 25 | 38.5 | 0 | 23.8 | 0 | 14.7 | 0 |
| Percha Creek | 32 | 24.7 | 0 | 24.7 | 0 | 0 | 0 |
| Caballo Reservoir | 21 | 62.7 | 10.8 | 12.9 | 0 | 49.8 | 10.8 |
| ***El Paso-Las Cruces Subbasin*** | | | | | | | |
| Cuervo Arroyo_Rio Grande | 17 | 48.8 | 9.1 | 36.8 | 9.1 | 12.0 | 0 |
| ***Mimbres Subbasin*** | | | | | | | |
| Gallinas Canyon-Mimbres River | 74 | 93.4 | 60.6 | 45.8 | 43.0 | 47.6 | 17.6 |
| Headwaters San Vicente Draw | 18 | 5.4 | 0 | 3.5 | 0 | 1.9 | 0 |
| Outlet San Vicente Draw | 1 | 24.2 | <0.1 | 24.2 | <0.1 | 0 | 0 |
| Lampbright Draw | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lampbright Draw-Mimbres River | 17 | 31.4 | 6.5 | 10.5 | 4.8 | 20.9 | 1.7 |
| Macho Creek | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Watershed Name | Gila NF % of Watershed | Assessed Stream Miles | | Miles Meeting All Water Quality Standards | | Impaired Miles [303(d) listed] | |
|---|---|---|---|---|---|---|---|
| | | Total | Gila NF | Total | Gila NF | Total | Gila NF |
| Upper Seventysix Draw | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cow Spring Draw-Seventysix Draw | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Little Colorado Headwaters Subbasin*** | | | | | | | |
| Coyote Creek | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Carrizo Wash Subbasin*** | | | | | | | |
| Rito Creek | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper Largo Creek | 76 | 32.7 | 11.6 | 32.7 | 11.6 | 0 | 0 |
| Agua Fria Creek | 35 | 0 | 0 | 0 | 0 | 0 | 0 |
| LA Draw-Cienega Amarilla | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***Upper Gila Subbasin*** | | | | | | | |
| Railroad Canyon | 16 | <0.1 | 0 | 0 | 0 | <0.1 | 0 |
| Corduroy Draw | 61 | 0 | 0 | 0 | 0 | 0 | 0 |
| Beaver Creek | 54 | 24.6 | 2.4 | 0 | 0 | 24.6 | 2.4 |
| Headwaters East Fork Gila River | 99 | 88.8 | 79.3 | 45.6 | 43.4 | 43.2 | 35.9 |
| Middle Fork Gila River | 100 | 84.7 | 81.6 | 20.3 | 20.3 | 64.4 | 61.3 |
| West Fork Gila River | 99 | 61.8 | 57.2 | 25.4 | 25.2 | 36.4 | 32.0 |
| Outlet East Fork Gila River | 99 | 41.8 | 39.0 | 0 | 0 | 41.8 | 39.0 |
| Sapillo Creek | 98 | 11.8 | 7.6 | 11.8 | 7.6 | 0 | 0 |
| Sapillo Creek-Gila River | 96 | 75.2 | 72.2 | <0.1 | <0.1 | 75.2 | 72.2 |
| ***Upper Gila-Mangas Subbasin*** | ***15*** | ***200.8*** | ***20.6*** | ***93.9*** | ***9.3*** | ***106.9*** | ***11.3*** |
| Bear Creek | 63 | 30.4 | 8.3 | 30.4 | 8.3 | 0 | 0 |
| Duck Creek | 12 | 0 | 0 | 0 | 0 | 0 | 0 |

| Watershed Name | Gila NF % of Watershed | Assessed Stream Miles | | Miles Meeting All Water Quality Standards | | Impaired Miles [303(d) listed] | |
|---|---|---|---|---|---|---|---|
| | | Total | Gila NF | Total | Gila NF | Total | Gila NF |
| Mangas Creek | 39 | 24.9 | 1.0 | 18.5 | 0.9 | 6.4 | 0.1 |
| Sycamore Creek-Upper Gila River | 3 | 8.4 | 1.0 | 0.1 | 0 | 8.3 | 1.0 |
| Blue Creek | 4 | 28.7 | 0 | 28.7 | 0 | <0.1 | 0 |
| Blue Creek-Upper Gila River | 25 | 28.8 | 10.2 | 0 | 0 | 28.8 | 10.2 |
| Apache Creek-Gila River | 5 | 28.2 | 0 | 0 | 0 | 28.2 | 0 |
| ***Animas Valley Subbasin*** | | | | | | | |
| Headwaters Burro Cienega | 16 | 5.6 | 1.2 | 5.6 | 1.2 | 0 | 0 |
| Outlet Burro Cienega | <1 | 3.4 | 0 | 3.4 | 0 | 0 | 0 |
| Lordsburg Draw | 19 | 0 | 0 | 0 | 0 | 0 | 0 |
| ***San Francisco Subbasin*** | | | | | | | |
| Headwaters Tularosa River | 94 | 28.7 | 9.1 | 26.5 | 8.7 | 2.2 | 0.4 |
| Outlet Tularosa River | 98 | 55.0 | 41.1 | 8.3 | 7.9 | 46.7 | 33.2 |
| Centerfire Creek-San Francisco River | 78 | 133.3 | 53.2 | 83.2 | 25.6 | 50.1 | 27.6 |
| Deep Creek-San Francisco River | 98 | 27.6 | 20.6 | 21.0 | 17.6 | 6.6 | 3.0 |
| Upper Blue River | 14 | 176.1 | 9.1 | 167.0 | 9.1 | 0 | 0 |
| Pueblo Creek-San Francisco River | 88 | 70.3 | 47.6 | 50.2 | 37.4 | 20.1 | 10.2 |
| Lower Blue River | <1 | 33.4 | 0 | 8.1 | 0 | 25.3 | 0 |
| Mule Creek-San Francisco River | 50 | 98.4 | 22.2 | 87.1 | 17.2 | 11.3 | 5.0 |

Table 113 displays watershed total and Gila NF impaired miles by cause of impairment. Stream miles do not include those through waterbodies. Water quality for waterbodies is discussed separately. Miles by cause do not always add up to the total impaired miles because some are impaired for more than one reason. For example, there are 19.5 miles of the East Fork Gila River in the (Headwaters East Fork Gila River watershed that are impaired for both temperature and nutrients/eutrophication. These same 19.5 miles are listed twice, once under temperature and once under nutrients/eutrophication. Causes are described and discussed following the table.

**Table 113. Plan area watershed total and Gila NF impaired stream miles by cause of impairment**

| Watershed Name | Total Impaired Stream Miles | Impaired Stream Miles by Cause of Impairment | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| *Plains of San Agustin Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Nester Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Y Canyon | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Patterson Lake | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Elephant Butte Reservoir Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Headwaters Alamosa Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Caballo Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Cuchillo Negro Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Palomas Creek-Rio Grande | 14.7 | - | - | - | - | - | - | - | - | 14.7 | 0 | - | - | - | - | - | - | - | - | - | - |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| Percha Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Caballo Reservoir | 33.6 | - | - | 16.2 | 10.8 | - | - | - | - | 6.6 | 0 | - | - | - | - | - | - | - | - | - | - |
| *El Paso-Las Cruces Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Cuervo Arroyo-Rio Grande | 11.9 | - | - | - | - | - | - | - | - | - | - | 11.9 | 0 | - | - | - | - | - | - | - | - |
| *Mimbres Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Gallinas Canyon-Mimbres River | 47.4 | - | - | - | - | - | - | - | - | - | - | 11.9 | 0 | 8.7 | 11.9 | 21.6 | 5.6 | - | - | - | - |
| Headwaters San Vincente Draw | 1.9 | - | - | - | - | - | - | - | - | - | - | - | - | 1.9 | 0 | - | - | - | - | - | - |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| Outlet San Vincente Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lampbright Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lampbright Draw-Mimbres River | 20.9 | - | - | - | - | 5.9 | 1.7 | - | - | - | - | 13.3 | 0 | - | - | 13.3 | 0 | - | - | - | - |
| Macho Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Upper Seventysix Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cow Spring Draw-Seventysix Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| *Little Colorado Headwaters Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Coyote Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Carrizo Wash Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Rito Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Upper Largo Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Agua Fria Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| LA Draw-Cienega Amarilla | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *Upper Gila Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Railroad Canyon[1] | <0.1* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | <0.1* | 0 | - | - | - | - |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| Corduroy Canyon | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Beaver Creek | 24.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 22.2 | 2.4 | - | - | - | - |
| Headwaters East Fork Gila River | 43.2 | - | - | 3.0 | 6.4 | - | - | - | - | - | - | - | - | 2.9 | 19.5 | 4.3 | 29.5 | - | - | - | - |
| Middle Fork Gila River | 64.4 | 1.4 | 5.8 | - | - | - | - | - | - | - | - | - | - | 1.0 | 13.1 | 2.1 | 48.2 | - | - | - | - |
| West Fork Gila River | 36.4 | - | - | 0 | <0.1 | - | - | - | - | - | - | - | - | - | - | 4.4 | 32.0 | - | - | - | - |
| Outlet East Fork Gila River | 41.8 | - | - | 2.7 | 14.0 | - | - | - | - | - | - | - | - | - | - | 0.1 | 25.0 | - | - | - | - |
| Sapillo Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sapillo Creek-Gila River | 75.2 | 1.1 | 15.6 | - | - | - | - | - | - | - | - | - | - | - | - | 1.9 | 56.6 | - | - | - | - |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| *Upper Gila-Mangas Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Bear Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Duck Creek | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Mangas Creek | 6.4 | - | - | - | - | - | - | - | - | - | - | - | - | 6.3 | 0.1 | 6.3 | 0.1 | - | - | - | - |
| Sycamore Creek-Upper Gila River | 15.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 14.9 | 1.0 | - | - | - | - |
| Blue Creek | <0.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | <0.1 | 0 | - | - | - | - |
| Blue Creek-Upper Gila River | 28.8 | - | - | - | - | - | - | - | - | - | - | - | - | 9.4 | 10.2 | 18.6 | 10.2 | - | - | - | - |
| Apache Creek-Gila River | 28.2 | - | - | - | - | - | - | - | - | - | - | 28.2 | 0 | - | - | - | - | 6.6 | 0 | - | - |
| *Animas Valley Subbasin* | | | | | | | | | | | | | | | | | | | | | |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| Headwaters Burro Cienega | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Outlet Burro Cienega | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lordsburg Draw | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| *San Francisco Subbasin* | | | | | | | | | | | | | | | | | | | | | |
| Headwaters Tularosa River | 2.2 | - | - | - | - | - | - | - | - | - | - | 1.8 | 0.4 | - | - | 1.8 | 0.4 | 1.8 | 0.4 | - | - |
| Outlet Tularosa River | 46.7 | - | - | - | - | - | - | - | - | - | - | 11.6 | 22.7 | - | - | 13.5 | 33.2 | 10.9 | 8.9 | - | - |
| Centerfire Creek-San Francisco River | 50.6 | - | - | 5.4 | 9.3 | - | - | 8.1 | 8.0 | - | - | 17.6 | 18.3 | 8.1 | 8.0 | 19.2 | 30.6 | 13.8 | 18.3 | 8.1 | 8.0 |

**Impaired Stream Miles by Cause of Impairment**

| Watershed Name | Total Impaired Stream Miles | Aluminum | | Benthic Macroinvertebrate Community | | Cadmium and Lead | | Conductance | | Dissolved Oxygen | | *E. coli* bacteria | | Nutrients and Eutrophication | | Temperature | | Turbidity or Suspended Sediment Concentration | | Sediment | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF | Off Gila NF | On Gila NF |
| Deep Creek-San Francisco River | 6.6 | - | - | - | - | - | - | - | - | - | - | 3.6 | 3.0 | - | - | - | - | - | - | - | - |
| Upper Blue River | 0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pueblo Creek-San Francisco River | 20.1 | - | - | 4.3 | 1.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5.5 | 8.9 |
| Lower Blue River | 25.3 | - | - | - | - | - | - | - | - | - | - | 25.3 | 0 | - | - | - | - | - | - | - | - |
| Mule Creek-San Francisco River | 11.3 | - | - | 0.1 | 0.7 | - | - | - | - | 6.3 | 4.2 | - | - | - | - | - | - | - | - | - | - |
| **Total** | **658.1** | **2.5** | **21.4** | **31.7** | **42.5** | **5.9** | **1.7** | **8.1** | **8.0** | **27.6** | **4.2** | **113.3** | **44.4** | **38.3** | **62.8** | **144.2** | **232.6** | **33.1** | **27.6** | **13.6** | **16.9** |

[1] This impairment in the Railroad Canyon watershed measures (0.03 miles), which represents a discrepancy between the NHD database and the water quality geospatial data as the NHD does not show any perennial or intermittent miles in this watershed.

Temperature is the number one cause of impairment on and off the Forest in plan area watersheds. Sixty two percent of temperature impairments in plan area watersheds occur on Forest. Streams listed as impaired due to temperature in the context and plan area are too warm to support their designated aquatic life uses. Temperature is important to aquatic species as most cannot regulate their own body temperatures. It also serves as a cue for certain biological processes and influences water chemistry characteristics such as dissolved oxygen concentrations. It is the sole cause of impairment in Beaver Creek, West Fork Gila River, Railroad Canyon[34], Sycamore Creek- Upper Gila River, Blue Creek and Blue Creek-Upper Gila River watersheds. It is the most common cause of impairment in Gallinas Canyon-Mimbres River, Lambright Draw-Mimbres River, Headwaters East Fork Gila River, Outlet East Fork Gila River, Middle Fork Gila River, Sapillo Creek Gila River, Mangas Creek and Outlet Tularosa River watersheds. It contributes to multiple causes of impairment in Headwaters Tularosa River and Centerfire Creek-San Francisco River watersheds, which has the most impairment causes of any watershed.

Temperature impairments may be caused by reduction in riparian canopy cover and shade over water, or changes in stream channel shape and function. Relatively wide shallow streams absorb more heat energy from the sun than relatively deep, narrow streams. Stream temperatures can also be elevated during low flow periods associated with seasonal precipitation patterns. There are also factors associated with measuring stream temperature that can lead to exceedances of the State standards, particularly the location of the temperature recorder in the stream. Most of the temperature impairments on the Forest occur within designated wilderness areas where fire and recreation are the only human activities. Nearly all of these impairments were first documented between 1996 and 2010 (NMED 2014b), prior to large extents of high and moderate burn severities in the watersheds containing these streams. At the time of the first documented impairments, these streams very likely expressed potential natural temperature conditions. Temperature water quality standards for most listed streams on the Forest are under review (NMED 2014b). However, whether or not changes in water quality standards occur, it is quite possible that temperature impairments will still exist on the Forest as watersheds, riparian areas and stream systems impacted by post-fire effects stabilize.

Nutrients and eutrophication are the second leading cause of impairment on the Forest. Excessive concentrations of nutrients necessary for plant growth may lead to eutrophication. Eutrophication is the process by which streams and waterbodies accumulate high concentrations of plant nutrients leading to excessive growth of algae (algal blooms). Algal blooms eventually deplete dissolved oxygen which leads to the death of aquatic organisms. This process occurs naturally, but human activity can accelerate the process. Nutrients chemically bond to soil particles, and often enter streams attached to sediment. Pollutant concentrations, including nutrients, also increase during low flow periods. Human activities that could potentially contribute plant nutrients to streams through nonpoint source pathways include mining activities, fire, grazing, roads, timber and fuelwood harvesting, recreational uses, septic systems, and ground disturbance generated by off-highway vehicle use. However, as it is primarily a nonpoint source pollutant, it would take intensive studies to determine the exact source along any given stream.

Dissolved oxygen is essential to aquatic life. Nutrients and the process of eutrophication, as well as temperature influence dissolved oxygen concentrations. The more advanced the eutrophication process and the warmer the temperatures, the less dissolved oxygen. Groundwater and surface water interactions also influence dissolved oxygen concentrations. Only the Mule Creek-San Francisco watershed contains streams located on the Gila NF impaired for dissolved oxygen.

Conductance is a measure of water's ability to carry an electrical current. The ability of water to carry an electrical current is directly related to the concentration and type of dissolved salts and inorganic

[34] This impairment in the Railroad Canyon watershed measures (0.03 miles), which represents a discrepancy between the NHD database and the water quality geospatial data as the NHD does not show any perennial or intermittent miles in this watershed.

compounds (solutes) contained in the water. Most streams maintain a fairly constant conductivity and any changes may be one of the first indicators of water quality issues. Most aquatic organisms can only survive within specific ranges of solute concentrations. Potential sources of solutes include all human activities identified as potential sources of nutrients, as well as natural geologic sources. Centerfire Creek-San Francisco watershed is the only one containing streams that are impaired due to conductance, which is only one of seven reasons why impaired streams in this watershed are not meeting water quality standards for their designated uses.

*E. coli* is a bacteria used as an indicator of contamination and health risk. Streams within the context and plan area that contain concentrations of *E. coli* that exceed the state standards are not meeting their designated use of primary (e.g. swimming) or secondary (e.g., wading) contact. It is a much larger problem off Forest (72 percent of all impairments) than on Forest (28 percent of impairments). Fecal matter may introduce *E. coli* and pathogens making people, wildlife and livestock potential sources of pollution. While septic systems occurring off-Forest have been identified as a probable source of nutrients contributing to water quality issues in the Mangas Creek watershed (NMED 2014b), septic systems have not been identified as a probable source of *E. coli* within plan area watersheds (NMED 2014b).

Benthic macroinvertebrates are aquatic organisms without backbones that live on the bottom of waterbodies. They have many important ecological functions and are found in all but the harshest or severely polluted streams. The size and composition of the benthic macroinvertebrate community serve as an indicator of water quality. Within a stream, the composition of benthic macroinvertebrate community is directly related to the water quality characteristics. For example, some families of invertebrates are found in high abundance in streams that are cold with a cobble substrate that have high dissolved oxygen, while others do quite well in warm, muddy rivers. Furthermore, in cases of very poor water quality, only the most tolerant invertebrate species will persist. Generally, decreased water quality (e.g., increased fine sediment) reduces intolerant species diversity and abundance (Reynoldson et al. 1997; Kaller and Hartman 2004). The fourth leading cause of water quality impairments on the Gila National Forest (42.5 miles) is related to benthic macroinvertebrate communities.

Two biological assessment approaches utilizing benthic macroinvertebrate communities are currently used in New Mexico for determining the attainment of water quality standards for aquatic life designated uses, namely the reference site approach (i.e., comparing an individual stream or waterbody to an appropriate individual reference site), and the reference condition approach (i.e., comparing an individual stream or waterbody to a reference condition for class or group of streams or waterbodies to which that stream or waterbody belongs). Currently, New Mexico has only defined a reference condition for wadeable, perennial streams in the Mountain ecoregions (NMED SWQB 2015a)[35]. The Gila NF falls entirely within the AZ/NM Mountains Ecoregion 23.

The reference condition approach expands on the original Rapid Bioassessment Protocol (RBP) methods (Plafkin et al. 1989) to acknowledge the reality of a wide range of aquatic conditions that reflect more than minimal impacts, including historic and current land and water use activities (Barbour et al. 1999; Stoddard et al. 2006). This broader concept of reference condition allows for the definition of reasonable and attainable targets or goals by class or group in order to assess potential impairment to the aquatic community at a larger number of study sites (NMED SWQB 2015a).

[35] Wadeable, perennial streams located outside of the Mountain ecoregions continue to be assessed using the reference site approach from the original Rapid Bioassessment Protocol (RBP) (Plafkin et al. 1989) as modified by Jacobi (2009) when a suitable reference site has be identified and sampled as well. The New Mexico Environment Department (NMED) does not apply either method to large non-wadeable rivers, lakes and reservoirs, or non-perennial streams at this time (NMED SWQB 2015a).

In order to determine reference condition, data from a continuum of reference to stressed sites in the ecoregion(s) of interest must be available. NMED has been collecting benthic macroinvertebrate data since 1979. The formal process of developing numeric biological translators began in 2002 with assistance from the EPA and Tetra Tech, Inc. In 2006, NMED, in collaboration with Drs. Jacobi and Tetra Tech, Inc., developed a regional Mountain Stream Condition Index (M-SCI) to determine aquatic life use attainment for the Mountain biological region which consists of Ecoregions 21 and 23 (Southern Rockies and AZ/NM Mountains, which includes the Gila NF) (Griffith et al. 2006; Jacobi et al. 2006).

The M-SCI is composed of twelve individual metrics (i.e. standard of measurement) from five metric categories, representing community and species attributes such as taxonomic composition, taxonomic richness, tolerance, habit, and functional feeding group. For additional descriptions of these twelve metrics, see Plafkin et al. 1989, Barbour et al. 1999, and Jacobi et al. 2006.

M-SCI scores are normalized[36] utilizing the 95th percentiles associated with each metric. Each metric is first calculated and normalized. All metrics are then summed and averaged to produce an M-SCI score between 0 and 100. The resulting score is then placed in a condition category of Very Good (100 – 78.36), Good (78.35 – 56.71), Fair (56.70 – 37.21), Poor (37.20 – 18.89), or Very Poor (18.90 – 0) based on the distribution of reference site scores. Sites with M-SCI ranking of poor or very poor are considered not meeting water quality standards for their designated aquatic life use. Sites falling in the fair range are considered "Not Assessed" until a second sample can be taken. These sites will be listed as impaired if a second sample within a 5-year period confirms a value in this range (NMED SWQB 2015a). Table 114 explains how to interpret macroinvertebrate data to assess aquatic life use support. Additional data are often needed to determine the specific pollutant or "pollution" of concern.

**Table 114. Interpreting benthic macroinvertebrate data to water quality status with respect to designated aquatic life use in wadeable, perennial streams**

| Type of data | Meeting all water quality standards | "not Assessed" | Impaired |
|---|---|---|---|
| Macroinvertebrate assemblages in Ecoregions 21 and 23 using M-SCI[2] | Reliable data indicate functioning, sustainable macroinvertebrate assemblages not modified significantly beyond the natural range of reference condition[1] (> 56.7 score). | Reliable data indicate macroinvertebrate assemblages might be modified beyond the natural range of reference condition (a) (≤56.7 and >37.2 score). | Reliable data indicate macroinvertebrate assemblage with impairment when compared to reference condition (a) (≤37.2 score). |

[1]Reference condition is defined as the best situation to be expected within an ecoregion. Reference sites have balanced trophic structure and optimum community structure (composition & dominance) for stream size and habitat quality.
[2]Percentages based on Jacobi et al. (2006).

The Gila NF falls entirely within the AZ/NM Mountains Ecoregion 23 and can be assessed using the M-SCI scores collected by NMED. There are 27 water quality monitoring stations within, or immediately adjacent to the Gila NF (NMED SWQB 2015b), where M-SCI scores were calculated with the most recent score represented in Table 115 below. Trend was calculated by taking all measurements from each individual site and developing a trend line. Sites that only have one year of data are identified as having "no trend".

[36] Normalization is a mathematical procedure that adjusts values measured on different scales to a common scale.

**Table 115. M-SCI scores for stations on the Gila NF**

| Watershed Name | Subwatershed Name | Site Name | Collection Date | M-SCI Score | Condition/Trend |
|---|---|---|---|---|---|
| *Caballo Subbasin* | | | | | |
| Caballo Reservoir | Outlet Las Animas Creek* | Las Animas Creek above box* | 11/14/2011 | 37.32 | Fair/Stable |
| *Mimbres Subbasin* | | | | | |
| Gallinas Canyon-Mimbres River | Allie Canyon-Mimbres River | McKnight Canyon Creek (aka East Fork of Mimbres) above the Mimbres | 10/10/2002 | 54.93 | Fair/No trend |
| | | Mimbres River at upper Nature Conservancy Property* | 11/18/2009 | 61.59 | Good/Improving |
| | Powderhorn Canyon-Mimbres River | Mimbres River at Cooney Campground Crossing 150A | 9/28/2005 | 47.43 | Fair/No trend |
| | Noonday Canyon-Mimbres River | Mimbres River at Mimbres near USGS gage* | 10/10/2002 | 52.77 | Fair/Improving |
| | Gallinas Canyon-Mimbres River* | Mimbres River below Dwyer* | 11/19/2009 | 36.77 | Poor/Declining |
| *Upper Gila Subbasin* | | | | | |
| Headwaters East Fork Gila River | Headwaters Diamond Creek | Diamond Creek at Trail 42 | 8/23/2011 | 67.54 | Good/Improving |
| Middle Fork Gila River | Indian Creek Canyon | Iron Creek at Forest Trail 151 | 9/29/2005 | 48.09 | Fair/No trend |
| | Indian Creek Canyon-Middle Fork Gila River | Middle Fork Gila River | 8/12/2000 | 71.58 | Good/No trend |

| Watershed Name | Subwatershed Name | Site Name | Collection Date | M-SCI Score | Condition/Trend |
|---|---|---|---|---|---|
| West Fork Gila River | Gilita Creek | Willow Creek above Gilita Creek | 11/5/2001 | 75.63 | Good/Improving |
| | Headwaters West Fork Gila River | Cub Creek 1 mile above Middle Fk Gila | 8/8/2000 | 150.08[1] | Very Good[1]/No trend |
| | | West Fork Gila River above White Creek | 8/9/2000 | 61.02 | Good/No trend |
| | Outlet West Fork Gila River | West Fork Gila above Cliff Dwelling Canyon | 9/19/2007 | 59.93 | Good/Stable |
| Outlet East Fork Gila River | Headwaters Black Canyon | Black Canyon Creek ~0.75 miles above Aspen Canyon | 11/6/2001 | 69.33 | Good/Improving |
| | Outlet Black Canyon | Bonner Creek 1.5 miles above Black Canyon | 7/6/2000 | 39.19 | Fair/No trend |
| | Black Canyon-East Fork Gila River | East Fork Gila above West Fork | 9/22/2011 | 53.58 | Fair/Stable |
| | | East Fork Gila River 1 mile above Black Canyon | 7/31/2000 | 36.94 | Poor/No trend |
| | | East Fork Gila River below Black Canyon | 11/8/2001 | 72.23 | Good/Improving |
| Sapillo Creek-Gila River | Mogollon Creek-Gila River | Gila River 300 meters above Turkey Creek | 10/27/2011 | 59.89 | Good/Stable |
| | Turkey Creek | Turkey Creek (at Wilderness Boundary Forest Trail 155) | 10/27/2011 | 49.21 | Fair/Improving |

| Watershed Name | Subwatershed Name | Site Name | Collection Date | M-SCI Score | Condition/Trend |
|---|---|---|---|---|---|
| *Upper Gila-Mangas Subbasin* | | | | | |
| Bear Creek | Middle Bear Creek | Bear Creek below Dorsey Springs* | 11/14/2006 | 58.19 | Good/Declining |
| Mangas Creek | Mangas Creek-Upper Gila River* | Gila River above Mangas Creek* | 9/22/2000 | 51.16 | Fair/No trend |
| Sycamore Creek-Upper Gila River | Bear Creek-Upper Gila River | Gila River at NM Hwy 211 Bridge* | 10/16/2007 | 64.7 | Good/No trend |
| Blue Creek-Upper Gila River | Bear Canyon-Upper Gila River | Gila River below Mangas Creek * | 11/8/2007 | 67.86 | Good/No trend |
| *San Francisco Subbasin* | | | | | |
| Centerfire Creek-San Francisco River | Stone Creek-San Francisco River | San Francisco River above Luna | 10/18/2007 | 65.19 | Good/Stable |
| Pueblo Creek-San Francisco River | Whitewater Creek | Whitewater Creek above campground | 10/6/2004 | 61.62 | Good/Stable |
| Mule Creek-San Francisco River | Big Pine Canyon-San Francisco River | San Francisco River below Glenwood at Hot Springs | 11/9/2011 | 56.34 | Fair/Improving |

*Not within plan area but within context area; included because upstream water quality can affect downstream water quality
[1]Data may not have been normalized by NMED

The M-SCI scores listed in the table are the most recent year the scores were calculated for each station. Some of the stations have had M-SCI calculated over multiple years with scores fluctuating through time. Of the 27 stations that had M-SCI calculations, 15 (56%) were in "Good" to "Very Good" condition and fully supporting aquatic life designated uses, 10 (37%) were in "Fair" condition indicating macroinvertebrate assemblages might be modified beyond the natural range of reference conditions, while two (7%) were considered to be in "Poor" condition indicating macroinvertebrate assemblages are impaired when compared to reference conditions. The 10 stations in fair condition are considered "Not Assessed" by NMED for assessment purposes under the Clean Water Act (Table 115 above) and a second sample taken within a 5-year period is required to reliably determine condition.

While additional data are needed to determine the specific pollutant responsible for benthic macroinvertebrate community conditions, one of the likely causes is sediment. Excess sediment in streams and waterbodies can negatively affect the biological processes of aquatic species and macroinvertebrate populations (Reynoldson et al. 1997; Kaller and Hartman 2004). Sediment can also carry with it other pollutants such as bacteria and nutrients. Turbidity is a measure of water clarity, which is affected by suspended fine sediments and dissolved solids. Suspended Sediment Concentration is a measure of the quantity of solid material per volume of water. Turbidity and Suspended Sediment Concentration are the most visible indicators of excess sediment. Sediments eventually settle out of suspension and can negatively impact benthic macroinvertebrate habitat. There are 30.5 total miles of impairments due to sediment, and 60.7 miles impaired for turbidity or suspended sediment concentrations. Miles of these impairments are similar on and off the Forest (Table 113). All of the activities identified as potential sources of nutrients leading to eutrophication or solutes leading to conductance impairments are also potential sources of sediment.

The remaining causes of water quality impairments are metals: aluminum, cadmium and lead. Aluminum is the third most common element in the earth's crust. At certain concentrations, aluminum is toxic. Mogollon Creek (Sapillo Creek-Upper Gila River watershed) and Willow Creek (Middle Fork Gila River watershed) have miles listed as impaired due to aluminum with concentrations that exceed those required to support the aquatic life criteria. A study conducted to determine the source of the aluminum leading to impairment of Mogollon Creek in the Sapillo Creek-Upper Gila River watershed concluded the probable source was geologic (Stevens and Clothier 2015). No such study is known to have been conducted for Willow Creek. Aluminum can be a component in emissions generated by coal fired power plants, and atmospheric deposition not impossible, however, there is no data related to the atmospheric deposition of aluminum. However, if the source was atmospheric deposition, it would most likely affect water quality across more of the plan area. Abandoned mine lands do not occur at watershed positions that could contribute aluminum to the impaired miles. Other potential industry related sources of aluminum are not present in these watersheds. The source of the aluminum is most likely geologic. Volcanic rocks, such as those that dominate these watersheds and are common across the Forest, contain varying amounts of aluminum. Therefore, the soils that form from these rocks also have varying amount of aluminum. A mineralogy study of the rocks and soils in these watersheds could potentially confirm or deny the probable source as natural. Cadmium and lead are naturally occurring metals toxic to plants, animals and microorganisms. Streams listed as impaired due to concentrations of these metals within Lampbright Draw-Mimbres River watershed (Table 113) are believed to be associated with historic mining operations. Remediation of a historic mine is anticipated to begin in 2017.

The water quality indicator from the watershed condition classification considers both water quality issues resulting in 303(d) listings, as well as other water quality concerns that have not resulted in a 303(d) listing. There are four watersheds without listed streams that have subwatersheds with other water quality concerns: Cuchillo Negro Creek, Cuervo Arroyo-Rio Grande, Lordsburg Draw and Percha Creek. All of these concerns are sediment related. Lordsburg Draw contains a large percentage of highly erodible soils formed

from granite. Improving and maintaining vegetative groundcover is critical to prevent accelerated erosion and sediment delivery in this watershed. Vegetative groundcover is also of concern in Cuchillo Negro Creek. In Percha Creek and Cuervo Arroyo-Rio Grande, accelerated erosion and sediment delivery resulting from large extents of high and moderate burn severity from the 2013 Silver Fire is the concern. Although much of these areas received emergency watershed stabilization treatments following the fire and monitoring data indicates the treatments were effective at reducing erosion (see discussion under fire heading in System Drivers and Stressors Chapter), accelerated erosion and sedimentation cannot be eliminated completely.

There are four assessed water bodies within the plan area watersheds, three of which occur entirely or in part within the Gila NF. These are located in the Carrizo Wash (Quemado Lake) and Upper Gila (Lake Roberts and Snow Lake) subbasins and all are listed impaired for nutrients and eutrophication (NMED 2014b). Bear Canyon Reservoir in Mimbres, which is downstream of the Forest boundary, is listed for nutrients and eutrophication, temperature and mercury in fish tissue (NMED 2014b). Bill Evans Lake is located off Forest, but is filled by water pumped from the Gila River by the mining company, Freeport McMoRan, Inc. Its overflow drains to Mangas Creek, a tributary of the Gila River, approximately five stream miles above the Gila River Bird Area. Bill Evans Lake is listed impaired for mercury in fish tissue (NMED 2014b). Mercury is most often deposited in lakes atmospherically and is related to emissions from coal burning power plants. More information about atmospheric deposition of mercury is found in the Air Chapter. Mercury negatively impacts the biological processes of fish and is toxic to humans and animals.

In 2010, the State of New Mexico's Water Quality Control Commission designated all perennial rivers, streams and wetlands located within wilderness areas as Outstanding National Resource Waters (ONRWs). Only those perennial rivers, streams and wetlands within wilderness areas carry this designation. The criteria for ONRW designations in New Mexico are set forth in the Water Quality Standards at Section 20.6.4.9.B NMAC (State of New Mexico 2013). These waters are subject to the same water quality criteria as other waters with the same designated uses but receive a higher degree of protection from human activities that could negatively alter their water quality status. However, forty four percent of all impaired stream miles are ONRWs. A discussion of why these streams receive a higher degree of protection, but so many are impaired follows Table 116 which displays the ONRW stream miles and wetland acres on the Gila NF and their water quality status by watershed.

**Table 116. Outstanding National Resource Waters and impairment status**

| Subbasin Name | Watershed Name | ONRW Stream Miles | ONRW Impaired Stream Miles | Cause of Impairment | ONRW Wetland Acres | ONRW Wetland acres within 300 ft. of Impaired Stream |
|---|---|---|---|---|---|---|
| Caballo | Cuchillo Negro Creek | 1.0 | 0 | Not Applicable | 0 | Not Applicable |
| | Palomas Creek-Rio Grande | 5.4 | 0 | Not Applicable | 6.1 | 0 |
| | Percha Creek | 0 | 0 | Not Applicable | 0.2 | 0 |
| | Caballo Reservoir | 25.2 | 3.6 | BMiC | 55.5 | 49.8 |
| Elephant Butte Reservoir | Milligan Gulch | 0 | 0 | Not Applicable | 0.2 | 0 |
| Mimbres | Gallinas Canyon-Mimbres River | 5.7 | 0 | Not Applicable | 31.9 | 0 |

| Subbasin Name | Watershed Name | ONRW Stream Miles | ONRW Impaired Stream Miles | Cause of Impairment | ONRW Wetland Acres | ONRW Wetland acres within 300 ft. of Impaired Stream |
|---|---|---|---|---|---|---|
| Upper Gila | Headwaters East Fork Gila River | 25.9 | 3.3 | BMiC | 135.7 | 92.5 |
| | Middle Fork Gila River | 74.6 | 47.2 | 81% Temp 8% each Nut/Eutro and Turbidity 4% Al | 684.2 | 626.5 |
| | West Fork Gila River | 56.4 | 28.6 | Temperature | 281.96 | 233.5 |
| | Outlet East Fork Gila River | 42.4 | 29.4 | 68% Temp 32% BMiC | 268.30 | 259.5 |
| | Sapillo Creek | 14.2 | 0 | Not Applicable | 12.37 | 1.7 |
| | Sapillo Creek-Gila River | 81.3 | 56.0 | 80 % Temp 20% Al | 677.73 | 672.8 |
| Upper Gila-Mangas | Duck Creek | 1.7 | 0 | Not Applicable | 0.17 | 0 |
| San Francisco | Deep Creek-San Francisco River | 0 | 0 | Not Applicable | 0.39 | 0 |
| | Pueblo Creek-San Francisco River | 19.7 | 0 | Not Applicable | 160.08 | 0 |
| | Mule Creek-San Francisco River | 13.9 | 0 | Not Applicable | 0.52 | 0 |
| **Totals** | | **367.5** | **161.1** | | **2,315.12** | **1,936.3** |

Note: Al=Aluminum; BMiC = Benthic macroinvertebrate community; Nut/Eutro=Nutrients/Eutrophication; Temp=Temperature

Temperature is the leading cause of impairment for all ONRWs. This is directly related to the previous discussion on temperature impairments and NMED's review of the related water quality standards (NMED 2014b). More investigation is needed to determine appropriate temperature water quality standards for ONRWs as human activities in these wilderness areas are limited. The previous discussions regarding benthic macroinvertebrate and aluminum impairments also apply to ONRWs. Data used to determine whether or not the ONRWs in the Gila and Aldo Leopold wildernesses met their water quality standards for temperature were collected prior to the Whitewater Baldy Complex and Silver Fires. Post-fire effects to ONRWs could reasonably be expected to result in short-term higher stream temperatures as the riparian vegetation recovers. Long-term stream temperatures will depend on the recovery of channel shape and function which could take decades. In some areas, recovery of channel shape and function may impact the recovery of riparian vegetation, extending the length of time water quality impacts might occur. Sediment related impairments such as turbidity and the combined impacts of sediment and temperature to the benthic-macroinvertebrate community are also probable given altered post-fire hydrologic and sediment regimes. These statements regarding post-fire recovery of water quality apply to all watersheds and stream systems impacted by large extents of high and moderate burn severity, not just those containing ONRWs.

Figure 130 summarizes departure in water quality conditions as discussed previously under the analysis methods heading.

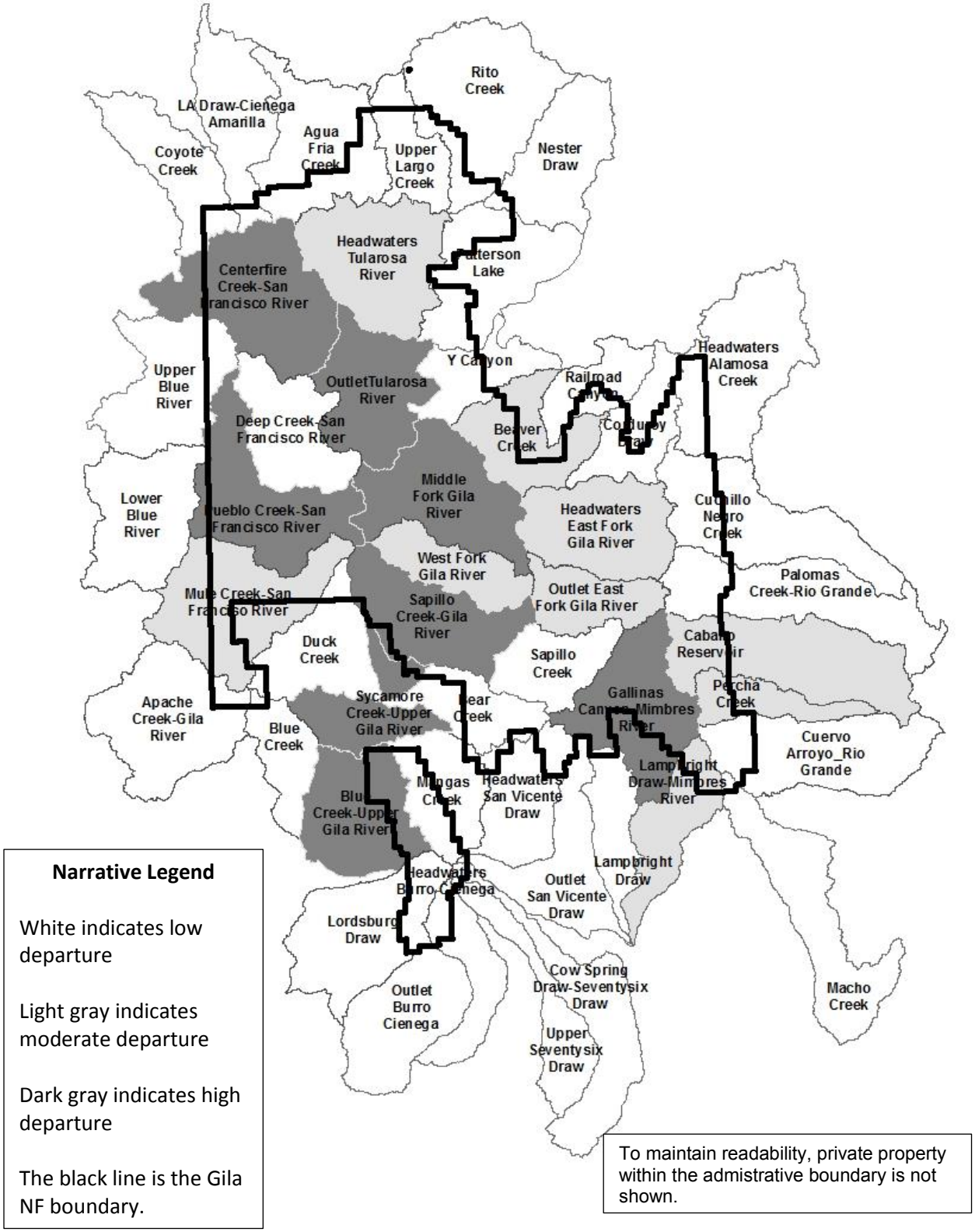


**Figure 130. Water quality departure by plan area watershed**

## Context Area

Current water quality status within the context area is displayed in Table 117 in terms of total impaired miles. Table 118 displays subbasin impaired miles by cause, both on and off Forest. Values do not add up to the total impaired miles because some miles are impaired for more than one reason. Miles are counted for each reason. Miles through waterbodies are not included, but are discussed later in this subsection. Subbasins without impairments are not included.

**Table 117. Impaired stream miles and Gila NF percent of impaired miles, subbasin area and stream miles.**

| Subbasin Name | Gila NF % of Subbasin | Assessed Stream Miles | | Miles Meeting All Water Quality Standards | | Impaired Miles [303(d) listed] | |
|---|---|---|---|---|---|---|---|
| | | Total | Gila NF | Total | Gila NF | Total | Gila NF |
| Plains of San Agustin | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| Elephant Butte Reservoir | 3 | 37.0 | 0 | 37.0 | 0 | 0 | 0 |
| Caballo | 27 | 110.8 | 10.8 | 62.5 | 0 | 48.3 | 10.8 |
| El Paso-Las Cruces | 1 | 159.7 | 9.1 | 86.5 | 9.1 | 73.2 | 0 |
| Mimbres | 5 | 154.2 | 67.0 | 84.0 | 47.7 | 70.2 | 19.3 |
| Little Colorado Headwaters | 3 | 234.4 | 0 | 185.3 | 0 | 49.1 | 0 |
| Carrizo Wash | 14 | 88.6 | 11.6 | 77 | 11.6 | 0 | 0 |
| Upper Gila | 84 | 388.6 | 339.3 | 103.1 | 96.6 | 285.5 | 242.7 |
| Upper Gila-Mangas | 15 | 200.8 | 20.6 | 93.9 | 9.3 | 106.9 | 11.3 |
| Animas Valley | 4 | 52.0 | 1.2 | 9.0 | 1.2 | 0 | 0 |
| San Francisco | 61 | 654.4 | 202.6 | 460.5 | 123.4 | 193.9 | 79.2 |

**Table 118. Context area miles of impairment by cause.**

| | Miles of Impairment[1] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Caballo | | El Paso-Las Cruces | | Mimbres | | Little Colorado Headwaters | | Upper Gila | | Upper Gila-Mangas | | San Francisco | | Cause % Impaired Miles | |
| Cause of Impairment | Total Miles | On Gila NF | Total Miles | On Gila NF | Total Miles | On Gila NF | Total Miles | On Gila NF | Total Miles | On Gila NF | Total Miles | On Gila NF | Total Miles | On Gila NF | % of Total | % On Gila NF |
| Aluminum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23.9 | 21.4 | 0 | 0 | 0 | 0 | 2 | 4 |
| Bacteria | 0 | 0 | 11.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Benthic Macroinvertabrate Community | 27.0 | 10.8 | 0 | 0 | 0 | 0 | 0 | 0 | 26.1 | 20.4 | 0 | 0 | 21.1 | 11.3 | 7 | 8 |
| Boron | 0 | 0 | 6.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Cadmium and Lead | 0 | 0 | 0 | 0 | 7.6 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | <1 |
| Conductance | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16.1 | 8.0 | 1 | 2 |
| Dissolved Oxygen | 21.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10.5 | 4.2 | 3 | 1 |
| *E. coli* | 0 | 0 | 61.6 | 0 | 25.2 | 0 | 0 | 0 | 0 | 0 | 38.8 | 0 | 135.5 | 44.3 | 23 | 9 |
| Nutrients / Eutrophication | 0 | 0 | 0 | 0 | 22.1 | 11.9 | 0 | 0 | 36.5 | 32.6 | 25.9 | 10.2 | 16.1 | 8.0 | 9 | 12 |
| Temperature | 0 | 0 | 0 | 0 | 40.5 | 5.6 | 0 | 0 | 228.5 | 193.6 | 68.2 | 11.3 | 95.6 | 61.1 | 38 | 53 |
| Turbidity/Suspended Sediment Concentration | 0 | 0 | 0 | 0 | 0 | 0 | 49.1 | 0 | 14.2 | 13.1 | 17.2 | 0 | 54.0 | 27.6 | 12 | 8 |
| Sediment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30.5 | 16.9 | 3 | 3 |
| Total All Causes (miles) | 48.3 | 10.8 | 79.2 | 0 | 95.3 | 19.3 | 49.1 | 0 | 329.3 | 281.1 | 150.0 | 21.5 | 379.4 | 181.5 | | |
| All Causes (%) | 29 | 22 | 7 | 0 | 8 | 20 | 4 | 0 | 29 | 85 | 13 | 14 | 34 | 48 | | |

[1] *The number of miles of impairment are greater than impaired stream miles; where there are multiple causes listed for the same miles, those miles are counted for each cause.*

There are very few perennial or intermittent stream miles on Forest (Table 102) in subbasins where no impairments exist on Forest (Table 113). In general, water quality impairments are far less frequent on the Forest than off when considering the higher stream densities on Forest. However, this is clearly not the case in Upper Gila. The vast majority of the impaired miles are on Forest as most of the watershed area and stream miles are on Forest. As discussed in the plan area analysis, the reason for these impairments is almost all related to stream temperatures that exceed water quality standards for aquatic life designated uses. However, temperature standards for many Forest streams are being reviewed by NMED (2014b), which may or may not result in fewer impaired miles.

Opportunities and limitations associated with the Gila NF's ability to contribute to integrity and sustainability of water quality within the context area are related primarily to contributing watershed area on Forest and nonpoint source pollutant of concern. The discussion related to causes of impairment and possible sources of those pollutants presented in the plan area analysis apply here as well. Off-Forest water quality conditions currently have little direct impact on water quality conditions on-Forest within most subbasins because the majority of off-Forest area is located downhill and downstream. Where this is less the case, as in the San Francisco and Upper Gila-Mangas subbasins, off-Forest water quality conditions may impact water quality on-Forest. Table 118 displays subbasin impaired miles by cause, both on and off Forest. Values do not add up to the total impaired miles because some miles are impaired for more than one reason. Miles are counted for each reason. Subbasins without impairments are not included. In addition to the impaired waterbodies described in the plan area analysis, Caballo and Elephant Butte reservoirs, located in Caballo, Elephant Butte Reservoir and El Paso-Las Cruces subbasins are also impaired. One is listed for mercury in fish tissue. The other is listed for both mercury and PCB in fish tissue. As discussed previously, the most likely source of mercury is atmospheric deposition. PCB is compound that was used for a variety of industrial purposes. Even though it was effectively banned in the 1970s, it does not break down easily in the environment and remains a problem to this day. The most likely origins of PCB are the communities along the Rio Grande River. The Gila NF is not contributing to these impairments and Forest management has no opportunity to contribute to solutions.

## Risk

Risk to water quality and its ability to continue providing current levels of ecosystem services is assessed at the watershed scale using the matrix displayed as Table 119.

**Table 119. Water quality risk matrix.**

| Departure | Trend Toward Reference | Trend Unknown or Static | Trend Away from Reference |
|---|---|---|---|
| Significant (High and Moderate) | Risk Addressed | Moderate Risk | High Risk |
| Not Significant (Low) | Low Risk | Low Risk | Moderate Risk |

Risk due to current management and under current water quality standards can be interpreted from Figure 130 above, with the watersheds in white being low risk (low departure; unknown or static trend), and both light gray (moderate departure; unknown or static trend) and dark gray (high departure; unknown or static trend) at moderate risk. The origins of this risk include all human activities and disturbance regimes discussed in the System Drivers and Stressors Chapter that can impact watershed and riparian condition including: fire, herbivory, non-fire vegetation treatments including timber and fuelwood harvest, insects and disease as they increase the risk of high severity fire, roads and trails, mining, recreation, invasive species and pesticide use. Watersheds and riparian areas that are Functioning Properly support water quality integrity. Therefore, the discussion of risk factors in the watershed subsection of this chapter, and the riparian chapter apply to water quality.

With 67 percent of its area represented by moderate risk ratings, risk to water quality at the Forest scale is also moderate. At the local unit scale, Lower Gila is represented by low risk ratings across 59 percent of its area, therefore risk to water quality in that local unit is low. All other local units are represented by risk ratings of moderate across 56 to 100 percent of their area, giving them a moderate risk rating overall.

Because of the nonpoint nature of most of the pollutants that can be produced as a result of these disturbances, it is difficult or impossible in most cases to determine the specific activity that is the source of the pollutant. The contributions of management activities that may generate non-point source pollutants have been discussed briefly throughout this chapter and are discussed in detail in the System Drivers and Stressors Chapter. Best Management Practices (BMPs) are methods or measures that are designed and implemented for site and project specific characteristics to mitigate risk to water quality associated with all activities. As in previous risk assessments, a moderate or greater watershed vulnerability to climate change is a stressor that elevates risk one category. Again, climate change is discussed in detail in the System Drivers and Stressors Chapter.

# Aquatic Biota

The status of watersheds and water resources across the larger landscape influences conditions on the Forest, and in turn the Forest contributes to the overall sustainability of areas far from the Forest Service boundary. Aquatic biota are an important component of aquatic ecosystems, and as such, are influenced by the conditions of watersheds and water resources on the Forest. This section focuses on current and historic native and non-native species richness and distribution.

## Analysis Methods

Prior to European settlement, only native fish species were present in the watersheds of the Gila NF. Their populations were more widespread, interconnected, and the aquatic habitat had all necessary components needed to persist. This pre-European settlement status of aquatic biota is used as the reference condition for this assessment. Although it is likely that aquatic habitat conditions have changed over time, this analysis assumes current perennial stream miles were only inhabited by native species; therefore, the current extent of perennial stream miles is used as a reference. Based on the available data concerning the current and historic distribution of native and non-native fishes, departure was calculated by conducting a similarity analysis using the Czekanowski coefficient (Czekanowski 1913 as cited in Kent and Coker 1992). Departure categories of low, moderate and high are assigned as follows:

- 0-33% Departure = Low
- 34-66% Departure = Moderate
- 67-100% Departure = High

Due to the differences between the available datasets, trend is not analyzed for individual species. Some data had numbers of individuals that were caught, while other data just recorded presence/absence in a stream with no indication of abundance. Also, some data recorded was only for rare fish and other fish information was not taken. However, what is known about current trends is discussed.

## Plan Area

Historically, 17 native fish occurred in plan area watersheds (Sublette et al. 1990). Currently, 15 of these native species still occur, while two of these native species, Beautiful shiner and Gila topminnow, are now considered extirpated (i.e. completely absent). Of the 15 native fish species still present within the Gila NF, five have decreased in their distribution, two have increased, and eight have remained relatively unchanged as displayed in Table 120.

**Table 120. Native fish species changes in distribution.**

| Increased | Decreased | Unchanged |
|---|---|---|
| Gila chub *(Gila intermedia)* | Spikedace *(Meda fulgida)* | Longfin dace *(Agosia chrysogaster)* |
| Gila trout *(Oncorhynchus gilae)* | Roundtail chub (*Gila robusta*) | Speckled dace *(Rhinichthys osculus)* |
| | Loach minnow *(Tiaroga cobitis)* | Desert sucker *(Catostomus (Pantosteus) clarkii)* |
| | Rio Grande sucker (*Catostomus plebeius)* | Sonora sucker *(Catostomus insignis)* |
| | Rio Grande chub *(Gila pandora)* | Rio Grande Cutthroat trout (*O. clarki virginalis)* |
| | | Chihuahua chub (*Gila nigrescens)* |
| | | Fathead minnow (*Pimephales promelas*) |
| | | Headwater chub (*Gila nigra)* |

Table 121 displays the reference and current fish species richness, including natives and non-natives, by subwatershed. Departure percents and categories are included.

**Table 121. Reference (R) and current (C) occurrences of native fish species for plan area watersheds and subwatersheds**

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plains of San Agustin** | | | | | | | | | | | | | | | | | | | | |
| **Patterson Lake** | | | | | | | | | C[1] | | | | | | | | 1/1 | 1 | 33 | L |
| Patterson Canyon | | | | | | | | | C[1] | | | | | | | | 1/1 | 1 | 33 | L |
| **Elephant Butte Reservoir** | | | | | | | | | | | | | | | | | | | | |
| **Headwaters Alamosa Creek** | | | | | | | | | | C[1] | | | | | | | 1/1 | 0 | 0 | L |
| Sim Yaten Canyon- Alamosa Creek | | | | | | | | | | C[1] | | | | | | | 1/1 | 0 | 0 | L |
| **Caballo** | | | | | | | | | | | | | | | | | | | | |
| **Palomas Creek-Rio Grande** | | | | | | | | | | C | | C | | | | | 2/2 | 1 | 20 | L |
| South Fork Palomas Creek | | | | | | | | | | C | | C | | | | | 2/2 | 1 | 20 | L |
| **Caballo Reservoir** | | | | | | | | | | C | R | C | | | | | 2/3 | 1 | 33 | L |
| North Seco Canyon | | | | | | | | | | C[1] | | R | | | | | 1/2 | 0 | 33 | L |

The letter "C" is used to indicate where native fish species occurred historically and still occur. The letter "R" is used to indicate where native fish species occurred historically, but are now extirpated from those watersheds. Blank cells within the table indicate native fish species were not present historically within that subwatershed. An asterix (*) indicates the two native fish species are extirpated from the entire Forest. The number "1" indicates that the fish found in the subwatershed were not collected on the Gila NF. The number "2" indicates subwatersheds that do not currently contain any native or non-native fish, but where native fish are expected to be re-introduced (repatriated).

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seco Creek | | | | | | | | | | C[1] | | C | | | | | 2/2 | 0 | 0 | L |
| Holden Prong[2] | | | | | | | | | | R | R | R | | | | | 0/3 | 0 | 100 | H |
| Headwaters Los Animas Creek[2] | | | | | | | | | | R | R | R | | | | | 0/3 | 1 | 100 | H |
| **El Paso-Las Cruces** | | | | | | | | | | | | | | | | | | | | |
| **Cuervo Arroyo_Rio Grande** | | | | | | | | | | R | | R | | | | | 0/2 | 0 | 100 | H |
| Headwaters Berenda Creek | | | | | | | | | | R[1] | | R[1] | | | | | 0/2 | 0 | 100 | H |
| **Mimbres** | | | | | | | | | | | | | | | | | | | | |
| **Gallinas Canyon-Mimbres River** | R | C | C | | | | | | | | | C | | | C | | 4/5 | 11 | 60 | M |
| Powderhorn Canyon-Mimbres River | R | R | R | | | | | | | | | R | | | R | | 0/5 | 5 | 100 | H |
| Allie Canyon-Mimbres River | R | C | C | | | | | | | | | C | | | C | | 4/5 | 5 | 43 | M |
| Sheppard Canyon-Mimbres River | R | C | R | | | | | | | | | C | | | R | | 2/5 | 10 | 76 | H |
| Noonday Canyon-Mimbres River | R | C | R | | | | | | | | | C | | | R | | 2/5 | 4 | 64 | M |
| Gallinas Canyon | R | R | R | | | | | | | | | R | | | R | | 0/5 | 3 | 100 | H |
| **Headwaters San Vicente Draw** | | | | | | | | | | | | | | | | | 0/0 | 2[1] | 100 | H |

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| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pipeline Draw-San Vicente Draw | | | | | | | | | | | | | | | | | 0/0 | 2[1] | 100 | H |
| **Lampbright Draw-Mimbres River** | R | R | | | | | | | | | | R | | | | | 0/3 | 4 | 100 | H |
| Gavilan Arroyo-Mimbres River | R | R | | | | | | | | | | R | | | | | 0/3 | 4 | 100 | H |
| **Carrizo Wash** | | | | | | | | | | | | | | | | | | | | |
| **Upper Largo Creek** | | | C | | | | | | | | | | | | C | | 2/2 | 5 | 56 | M |
| Sawmill Canyon-Largo Creek | | | R | | | | | | | | | | | | R | | 0/2 | 5 | 100 | H |
| Paradise Canyon-Largo Creek | | | R | | | | | | | | | | | | C | | 1/2 | 0 | 33 | L |
| Rito Creek-Largo Creek | | | C[1] | | | | | | | | | | | | R | | 1/2 | 0 | 33 | L |
| **Beaver Creek** | | | R | | | | R | | R | | | | | | R | | 0/4 | 0 | 100 | H |
| Houghton Canyon-Beaver Creek | | | R | | | | R | | R | | | | | | R | | 0/4 | 0 | 100 | H |
| **Headwaters East Fork Gila River** | | | C | | | C | C | R | C | | | | | C | C | R | 6/8 | 11 | 52 | M |
| Hoyt Creek | | | C | | | | | | C | | | | | R | C | | 3/4 | 1 | 25 | L |
| Taylor Creek | | | C | | | | R | R | C | | | | | C | C | R | 4/7 | 9 | 60 | M |
| Taylor Creek-Beaver Creek | | | C | | | | R | R | C | | | | | C | C | R | 4/7 | 4 | 47 | M |

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| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Headwaters Diamond Creek | | | | | | C | | | | | | | | | R | | 1/2 | 0 | 50 | M |
| South Diamond Creek | | | | | | C | | | | | | | | | R | | 1/2 | 0 | 50 | M |
| Outlet Diamond Creek | | | C | | | R | C | R | C | | | | | C | C | R | 5/8 | 2 | 38 | M |
| Diamond Creek-East Fork Gila River | | | C | | | R | C | R | C | | | | | C | C | R | 5/8 | 9 | 55 | M |
| **Middle Fork Gila River** | | | C | | | C | C | C | C | | | | | C | C | C | 8/8 | 13 | 45 | M |
| Gilita Creek | | | C | | | C | | | C | | | | | C | C | | 5/5 | 4 | 29 | L |
| Snow Canyon | | | | | | | | | R | | | | | | C | | 1/2 | 4 | 71 | H |
| Canyon Creek-Middle Fork Gila River | | | C | | | C | C | | C | | | | | C | C | | 6/6 | 4 | 25 | L |
| Indian Creek Canyon | | | C | | | R | R | | C | | | | | R | C | | 3/6 | 1 | 40 | M |
| Indian Creek Canyon-Middle Fork Gila River | | | C | | | R | C | | C | | | | | C | C | | 5/6 | 4 | 33 | L |
| Big Bear Canyon-Middle Fork Gila River | | | C | | | | C | C | C | | | | | C | C | C | 7/7 | 12 | 46 | M |
| **West Fork Gila River** | | | C | | | C | C | C | C | | | | | C | C | C | 8/8 | 12 | 43 | M |
| White Creek | | | | | | C | R | | | | | | | | R | | 1/3 | 2 | 67 | H |
| Headwaters West Fork Gila River | | | C | | | C | R | | | | | | | | C | | 3/4 | 2 | 33 | L |

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| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Creek | | | C | | | C | R | C | C | | | | | C | C | R | 6/8 | 7 | 43 | M |
| Outlet West Fork Gila River | | | C | | | R | C | C | C | | | | | C | C | C | 7/8 | 12 | 48 | M |
| **Outlet East Fork Gila River** | | | C | | | C | C | R | C | | | | | C | C | R | 6/8 | 12 | 54 | M |
| Headwaters Black Canyon | | | R | | | C | | | | | | | | R | C | | 2/4 | 2 | 50 | M |
| Apache Creek | | | | | | | | | C | | | | | | C | | 2/2 | 1 | 20 | L |
| Outlet Black Canyon | | | C | | | C | R | R | C | | | | | C | C | R | 5/8 | 2 | 33 | L |
| Black Canyon-East Fork Gila River | | | C | | | R | C | R | C | | | | | C | C | R | 5/8 | 11 | 58 | M |
| **Sapillo Creek** | | | C | | | C | | | C | | | C | R | C | C | | 6/7 | 10 | 48 | M |
| Rocky Canyon-Sapillo Creek | | | | | | | | | C | | | C | | | C | | 3/3 | 0 | 0 | L |
| Lake Roberts-Sapillo Creek | | | C | | | R | | | C | | | C | | C | C | | 5/6 | 10 | 52 | M |
| Copperas Creek-Sapillo Creek | | | C | | | R | | | C | | | C | | C | C | | 5/6 | 7 | 44 | M |
| Sheep Corral Canyon-Sapillo Creek | | | C | | | C | | | C | | | C | R | C | C | | 6/7 | 4 | 29 | L |
| **Sapillo Creek-Gila River** | | | C | C | | C | | C | C | | | | R | C | C | C | 8/9 | 14 | 48 | M |
| Sapillo Creek-Gila River | | | C | | | R | | C | C | | | | R | C | C | C | 6/8 | 8 | 45 | M |
| Hells Canyon-Gila River | | | C | | | | | R | C | | | | R | C | C | R | 4/7 | 7 | 56 | M |

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| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Turkey Creek | | | C | C | | R | | | C | | | | | C | C | | 5/6 | 3 | 29 | L |
| Upper Mogollon Creek | | | | | | C | | | | | | | | | | | 1/1 | 2 | 50 | M |
| Middle Mogollon Creek | | | C | | | R | | | C | | | | | C | C | | 4/5 | 2 | 27 | L |
| Lower Mogollon Creek | | | C | | | | | | C | | | | | C | C | | 4/4 | 3 | 27 | L |
| Mogollon Creek-Gila River | | | C | | | R | | C | C | | | | R | C | C | C | 6/8 | 12 | 54 | M |
| **Upper Gila-Mangas** | | | | | | | | | | | | | | | | | | | | |
| **Bear Creek** | | | C | | | | | C | C | | | | | C | | | 4/4 | 1 | 11 | L |
| Middle Bear Creek | | | C | | | | | C | C | | | | | C | | | 4/4 | 1 | 11 | L |
| **Duck Creek** | | | | | | | | | | | | | | | | | 0/0 | 1 | 100 | H |
| Headwaters Duck Creek | | | | | | | | | | | | | | | | | 0/0 | 1 | 100 | H |
| **Mangas Creek** | | | C | | | | | C | C | | | | | C | | C | 5/5 | 6 | 38 | M |
| Schoolhouse Canyon-Mangas Creek | | | C | | | | | C | C | | | | | C | | C | 5/5 | 6 | 38 | M |
| **Sycamore Creek-Upper Gila River** | | | C | | | | | C | C | | | | R | C | C | C | 6/7 | 12 | 52 | M |
| Bear Creek-Upper Gila River | | | C | | | | | C | C | | | | R | C | C | C | 6/7 | 12 | 52 | M |
| **Blue Creek** | | | C | | | | | R | C | | | | | C | C | | 4/5 | 0 | 11 | L |

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| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cherry Creek-Blue Creek | | | C | | | | | R | C | | | | | C | C | | 4/5 | 0 | 11 | L |
| **Blue Creek-Upper Gila River** | | | C | | | | | C | C | | | | C | C | R | C | 6/7 | 13 | 54 | M |
| Bear Canyon-Upper Gila River | | | C | | | | | C | C | | | | R | C | R | C | 5/7 | 13 | 60 | M |
| Swan Canyon-Upper Gila River | | | C | | | | | C | C | | | | C | C | | C | 6/6 | 6 | 33 | L |
| **Apache Creek-Gila River** | | | | | | | | | | | | | | | | | 0/0 | 1[1] | 100 | H |
| Apache Creek | | | | | | | | | | | | | | | | | 0/0 | 1[1] | 100 | H |
| **San Francisco** | | | | | | | | | | | | | | | | | | | | |
| **Headwaters Tularosa River** | | | C | | | | | | C | | | | | C | C | | 4/4 | 8 | 50 | M |
| Negro Canyon-Tularosa River | | | C | | | | | | C | | | | | C | C | | 4/4 | 3 | 27 | L |
| Apache Creek | | | C | | | | | | C | | | | | C | C | | 4/4 | 0 | 0 | L |
| Apache Creek-Tularosa River | | | C | | | | | | C | | | | | C | C | | 4/4 | 2 | 20 | L |
| Cold Springs Canyon-Tularosa River | | | C | | | | | | C | | | | | C | C | | 4/4 | 7 | 47 | M |
| **Outlet Tularosa River** | | | C | | | R | | C | C | | | | | C | C | | 5/6 | 6 | 41 | M |
| Long Canyon-Tularosa River | | | C | | | | | C | C | | | | | C | C | | 5/5 | 0 | 0 | L |
| Headwaters North Fork Negrito Creek | | | | | | | | | | | | | | | C | | 1/1 | 0 | 0 | L |

The letter "C" is used to indicate where native fish species occurred historically and still occur. The letter "R" is used to indicate where native fish species occurred historically, but are now extirpated from those watersheds. Blank cells within the table indicate native fish species were not present historically within that subwatershed. An asterix (*) indicates the two native fish species are extirpated from the entire Forest. The number "1" indicates that the fish found in the subwatershed were not collected on the Gila NF. The number "2" indicates subwatersheds that do not currently contain any native or non-native fish, but where native fish are expected to be re-introduced (repatriated).

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Fork Negrito Creek | | | C | | | R | | | C | | | | | C | C | | 4/5 | 3 | 33 | L |
| Outlet North Fork Negrito Creek | | | R | | | R | | | C | | | | | | C | | 2/4 | 0 | 33 | L |
| Negrito Creek | | | C | | | R | | C | C | | | | | C | C | | 5/6 | 2 | 23 | L |
| Negrito Creek-Tularosa River | | | C | | | R | | C | C | | | | | C | C | | 5/6 | 5 | 38 | M |
| **Centerfire Creek-San Francisco River** | | | C | | | | | C | C | | | C | R | C | C | R | 6/8 | 6 | 40 | M |
| Trout Creek | | | C | | | | | | R | | | C | | | C | | 3/4 | 5 | 40 | M |
| Stone Creek-San Francisco River | | | C | | | | | | C | | | C | | | C | | 4/4 | 3 | 27 | L |
| SA Creek | | | | | | | | | C | | | C | | | C | | 3/3 | 1 | 14 | L |
| Headwaters Centerfire Creek | | | | | | | | | C | | | C | | | C | | 3/3 | 0 | 0 | L |
| Outlet Centerfire Creek | | | C | | | | | | C | | | C | | R | C | | 4/5 | 0 | 11 | L |
| Big Canyon-San Francisco River | | | C | | | | | | C | | | C | | R | C | | 4/5 | 0 | 11 | L |
| Starkweather Canyon | | | | | | | | | C | | | | | | C | | 2/2 | 0 | 0 | L |
| Cienega Canyon-San Francisco River | | | C | | | | | C | C | | | R | R | C | C | R | 5/8 | 2 | 33 | L |
| **Deep Creek-San Francisco River** | | | C | | | | | C | C | | | | R | C | C | R | 5/7 | 4 | 38 | M |
| Headwaters Saliz Canyon | | | C | | | | | | C | | | | | C | C | | 4/4 | 1 | 11 | L |

The letter "C" is used to indicate where native fish species occurred historically and still occur. The letter "R" is used to indicate where native fish species occurred historically, but are now extirpated from those watersheds. Blank cells within the table indicate native fish species were not present historically within that subwatershed. An asterix (*) indicates the two native fish species are extirpated from the entire Forest. The number "1" indicates that the fish found in the subwatershed were not collected on the Gila NF. The number "2" indicates subwatersheds that do not currently contain any native or non-native fish, but where native fish are expected to be re-introduced (repatriated).

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outlet Saliz Canyon | | | C | | | | | | C | | | | | C | C | | 4/4 | 1 | 11 | L |
| Saliz Canyon-San Francisco River | | | C | | | | | C | C | | | | R | C | C | | 5/6 | 2 | 23 | L |
| Deep Creek | | | | | | | | | R | | | | | | C | | 1/2 | 1 | 50 | M |
| Devils Creek-San Francisco River | | | C | | | | | C | C | | | | R | C | C | R | 5/7 | 2 | 29 | L |
| **Upper Blue River** | | | C | | | | | C | C | | | | | C | C | R | 5/6 | 6 | 41 | M |
| Dry Blue Creek | | | R | | | | | R | C | | | | | R | C | R | 2/6 | 5 | 69 | H |
| Campbell Blue Creek | | | C | | | | | R | C | | | | | C | C | | 4/5 | 4 | 38 | M |
| Centerfire Creek-Blue River | | | C | | | | | C | C | | | | | C | C | R | 5/6 | 2 | 23 | L |
| **Pueblo Creek-San Francisco River** | | | C | | R | R | | C | C | | | | R | C | C | R | 5/9 | 8 | 55 | M |
| Lower Pueblo Creek | | | C | | | | | | C | | | | | C | C | | 4/4 | 1 | 11 | L |
| Mineral Creek | | | C | | | R | | | C | | | | | C | C | | 4/5 | 1 | 11 | L |
| Wendy Flat-San Francisco River | | | C | | | | | C | C | | | | R | C | C | R | 5/7 | 1 | 38 | M |
| Whitewater Creek | | | C | | | R | | C | C | | | | | C | C | | 5/6 | 4 | 29 | L |
| South Dugway Creek-San Francisco River | | | C | | R | | | C | C | | | | R | C | C | R | 5/8 | 7 | 57 | M |
| **Mule Creek-San Francisco River** | | | C | C | R | C | | C | C | | | | R | C | C | R | 7/10 | 11 | 50 | M |

The letter "C" is used to indicate where native fish species occurred historically and still occur. The letter "R" is used to indicate where native fish species occurred historically, but are now extirpated from those watersheds. Blank cells within the table indicate native fish species were not present historically within that subwatershed. An asterix (*) indicates the two native fish species are extirpated from the entire Forest. The number "1" indicates that the fish found in the subwatershed were not collected on the Gila NF. The number "2" indicates subwatersheds that do not currently contain any native or non-native fish, but where native fish are expected to be re-introduced (repatriated).

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | Beautiful shiner* | Chihuahua chub | Desert sucker | Gila chub | Gila topminnow * | Gila trout | Headwater chub | Loach minnow | Longfin dace | Rio Grande chub | Rio Grande cutthroat | Rio Grande sucker | Roundtail chub | Sonora sucker | Speckled dace | Spikedace | Current/Historic species present | # of Non-Native fish species | Percent departure of current from historic | Departure Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big Dry Creek | | | R | | | C | | | C | | | | | | C | | 3/4 | 3 | 40 | M |
| Upper Mule Creek | | | | | | | | | C | | | | | | C | | 2/2 | 0 | 0 | L |
| Lower Mule Creek | | | C | C | | | | | C | | | | | C | C | | 5/5 | 4 | 29 | L |
| Big Pine Canyon-San Francisco River | | | C | R | R | | | R | C | | | | R | C | C | R | 4/9 | 10 | 65 | M |

The letter "C" is used to indicate where native fish species occurred historically and still occur. The letter "R" is used to indicate where native fish species occurred historically, but are now extirpated from those watersheds. Blank cells within the table indicate native fish species were not present historically within that subwatershed. An asterix (*) indicates the two native fish species are extirpated from the entire Forest. The number "1" indicates that the fish found in the subwatershed were not collected on the Gila NF. The number "2" indicates subwatersheds that do not currently contain any native or non-native fish, but where native fish are expected to be re-introduced (repatriated).

Table 122 displays native and non-native fish distribution within perennial stream miles by subwatershed. Departure percents and categories are included. As an example of how to interpret this table, Patterson Canyon subwatershed contains 0.5 miles of perennial streams that currently do not contain any native fish, but do contain non-native fish. With only non-native fish present, departure is 100 percent and departure is categorized as high.

**Table 122. Native and non-native fish distribution within perennial stream miles by subwatershed.**

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| **Plains of San Agustin** | **0.7** | | | | |
| **Patterson Lake** | **0.5** | **0.0** | **0.5** | **100** | High |
| Patterson Canyon | 0.5 | 0.0 | 0.5 | 100 | High |
| **Elephant Butte Reservoir** | **74.3** | | | | |
| **Headwaters Alamosa Creek** | **1.4** | **1.4** | **0.0** | **0** | Low |
| **Caballo** | **160.8** | | | | |
| **Palomas Creek-Rio Grande** | **49.0** | **0.00** | **6.6** | **100** | High |
| South Fork Palomas Creek | 6.6 | 0.0 | 3.4 | 100 | High |
| **Caballo Reservoir** | **47.8** | **31.0** | **0.00** | **0** | Low |
| North Seco Canyon | 9.9 | 9.4 | 0.0 | 0 | Low |
| Holden Prong | 9.2 | 0.0 | 0.0 | 100 | High |
| Headwaters Los Animas Creek | 11.8 | 0.0 | 0.0 | 100 | High |
| **El Paso-Las Cruces** | **116.0** | | | | |
| **Cuervo Arroyo_Rio Grande** | **21.2** | **2.2** | **0.0** | **0** | Low |
| Headwaters Berenda Creek | 2.2 | 2.2 | 0 | 0 | Low |
| **Mimbres** | **98.6** | | | | |
| **Gallinas Canyon-Mimbres River** | **83.1** | **0.0** | **70.0** | **100** | High |

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| Powderhorn Canyon-Mimbres River | 15.3 | 0.0 | 13.9 | 100 | High |
| Allie Canyon-Mimbres River | 18.1 | 0.0 | 17.0 | 100 | High |
| Sheppard Canyon-Mimbres River | 17.8 | 0.0 | 13.4 | 100 | High |
| Noonday Canyon-Mimbres River | 5.0 | 0.0 | 4.0 | 100 | High |
| Gallinas Canyon | 13.8 | 0.0 | 13.5 | 100 | High |
| **Headwaters San Vicente Draw** | **4.1** | **0.0** | **0.0** | **0** | Low |
| **Lampbright Draw-Mimbres River** | **1.5** | **0.0** | **1.5** | **100** | High |
| Gavilan Arroyo-Mimbres River | 1.5 | 0.0 | 0.1 | 100 | High |
| **Carrizo Wash** | **43.6** | | | | |
| **Upper Largo Creek** | **19.3** | **10.3** | **9.0** | **47** | Moderate |
| Sawmill Canyon-Largo Creek | 9.0 | 0.0 | 3.5 | 100 | High |
| Paradise Canyon-Largo Creek | 10.3 | 3.1 | 0.0 | 0.0 | Low |
| **1504000104 Headwaters East Fork Gila River** | **68.6** | **21.0** | **47.5** | **69** | Moderate |
| Hoyt Creek | 8.2 | 0.0 | 7.4 | 100 | High |
| Taylor Creek | 17.0 | 0.0 | 14.1 | 100 | High |
| Taylor Creek-Beaver Creek | 6.2 | 0.0 | 4.7 | 100 | High |
| Headwaters Diamond Creek | 9.9 | 9.9 | 0.0 | 0 | Low |
| South Diamond Creek | 11.1 | 11.1 | 0.0 | 0 | Low |
| Outlet Diamond Creek | 5.7 | 0.0 | 5.7 | 100 | High |
| Diamond Creek-East Fork Gila River | 10.5 | 0.0 | 7.3 | 100 | High |
| **Middle Fork Gila River** | **96.6** | **0.0** | **91.0** | **100** | High |
| Gilita Creek | 20.1 | 0.0 | 18.7 | 100 | High |
| Snow Canyon | 0.8 | 0.0 | 0.8 | 100 | High |

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| Canyon Creek-Middle Fork Gila River | 29.3 | 0.0 | 29.3 | 100 | High |
| Indian Creek Canyon | 6.3 | 0.0 | 6.3 | 100 | High |
| Indian Creek Canyon-Middle Fork Gila River | 17.9 | 0.0 | 17.9 | 100 | High |
| Big Bear Canyon-Middle Fork Gila River | 16.7 | 0.0 | 16.0 | 100 | High |
| **West Fork Gila River** | **86.3** | **0.0** | **86.3** | **100** | High |
| White Creek | 19.9 | 0.0 | 19.9 | 100 | High |
| Headwaters West Fork Gila River | 23.4 | 0.0 | 23.4 | 100 | High |
| Little Creek | 11.9 | 0.0 | 11.7 | 100 | High |
| Outlet West Fork Gila River | 31.1 | 0.0 | 26.1 | 100 | High |
| **Outlet East Fork Gila River** | **56.4** | **0.0** | **56.4** | **100** | High |
| Headwaters Black Canyon | 11.0 | 0.0 | 11.0 | 100 | High |
| Apache Creek | 5.9 | 0.0 | 5.9 | 100 | High |
| Outlet Black Canyon | 21.8 | 0.0 | 21.7 | 100 | High |
| Black Canyon-East Fork Gila River | 17.7 | 0.0 | 14.7 | 100 | High |
| **Sapillo Creek** | **45.3** | **8.7** | **29.6** | **65** | Moderate |
| Rocky Canyon-Sapillo Creek | 8.7 | 8.7 | 0.0 | 0 | Low |
| Lake Roberts-Sapillo Creek | 7.9 | 0.0 | 6.3 | 100 | High |
| Copperas Creek-Sapillo Creek | 3.2 | 0.0 | 0.01 | 100 | High |
| Sheep Corral Canyon-Sapillo Creek | 18.5 | 0.0 | 18.5 | 100 | High |
| **Sapillo Creek-Gila River** | **139.9** | **0.0** | **139.9** | **100** | High |
| Sapillo Creek-Gila River | 17.9 | 0.0 | 17.87 | 100 | High |
| Hells Canyon-Gila River | 22.6 | 0.0 | 22.58 | 100 | High |
| Turkey Creek | 25.2 | 0.0 | 24.85 | 100 | High |

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| Upper Mogollon Creek | 34.5 | 0.0 | 34.53 | 100 | High |
| Middle Mogollon Creek | 12.7 | 0.0 | 10.02 | 100 | High |
| Lower Mogollon Creek | 5.3 | 0.0 | 5.27 | 100 | High |
| Mogollon Creek-Gila River | 21.8 | 0.0 | 20.21 | 100 | High |
| **Upper Gila-Mangas** | **100.9** | | | | |
| **Bear Creek** | **10.5** | **0.0** | **1.5** | **100** | High |
| Middle Bear Creek | 1.5 | 0.0 | 0.4 | 100 | High |
| **Mangas Creek** | **0.4** | **0.0** | **0.4** | **100** | High |
| Schoolhouse Canyon-Mangas Creek | 0.4 | 0.0 | 0.4 | 100 | High |
| **Sycamore Creek-Upper Gila River** | **17.1** | **0.0** | **8.7** | **100** | High |
| 150400020401 Bear Creek-Upper Gila River | 8.7 | 0.0 | 1.05 | 100 | High |
| **Blue Creek-Upper Gila River** | **33.5** | **0.0** | **19.0** | **100** | High |
| Bear Canyon-Upper Gila River | 10.3 | 0.0 | 8.9 | 100 | High |
| 150400020603 Swan Canyon-Upper Gila River | 8.7 | 0.0 | 2.8 | 100 | High |
| **Apache Creek-Gila River** | **1.4** | **0.0** | **1.4** | **100** | High |
| Apache Creek | 1.4 | 0.0 | 0.7 | 100 | High |
| **San Francisco** | **759.8** | | | | |
| **Headwaters Tularosa River** | **39.3** | **16.7** | **15.1** | **38** | Low |
| Negro Canyon-Tularosa River | 5.9 | 0.0 | 1.3 | 100 | High |
| Apache Creek | 16.7 | 5.2 | 0 | 0 | Low |
| Apache Creek-Tularosa River | 6.7 | 0.0 | 0.4 | 100 | High |
| Cold Springs Canyon-Tularosa River | 2.5 | 0.0 | 0.5 | 100 | High |

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| **Outlet Tularosa River** | **54.6** | **14.5** | **40.1** | **73** | High |
| Long Canyon-Tularosa River | 6.7 | 4.0 | 0.0 | 0 | Low |
| South Fork Negrito Creek | 12.7 | 0.0 | 11.9 | 100 | High |
| Outlet North Fork Negrito Creek | 7.8 | 7.3 | 0.0 | 0 | Low |
| Negrito Creek | 13.0 | 0.0 | 11.0 | 100 | High |
| Negrito Creek-Tularosa River | 14.4 | 0.0 | 5.3 | 100 | High |
| **Centerfire Creek-San Francisco River** | **145.9** | **23.5** | **84.4** | **58** | Moderate |
| Trout Creek | 24.6 | 0.0 | 14.7 | 100 | High |
| Stone Creek-San Francisco River | 28.8 | 0.0 | 11.4 | 100 | High |
| SA Creek | 7.0 | 0.0 | 6.6 | 100 | High |
| Headwaters Centerfire Creek | 6.2 | 3.1 | 0.0 | 0 | Low |
| Outlet Centerfire Creek | 7.6 | 0.5 | 0.0 | 0 | Low |
| Big Canyon-San Francisco River | 7.6 | 5.7 | 0.0 | 0 | Low |
| Starkweather Canyon | 2.2 | 1.5 | 0.0 | 0 | Low |
| Cienega Canyon-San Francisco River | 24.1 | 0.0 | 12.8 | 100 | High |
| **Deep Creek-San Francisco River** | **60.6** | **0.0** | **58.5** | **100** | High |
| Headwaters Saliz Canyon | 3.8 | 0.0 | 3.8 | 100 | High |
| Outlet Saliz Canyon | 7.3 | 0.0 | 5.1 | 100 | High |
| Saliz Canyon-San Francisco River | 15.4 | 0.0 | 11.3 | 100 | High |
| Deep Creek | 18.4 | 0.0 | 16.9 | 100 | High |
| Devils Creek-San Francisco River | 13.6 | 0.0 | 10.0 | 100 | High |
| **Upper Blue River** | **172.3** | **0.0** | **64.5** | **100** | High |
| Dry Blue Creek | 16.3 | 0.0 | 8.5 | 100 | High |

| **Subbasin (4th Level), Watershed (5th Level) &** Subwatershed (6th level) | **Total HU Perennial Miles** | **Current Native Fish Only Stream Miles** | **Current Native/Non-native Fish Stream Miles** | **% Departure of Current Native Only from Stream Miles** | **Departure Category** |
|---|---|---|---|---|---|
| Campbell Blue Creek | 32.1 | 0.0 | 0.4 | 100 | High |
| Centerfire Creek-Blue River | 16.1 | 0.0 | 0.4 | 100 | High |
| **Pueblo Creek-San Francisco River** | **81.7** | **0.0** | **72.6** | **100** | High |
| Lower Pueblo Creek | 2.6 | 0.0 | 2.5 | 100 | High |
| Mineral Creek | 18.9 | 0.0 | 16.7 | 100 | High |
| Wendy Flat-San Francisco River | 11.1 | 0.0 | 1.9 | 100 | High |
| Whitewater Creek | 26.2 | 0.0 | 26.2 | 100 | High |
| South Dugway Creek-San Francisco River | 13.8 | 0.0 | 8.4 | 100 | High |
| **Mule Creek-San Francisco River** | **82.7** | **29.2** | **46.5** | **56** | Moderate |
| Big Dry Creek | 18.9 | 0.0 | 18.8 | 100 | High |
| Upper Mule Creek | 13.9 | 7.1 | 0.0 | 0 | Low |
| Lower Mule Creek | 8.8 | 0.0 | 4.3 | 100 | High |
| Big Pine Canyon-San Francisco River | 18.8 | 0.0 | 18.3 | 100 | High |
| **TOTALS** | | | | | |
| **Watershed level (5th level)** | **1,421*** | **158.5*** | **955.1*** | **67** | High |
| Sub-watershed level (6th level) | 1,094.7* | 80.5* | 734.99* | 67 | High |

*-There are differences of 307 and 279 stream miles in the 5th and 6th levels for current native only and current native/non-native stream miles, respectively, from the total hydrologic unit perennial miles, that likely have fish but may not have been surveyed because of difficult access areas, or a portion of the stream traverses private land.

Native-only streams are generally found in headwaters, where there are generally assemblages of native suckers, chubs, and dace. Historic land uses and introduction of nonnative species that occurred within the last hundred years or more have resulted in substantial negative impacts to aquatic communities and their watersheds. Although native fish may still inhabit these streams, their population and condition are likely in a diminished state. As a result, native fish populations have been reduced from a large interconnected population to isolated populations within altered and degraded habitats (Alves et al. 2008). Because of the altered habitat and isolated populations, all native fish species have lost much of their population redundancy within and outside the Gila NF.

Departure from the historical range of variability in streamflow characteristics, water chemistry, riparian vegetation, water temperature, nutrient supply, stream channel shape and function, large (coarse) woody debris and upland watershed condition can negatively impact aquatic habitat and affect native fish diversity and distribution. The severity and extent of recent wildfire has resulted in many of these changes (see Riparian and System Drivers and Stressors Chapters). Drought and the legacy of past fire suppression has increased both the possibility and the actual occurrence of large, high severity wildfires (see the System Drivers and Stressors Chapter). The degree to which native fishes are affected depends largely on the location and extent of the fire within the watershed, severity and post-fire precipitation events (Myers pers. comm. 2016).

Post-fire effects on cold and warm-water aquatic communities including oligochaetes (segmented worms resembling earthworms), insects, crayfish, fishes, and tadpoles have been studied following these large-scale fires in the upper Gila watershed (Whitney 2015). Several insect taxa responded to these fires with reduced biomass, whereas oligochaete biomass was unaffected. Biomass of six native fish species decreased after the fires, primarily attributed to site proximity to fire. Native and nonnative fish decreases after fire were most pronounced for cold-water salmonids (e.g. trout), while warm-water nonnative fishes exhibited limited responses. Nonnative crayfish and tadpoles collected were unresponsive to fire disturbance. In Rain, West Fork Mogollon, Whitewater, South Fork Whitewater and Turkey Creeks, non-native trout were greatly reduced and eliminated from most of the streams; however, a few individuals persisted in short stream reaches where impacts were less severe. In Mineral and Willow Creeks, non-native species were eliminated post-fire, while native dace and suckers were reduced. However, these native populations have since increased. In Turkey Creek, hybrid Gila x rainbow trout were almost eliminated, while Gila chub populations remained relatively stable. Also, in the Mimbres River, rainbow and brown trout have been eliminated post-fire, but Chihuahua chub and Rio Grande sucker have survived in several places (Myers pers. comm. 2016).

Motorized roads and trails and grazing by wildlife and livestock, both within the riparian zone and in the upland watershed, have the potential to influence sediment and nutrient delivery to streams, degrade water quality, alter peak run-off flows, and lead to greater habitat fragmentation (see the System Drivers and Stressors Chapter). Roads can act as barriers to fish movement (Furniss et al. 1991), reducing distribution and diversity of species. Many roads located in stream bottoms have likely contributed to habitat fragmentation if they were not designed with appropriate fish crossings where roads cross the creeks.

Hybridization, depredation, and competition from non-native fish have likely contributed to diversity and distribution declines in native fish species as well. For example, the Rio Grande cutthroat trout that occurred in Las Animas Creek were found through genetic testing to have been hybridized with rainbow trout. There are 21 non-native species that currently inhabit the streams within plan area watersheds. Moreover, long-fin dace (*Agosia chrysogaster*), is native to certain watersheds, but have been introduced into watersheds they historically did not occupy. Non-native fish species were introduced into these watersheds for sport fishing or by accident (see Chapter 11 for the economic and social values of

recreational fishing on the Gila NF). In 2008, New Mexico State Fish Hatcheries converted to raising triploid Rainbow trout, which are sterile and cannot reproduce, to be stocked in waters to minimize hybridization concerns with native trout species (NMDGF 2016a). The New Mexico Department of Game and Fish (NMDGF) only stocks lakes within the Gila NF with triploid Rainbow trout or channel catfish, and only stocks certain streams with native Gila trout or Chihuahua chub to promote native fish (NMDGF 2016a). While non-native warm water fish occur and successfully reproduce in rivers and streams on the Gila NF, NMDGF provides fishing opportunities through regulations on those but does not actively stock any fish (NMDGF 2016a).

### Context Area

Data to assess aquatic biota at the subbasin scale is not available.

### Risk

Risk is a direct interpretation of departure (low departure equals low risk, etc.) For many 6$^{th}$ code sub-watersheds, risk is low to moderate mostly due to many native fish species present with few non-native fish in the system. The highly departed, high risk 6$^{th}$ codes typically have most or all native species absent and/or a high number of non-native species present in the sub-watershed. The highly departed 5$^{th}$ codes were absent any native fish. Where post-fire responses of native insects and fishes are pronounced, it may indicate that the extent and frequency of fire threatens the persistence of native fauna and suggest that management activities promoting ecosystem resilience might help ameliorate wildfire effects (Whitney et al. 2015).

Native fish populations may continue to diminish in the presence of non-natives without active management to remove non-natives. However, with the high number of projects on-going to repatriate streams with native fish, fish barriers to prevent non-native species mixing with native species in certain streams, and the commitment from NMDGF to not actively stock non-native species in streams, native fish should have a higher likelihood of persistence. With the popularity of sport fishing and NMDGF managing certain water bodies for sportfishing, it is unlikely the Gila NF will ever be comprised of 100 percent native fishes.

## Groundwater Resources

### Quantity

The majority of groundwater resources within the Forest occur in fractured volcanic and sedimentary rock and are not considered important sources of groundwater by the State. Portions of important basin fill aquifers[37] do occur to a limited extent on Forest, but largely occur in the surrounding context area (NMED 2001). While the Forest may not be considered an important reservoir of groundwater overall, it is a very important source of recharge in the basin fill aquifers surrounding the Forest. The Forest contributes to groundwater recharge in the Gila-San Francisco, Mimbres, Middle and Lower Rio Grande, Las Animas, Hot Springs Artesian, and Lordsburg Underground Water Basins declared by the New Mexico Office of the State Engineer.

Data provided by the State Engineer's Office indicates that approximately one percent of context area groundwater wells occur on Forest. Appendix D contains a table based on information from the New Mexico, Arizona, and Texas Offices of the State Engineers about the number of wells within the context and plan areas, both on and off-Forest. Wells constructed on the Gila NF are able to be used for domestic, livestock, irrigation, municipal, industrial, and commercial purposes, although not all wells can be used for all purposes. Most are currently used to provide livestock water, providing a secondary benefit as water

[37] Basin fill aquifers are thick deposits of sediment that accumulated in valley bottoms.

for wildlife. Wells on the Gila NF also provide water for 15 drinking water systems associated with recreation and administrative sites (see Infrastructure Chapter).

Groundwater recharge occurs as a result of mountain-front or alluvial mechanisms. Mountain-front recharge is very important in arid and semiarid regions like the Southwest. It occurs as the result of higher precipitation and lower temperatures in the mountainous areas, the relatively shallow nature of mountain soils compared to lower lying area and fractured nature of the bedrock. Alluvial recharge occurs as a result of high flow events, originating from Forest streams. The importance of alluvial recharge has been emphasized in the Mimbres subbasin (Conover and Akin 1942). Recharge rates are very slow.

Locally important, but relatively small, shallow alluvial aquifers are found in valley bottoms across the plan area. Groundwater is both recharged and discharged in these aquifers. Zones of recharge and discharge may change over time along any particular stream in response to surface runoff contributions and changes in channel and floodplain location and materials. Also of local importance are perched aquifers. Although information describing their extent and distribution is not available, these aquifers support springs, seeps and wetlands on the Forest.

Anything that impacts any element of the hydrological cycle, has the potential to impact groundwater quantity through alteration of recharge and discharge patterns. Climate change and associated declines in snowpack and alterations to streamflow are of particular relevance, as is balance between water supply and demand.

There is limited scientific information available related specifically to groundwater, climate and climate change. However, the information that is available has largely been the result of studies conducted in arid and semiarid regions, such as the Gila NF is located in. The evidence suggests that groundwater flowing in these regional aquifers accumulated thousands of years ago, before and during the last ice age, and that very little has accumulated since, rendering groundwater a non-renewable resource (Taylor et al. 2012).

The primary impact of climate change on groundwater resources is indirect, such as the increased demand for groundwater by human populations during times of drought. Prior to European settlement, groundwater use was probably limited to natural discharge from springs and baseflow provided during low streamflow periods. The reference condition for groundwater is that the rate of discharge did not exceed the recharge rate. However, as discussed in the System Drivers and Stressors chapter, this is not currently the case. This characteristic is considered to be in high departure and trending away from reference at context and plan scales.

### *Risk*

Risk to groundwater quantity is driven by climate and water use. The Gila NF does not have the ability or authority to control or influence either of these things. Regardless, risk is assessed here, and is a direct reflection of departure. There is a high risk at both the context and plan scales. As droughts are expected to become more frequent and severe with climate change (IPCC 2007; Seager et al. 2007), and since most of the groundwater pumped is used for irrigation purposes, demand may be expected to increase independent of population trends. Groundwater supply, on the other hand, is expected to decline. It has been estimated that over the next several decades, the western United States could experience a 10 to 30 percent reduction in groundwater recharge (Taylor et al. 2012), elevating the risk to groundwater sustainability. The Gila NF has observed a large increase over the last three years in the number of wells on the Forest that need to be deepened because they are no longer producing enough water. There has also been an observed increase in the number of new wells needed to supplement livestock grazing allotments with unreliable surface water.

## Springs, Seeps and Non-Riverine Wetlands

The following analysis concerns the occurrence, extent and distribution of springs, seeps and non-riverine wetlands. It does not analyze any riparian vegetation communities that may be associated with these resource features. That is done in the riparian chapter of the assessment report. The water associated with riverine wetlands is accounted for in the perennial and intermittent streams, and streamflow analyses. These streamside wetlands cannot be separated from the streams themselves.

Groundwater is discharged to springs, seeps and wetlands in a variety of ways. The perched aquifers previously mentioned, are zone of saturated soils that form above a layer of low-permeability and the main water table. Depression springs are located in low lying areas where the surface topography corresponds with a near surface groundwater table. These types of springs typically receive some contribution from surface runoff as well. Contact springs are associated with abrupt changes in rock type. Springs also occur along fault lines, or where there are joints or fractures in the rock. Springs or seeps may or may not be associated with wetlands or riparian vegetation and some wetlands are not supported by groundwater. Nor do all wetlands support riparian or wetland species; playa lakes, as described subsequently, are an example.

Because of data limitations that prevent separation of wetlands that are supported by groundwater and those that are not, all wetlands, except riverine wetlands, are considered here. Riverine wetlands are considered in the Riparian Chapter. The US Fish and Wildlife Service (USFWS) National Wetlands Inventory describes plan and context area wetlands in terms of riverine, freshwater emergent and freshwater forested/shrub. Wetlands that do not rely on groundwater are typically seasonal and occur in low lying areas where the surface topography does not correspond with a high in the water table, such as playa lakes. While they may support upland vegetation that are adapted to periods of inundation and the salt accumulations that can occur in these systems, obligate wetland or riparian species are typically not present. Very few of these types of wetlands are known to occur on the Forest. They do exist to a larger extent within the context area.

### *Analysis Methods*

The representativeness and redundancy approach utilized to assess the extent and distribution of perennial and intermittent streams is also applied to springs, seeps and wetlands.

### *Plan Area*

The Forest does not have a detailed inventory of springs and seeps or non-riverine wetlands. Information about the extent and distribution of these features is limited to the NHD and the USFWS National Wetlands Inventory. The NHD documents what is known about the location and number of springs and seeps in the plan and context area, but does not provide any information as to whether they produce water seasonally, all year long, or if they no longer produce water at all. The USFWS wetlands dataset provides national coverage, but has not been entirely verified on the ground. Table 123 lists each of the 49 plan area watersheds and displays total watershed area, watershed area located on Forest, total number of springs and seeps, and acres of non-riverine wetlands, as well as the percentage occurring on and off-Forest. Appendix D contains a table with the same information but including the subwatersheds.

**Table 123. Plan area extent and distribution of springs, seeps and non-riverine wetlands**

| Watershed Name | Watershed Area | | | Springs/Seeps (number) | | | Non-Riverine Wetlands (acres) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total (acres) | Gila NF (acres) | % Gila NF | Total | On Gila NF | % On Gila NF | Total | On Gila NF | % on Gila NF |
| *Plains of San Agustin Subbasin* | | | | | | | | | |
| Nester Draw | 169,190 | 5,328 | 3 | 32 | 0 | 0 | 0 | 0 | -- |
| Patterson Lake | 207,398 | 78,514 | 38 | 30 | 12 | 40 | 18 | 0 | 0 |
| Y Canyon | 97,476 | 52,140 | 38 | 3 | 2 | 67 | 0 | 0 | -- |
| *Elephant Butte Reservoir Subbasin* | | | | | | | | | |
| Headwaters Alamosa Creek | 257,399 | 40,451 | 16 | 19 | 0 | 0 | 0 | 0 | -- |
| *Caballo Subbasin* | | | | | | | | | |
| Caballo Reservoir | 247,026 | 52,993 | 21 | 35 | 21 | 60 | 2,423 | 68 | 3 |
| Cuchillo Negro Creek | 236,142 | 76,046 | 32 | 33 | 21 | 64 | 7 | 0 | 0 |
| Palomas Creek-Rio Grande | 234,606 | 57,833 | 25 | 40 | 22 | 55 | 1,548 | 21 | 1 |
| Percha Creek | 77,379 | 24,763 | 32 | 25 | 18 | 72 | 85 | 0 | 0 |
| *El Paso-Las Cruces Subbasin* | | | | | | | | | |
| Cuervo Arroyo-Rio Grande | 226,938 | 37,572 | 17 | 39 | 25 | 64 | 195 | 0 | 0 |
| *Mimbres Subbasin* | | | | | | | | | |
| Cow Spring Draw-Seventysix Draw | 184,549 | 3,070 | 2 | 1 | 0 | 0 | 0 | 0 | -- |
| Gallinas Canyon-Mimbres River | 205,881 | 151,448 | 74 | 67 | 64 | 96 | 468 | 39 | 8 |
| Headwaters San Vicente Draw | 144,197 | 26,072 | 18 | 29 | 23 | 6 | 0 | 0 | -- |
| Lampbright Draw | 92,105 | 2,351 | 3 | 5 | 0 | 0 | 0 | 0 | -- |
| Lampbright Draw-Mimbres River | 124,477 | 20,713 | 17 | 19 | 12 | 7 | 896 | 0 | 0 |
| Macho Creek | 213,735 | 3,641 | 2 | 13 | 0 | 0 | 37 | 0 | 0 |
| Outlet San Vicente Draw | 160,634 | 1,684 | 1 | 9 | 1 | 11 | 0 | 0 | -- |
| Upper Seventysix Draw | 114,409 | 1,313 | 1 | 3 | 2 | 67 | 0 | 0 | -- |
| *Little Colorado Headwaters Subbasin* | | | | | | | | | |
| Coyote Creek | 147,501 | 13,510 | 9 | 16 | 5 | 31 | 52 | 0 | 0 |

| Watershed Name | Watershed Area | | | Springs/Seeps (number) | | | Non-Riverine Wetlands (acres) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total (acres) | Gila NF (acres) | % Gila NF | Total | On Gila NF | % On Gila NF | Total | On Gila NF | % on Gila NF |
| *Carrizo Wash Subbasin* | | | | | | | | | |
| Agua Fria Creek | 218,968 | 76,850 | 35 | 29 | 21 | 72 | 5 | 0 | 0 |
| LA Draw-Cienega Amarilla | 160,256 | 7,918 | 5 | 16 | 3 | 19 | 34 | 0 | 0 |
| Rito Creek | 279,878 | 37,218 | 13 | 35 | 21 | 60 | 107 | 0 | 0 |
| Upper Largo Creek | 98,300 | 75,156 | 76 | 16 | 9 | 56 | 7 | 0 | 0 |
| *Upper Gila Subbasin* | | | | | | | | | |
| Beaver Creek | 147,638 | 79,799 | 54 | 5 | 3 | 60 | 0 | 0 | -- |
| Corduroy Draw | 111,118 | 68,279 | 61 | 10 | 8 | 80 | 0 | 0 | -- |
| Headwaters East Fork Gila River | 193,943 | 192,473 | 99 | 32 | 30 | 94 | 153 | 140 | 91 |
| Middle Fork Gila River | 218,844 | 218,128 | >99 | 26 | 24 | 92 | 716 | 705 | 98 |
| Outlet East Fork Gila River | 104,412 | 103,887 | 99 | 19 | 18 | 95 | 413 | 384 | 93 |
| Railroad Canyon | 89,105 | 14,046 | 16 | 0 | 0 | -- | 0 | 0 | -- |
| Sapillo Creek | 110,693 | 108,907 | 98 | 25 | 24 | 96 | 19 | 19 | 0 |
| Sapillo Creek-Gila River | 189,860 | 181,341 | 96 | 56 | 56 | 100 | 301 | 269 | 89 |
| West Fork Gila River | 103,948 | 102,439 | 99 | 23 | 21 | 91 | 312 | 275 | 88 |
| *Upper Gila-Mangas Subbasin* | | | | | | | | | |
| Apache Creek-Gila River | 237,306 | 12,270 | 5 | 62 | 14 | 23 | 252 | 0 | 0 |
| Bear Creek | 103,985 | 65,069 | 63 | 56 | 46 | 82 | 1 | 0 | 0 |
| Blue Creek | 88,931 | 3,428 | 4 | 7 | 0 | 0 | 3 | 0 | 0 |
| Blue Creek-Upper Gila River | 186,504 | 46,732 | 25 | 56 | 26 | 46 | 742 | 267 | 36 |
| Duck Creek | 144,993 | 16,862 | 12 | 4 | 4 | 100 | 3 | <1 | <1 |
| Mangas Creek | 130,597 | 50,698 | 39 | 32 | 21 | 66 | 5 | 0 | 0 |
| Sycamore Creek-Upper Gila River | 121,829 | 3,601 | 3 | 8 | 3 | 5 | 709 | 41 | 6 |
| *Animas Valley Subbasin* | | | | | | | | | |
| Headwaters Burro Cienega | 109,203 | 17,666 | 16 | 2 | 1 | 50 | 0 | 0 | -- |

| Watershed Name | Watershed Area | | | Springs/Seeps (number) | | | Non-Riverine Wetlands (acres) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total (acres) | Gila NF (acres) | % Gila NF | Total | On Gila NF | % On Gila NF | Total | On Gila NF | % on Gila NF |
| Lordsburg Draw | 221,184 | 41,617 | 19 | 20 | 18 | 90 | 0 | 0 | -- |
| Outlet Burro Cienega | 179,037 | 291 | <1 | 1 | 0 | 0 | 0 | 0 | -- |
| *San Francisco Subbasin* | | | | | | | | | |
| Centerfire Creek-San Francisco River | 267,108 | 207,266 | 78 | 185 | 84 | 45 | 537 | 91 | 17 |
| Deep Creek-San Francisco River | 153,321 | 149,537 | 98 | 39 | 38 | 97 | 120 | 86 | 72 |
| Headwaters Tularosa River | 225,391 | 211,838 | 94 | 68 | 51 | 75 | 351 | 29 | 8 |
| Lower Blue River | 198,105 | 277 | <1 | 215 | 0 | 0 | 240 | 0 | 0 |
| Mule Creek-San Francisco River | 244,422 | 121,064 | 50 | 118 | 56 | 47 | 402 | 71 | 18 |
| Outlet Tularosa River | 184,206 | 180,493 | 98 | 44 | 42 | 95 | 133 | 37 | 72 |
| Pueblo Creek-San Francisco River | 226,379 | 198,993 | 88 | 52 | 44 | 85 | 245 | 175 | 71 |
| Upper Blue River | 198,049 | 27,915 | 14 | 128 | 4 | 3 | 607 | 0 | 0 |
| **Total** | **8,388,553** | **3,271,497** | **39** | **1807** | **918** | **51** | **12,146** | **2,718** | **22** |

The results of the representativeness and redundancy analyses for springs and seeps are presented in Figure 131 and Figure 132, followed by Figure 133 and Figure 134 displaying the same information for non-riverine wetlands.

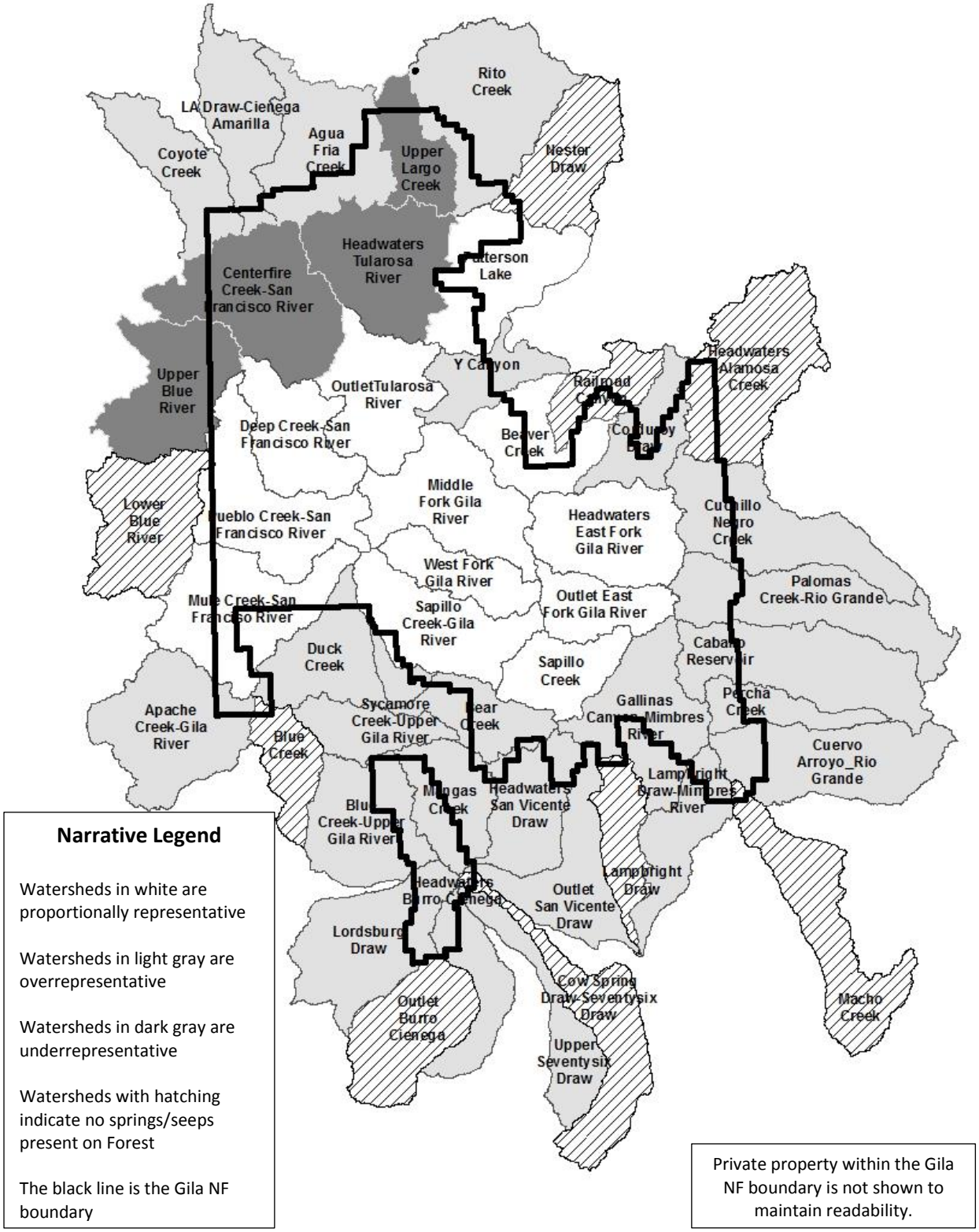



**Figure 131. Representativeness of springs and seeps in plan area watersheds**

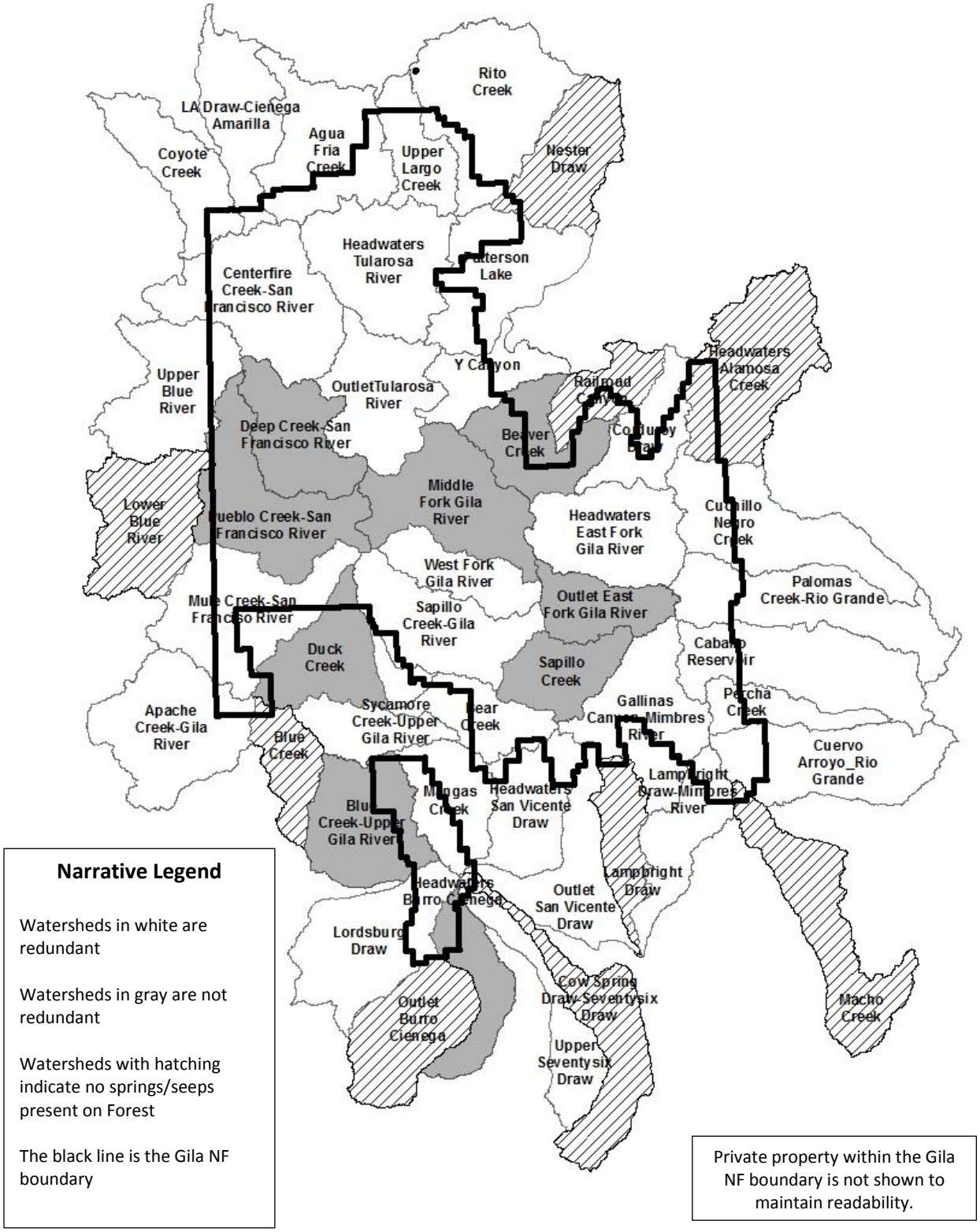
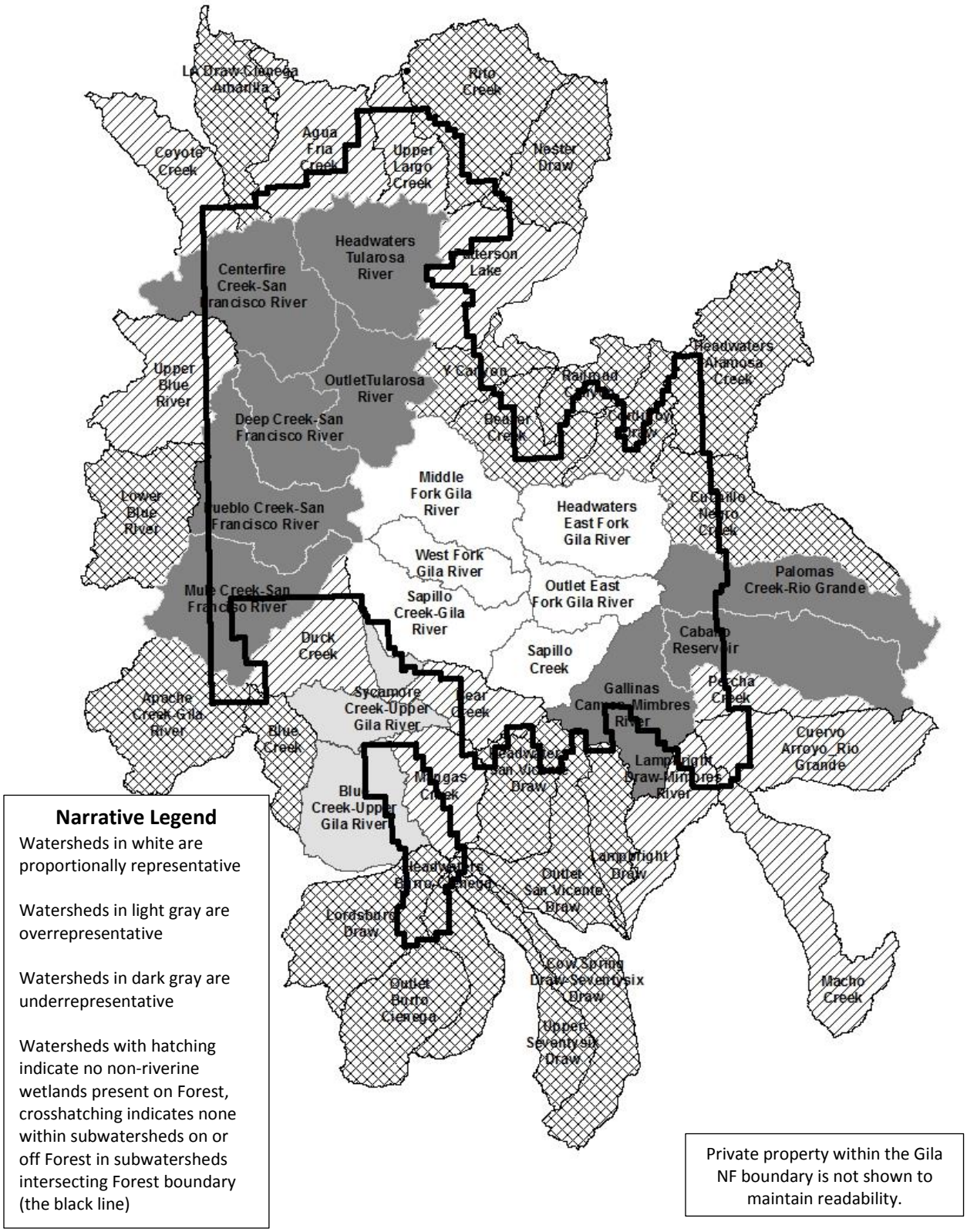



**Figure 132. Redundancy of springs and seeps in plan area watersheds**




**Narrative Legend**

Watersheds in white are proportionally representative

Watersheds in light gray are overrepresentative

Watersheds in dark gray are underrepresentative

Watersheds with hatching indicate no non-riverine wetlands present on Forest, crosshatching indicates none within subwatersheds on or off Forest in subwatersheds intersecting Forest boundary (the black line)

Private property within the Gila NF boundary is not shown to maintain readability.

**Figure 133. Representativeness of non-riverine wetlands in plan area watersheds**

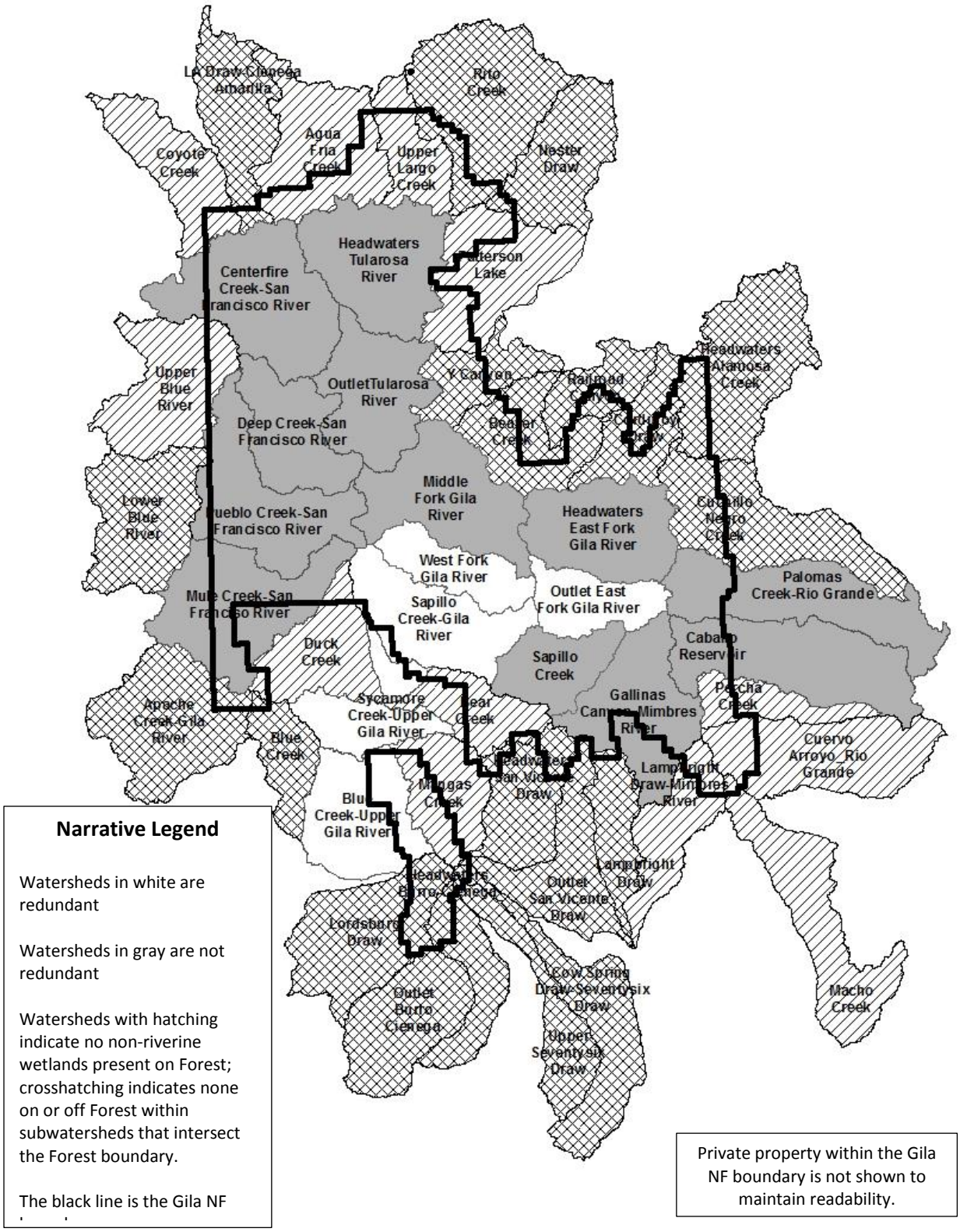



**Figure 134. Redundancy of non-riverine wetlands in plan area watersheds**

### *Context Area*

Table 124 displays the number of springs and seeps and acres of non-riverine wetlands by subbasin, and the portion located within the Forest.

**Table 124. Extent and distribution of springs and seeps, and non-riverine wetlands within the context area.**

| Subbasin Name | Number of Springs and Seeps | | Acres of Non-Riverine Wetlands | |
|---|---|---|---|---|
| | Total | On Gila NF | Total | On Gila NF |
| Plains of San Agustin | 83 | 14 | 18 | 0 |
| Elephant Butte Reservoir | 115 | 0 | 11,787 | 0 |
| Caballo | 133 | 82 | 4,062 | 90 |
| El Paso-Las Cruces | 58 | 25 | 1,310 | 0 |
| Mimbres | 164 | 102 | 1,408 | 39 |
| Little Colorado Headwaters | 168 | 5 | 1,016 | 0 |
| Carrizo Wash | 118 | 54 | 285 | 0 |
| Upper Gila | 196 | 184 | 1,914 | 1,791 |
| Upper Gila-Mangas | 235 | 114 | 1,941 | 308 |
| Animas Valley | 29 | 19 | 2 | 0 |
| San Francisco | 912 | 319 | 2,836 | 490 |
| **Total** | **2,211** | **918** | **26,579** | **2,718** |

The Gila NF occupies 17 percent of the context area (Table 102) and contains 42 percent of the total number of springs and seeps and 10 percent of the non-riverine wetland acres. The opportunities for the Forest to contribute to sustainability of springs and seeps is directly related to their occurrence on Forest. In regard to non-riverine wetlands, this is also the case except where those wetlands are contiguous across jurisdictions. The Forest's contributions to integrity and sustainability and opportunities are greatest for both springs and seeps, and non-riverine wetlands in Upper Gila, San Francisco, Upper Gila-Mangas, Mimbres and Caballo. Other jurisdictions and their contributions and opportunities to integrity and sustainability are important in all subbasins.

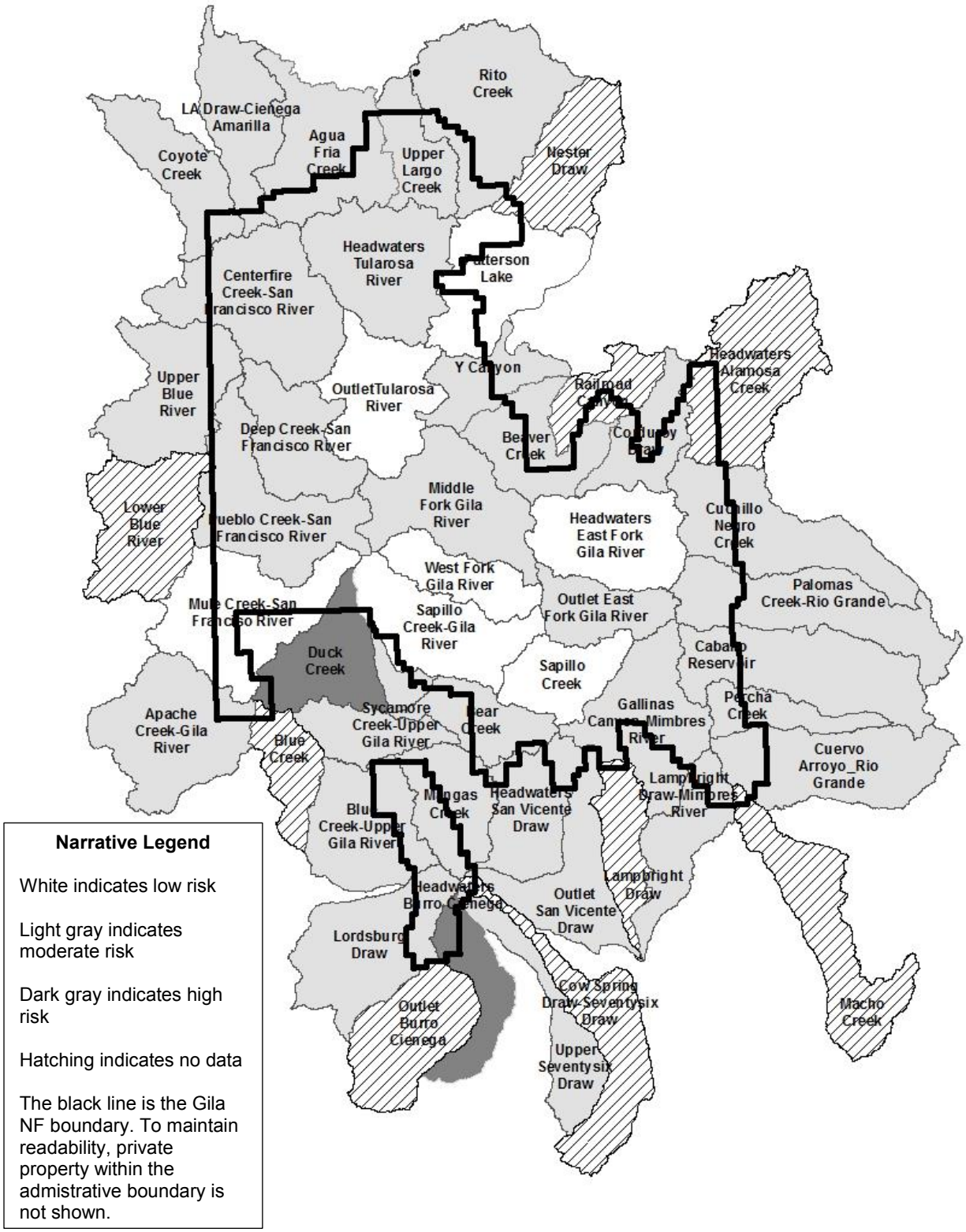
### *Risk*

The results of the representativeness and redundancy analysis are applied to the assessment of risk to the extent and distribution of springs and seeps, and non-riverine wetlands using the matrix displayed as Table 125. In watersheds that do not contain any springs and seeps, or non-riverine wetlands in subwatersheds that intersect the Forest boundary, there is no risk.

**Table 125. Risk matrix for representativeness and redundancy analysis results.**

| | Redundant | Not Redundant |
|---|---|---|
| Proportionally Represented | Low Risk | Moderate Risk |
| Not Proportionally Represented | Moderate Risk | High Risk |

The results of the watershed scale risk assessment are displayed in Figure 135 (springs and seeps) and Figure 136 (non-riverine wetlands).




**Narrative Legend**

White indicates low risk

Light gray indicates moderate risk

Dark gray indicates high risk

Hatching indicates no data

The black line is the Gila NF boundary. To maintain readability, private property within the admistrative boundary is not shown.

**Figure 135. Risk to springs and seeps across the plan area.**

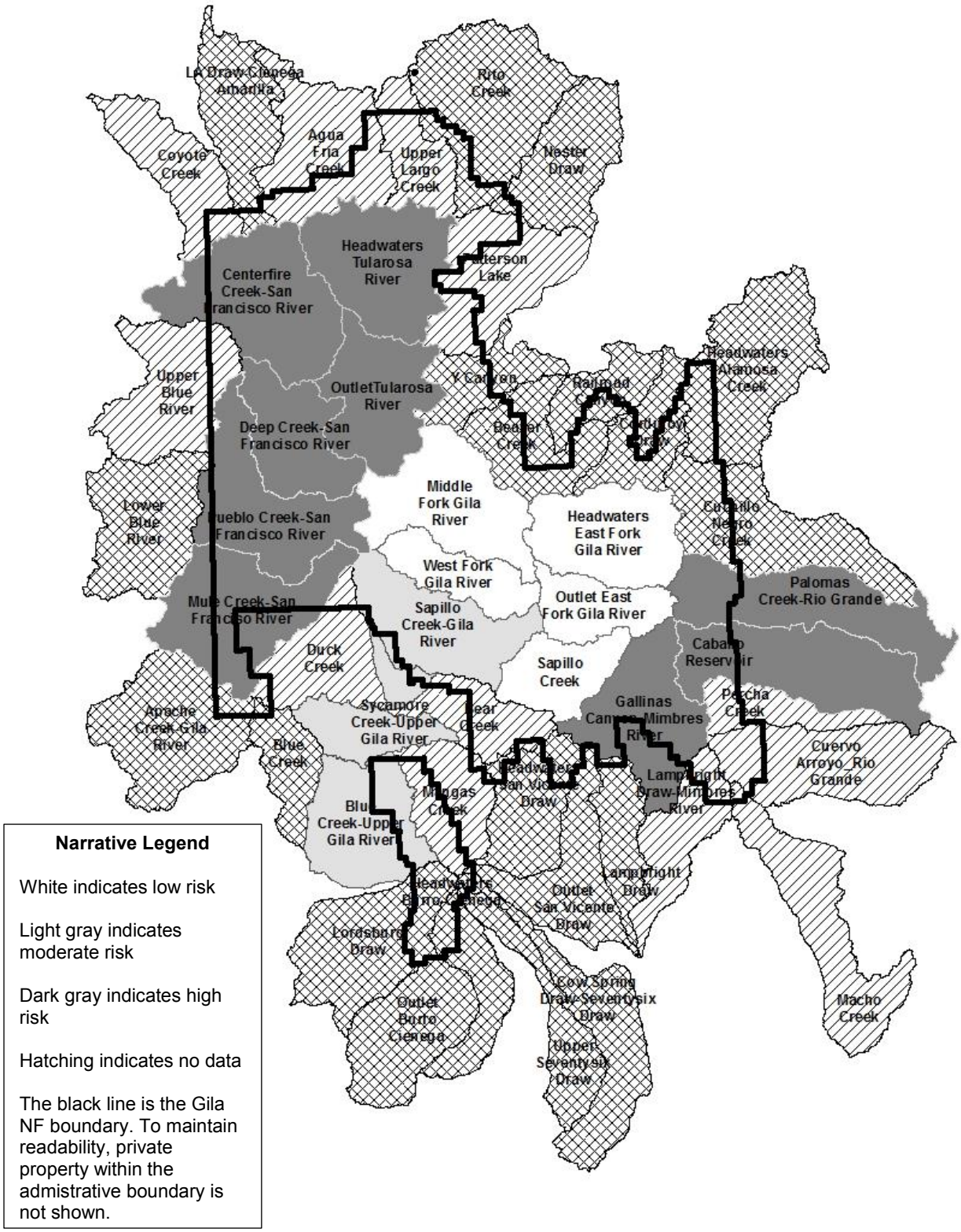



**Figure 136. Risk to non-riverine wetlands across the plan area.**

There is no relationship between risk interpreted from the representativeness and redundancy analysis and the status of system drivers or stressors, including Gila NF management. Rather, it is mostly a reflection of climate, site specific topography and patterns of land ownership. Private property within the Gila NF administrative boundary tends to be located near water sources, which causes these features to be underrepresented on Forest in some cases where it might appear reasonable to expect proportional representation. Because these features are relatively small, they are more susceptible to impacts related to management activities. In particular, those springs and seeps, and non-riverine wetlands that are seasonal or produce relatively small quantities of water are more likely to be dry up when fire or herbivory reduces the vegetative canopy that shades them, reduces site temperatures and therefore evaporation; while transpiration losses are reduced, evaporative losses are increased. The most significant risk to springs and seeps from management activity is development. Spring development involves any method or practice that diverts water produced by the spring and/or alters natural water flow paths. Based on the Gila NF's range improvements database 49 percent of the springs occurring on Forest have been developed to provide livestock water. As with the stock tanks discussed under the Waterbodies heading, there is no information on the reliability of the water produced from these springs. The relationship between how much water the spring produces, and how much is diverted is important to understand the magnitude of the ecological risk. While the water that is left is still available to support ecological values, its potential to do so is reduced. This competition between ecological and socio-economic demands for water, as well as climate change are the primary stressors contributing to risk.

Forest and local unit risk is assessed by assigning each local unit the risk category associated with the majority of its area. Based on this approach, the Forest and all local units are associated with a moderate risk to springs and seeps, except the Upper Gila local unit which is associated with a low risk. With respect to non-riverine wetlands, there is a high risk Forest-wide. Risk in all local units except Lower Gila is also high. Risk is low in Lower Gila because most of this local unit's area does not contain non-riverine wetlands across much of its area. This should not be taken to mean the wetlands in this local unit are of lesser value. All wetlands are ecologically important.

### Groundwater Quality

There is not a lot of information about groundwater quality in the context or plan area. The State of New Mexico, through the Water Quality Control Commission, has developed regulations (20.6.2 NMAC) to protect groundwater resources. The State of New Mexico also relies on its State Drinking Water Rules that incorporate regulations in the federal Safe Drinking Water Act and establish additional requirements. The Safe Drinking Water Act and State Drinking Water Rules only apply to public water systems. Groundwater quality monitoring is typically only conducted at facilities with a permit to discharge pollutants or when individuals test their own domestic well water (NMED 2014b).

However, there is some departure from historic groundwater quality conditions in and around the Forest associated old landfills, historic mining activity and leaky underground storage tanks. These are documented by the soil contamination attribute of the watershed condition classification's soil condition indicator and would not have existed prior to European settlement. Historic mines are documented as a concern in five subwatersheds: Gavilon Arroyo-Mimbres River in Lampbright Draw-Mimbres River watershed and Headwaters Cow Spring Draw in Cow Spring Draw-Upper Seventysix Draw watershed, both in the Mimbres subbasin; Willow Creek-Mangas Creek in Mangas Creek watershed of Upper Gila-Mangas subbasin; and Hoodoo Canyon-Lordsburg Draw and Outlet Thompson Canyon in Lordsburg Draw watershed of the Animas subbasin.

In Cold Springs-Tularosa River of Headwaters Tularosa River watershed (San Francisco subbasin) there is a leaky underground fuel tank of concern to soil, groundwater and surface water quality as fuel is moving toward the Tularosa wetlands near Apache Creek, NM. There is also an old landfill in Starkweather Canyon

of Centerfire Creek-San Francisco River watershed (San Francisco subbasin). There are some documented cases of groundwater contamination due to septic tanks within the context area on private property, but none are known to have impacted Forest groundwater resources. While there are localized groundwater quality concerns, the departure from pre-European groundwater quality is low overall. There is no information available to assess trend.

### *Risk*

Based on low departure, there is a low risk to groundwater quality at all scales considered in this assessment.

## Stakeholder Input

Watersheds and water resources are of great concern to the Gila NF and stakeholders. From stakeholder input received during the assessment, the importance of water to the overall health of the Forest, aquatic and riparian species, and recreational and economic value of the Forest were frequently visited topics. Observations concerning poor watershed conditions and water quality, altered streamflow, reduced streamflow and water availability in uplands springs and earthen tanks were common to all communities. Some are also concerned about groundwater supplies and declining recharge.

Some appreciate the challenges of balancing competing demands on water resources provided by the Forest and recognize that water has and will always be a limited and limiting ecological and economic resource. Others just want the Forest to provide more of it. While all desire clean and abundant water resources from watersheds that are functioning properly, there is disagreement of what that means and how to move toward those conditions.

There is broad recognition of altered ecological processes (stressors) due to Forest management but conflict regarding the causes and possible solutions. Poor watershed conditions are associated with fire suppression, altered fire regimes and post-fire effects, as well as increased densities of upland woody vegetation, reductions in timber harvesting and grazing, overgrazing by both livestock and elk, roads and trails, recreation, drought, and climate change. Increased timber and fuelwood harvesting, more grazing and less grazing, and construction of erosion control structures are proposed management solutions.

Roads, trails and recreation are also viewed as contributing to poor watershed conditions and water quality, but are valued for providing recreational and livestock management access to water resources. Timber harvesting and associated road maintenance, more frequent road maintenance, improved drainage features, and decommissioning of roads are proposed management solutions. Monitoring and maintenance of recreational facilities in drainage bottoms for water quality and stream health is recommended. Monitoring and managing upland recreational facilities and dispersed camping sites to improve watershed condition and protect water quality are also suggested.

Livestock access to perennial and intermittent streams is perceived both as something to be restricted and something that should not be restricted. Management recommendations include maintenance of existing livestock exclosures, construction of new exclosures and removal of all exclosures. These recommendations also apply to upland springs and wetlands. The construction of wetlands was also suggested.

The availability, reliability and quality of upland water resources are a concern. Many livestock tanks and wildlife waters are no longer functioning and in need of maintenance. Eutrophication and poor water quality associated with these developments could be improved with maintenance as well. There are springs that used to produce water are no longer doing so and many spring developments require maintenance. Partnerships are a suggested method to accomplish this work.

The importance of the ecosystem services provided by groundwater, in terms of livestock management and contributions to stream flow are recognized and declining groundwater tables are a concern. These concerns are largely attributed to climate change and declining snowpack.

Altered streamflow and associated reduction in water quantity are attributed to climate change, drought, changes in channel shape and function related to post-fire and livestock grazing, increased densities of upland woody vegetation, as well as native and non-native riparian vegetation.

There is great concern about interstate water compacts, future impacts to water resources, and therefore riparian and aquatic ecosystems on the Forest. There are also concerns about possible implications any Forest management decisions, or lack thereof, might influence the ability of streamflow to continue to support ecological values or interfere with the State's administration of water rights and local economies dependent on water use. These concerns are mostly specific to the Arizona Water Settlement Act and the proposed diversion of the Gila River and San Francisco rivers. The public holds conflicting viewpoints.

On one hand, many value the free flowing nature of the rivers for their ecological and recreational value and are concerned about negative impacts to those values resulting from a diversion. Their interest in plan revision includes a full consideration of ecological flow needs, climate change and the supporting science. A substantial body of scientific literature supporting their concerns, including but not limited to the Gila River Flow Needs Assessment, was provided during the assessment.

On the other hand, there are those that point to the historic and current water diversions for irrigation in along the rivers and feel the Gila River can remain free flowing in designated wilderness, but that downstream water users should continue to decide what do with the water. The concern being that changes in the Forest's land management plan could negatively affect downstream water rights holders or impinge on the State's ability to exercise its legal rights to administer water use.

## Summary

This assessment reviews the best available information at the subbasin, watershed and subwatershed level to explore the ability of the Forest's water resources to sustain the key ecosystem services they provide under current climate, existing budgets and Forest Plan direction. These ecosystem services are associated with watershed condition, streamflow, the extent and distribution of perennial and intermittent streams, springs, seeps and wetlands, surface water quality, aquatic biota and groundwater quantity and quality. Table 126 summarizes risk for these characteristics at the watershed scale (only for subwatersheds that intersect the Forest boundary), Forest and local unit scales. An entry of "L" represents low risk, "M" represents moderate risk, "H" high risk, and "VH" very high. No risk is assigned only where the characteristic analyzed is not present at a particular scale ("N") or there is no information ("ND"). Factors contributing to risk have been discussed throughout this chapter and the System Drivers and Stressors Chapter.

**Table 126. Water resources risk summary by characteristic at the watershed, Forest and local unit scales.**

| Watershed Name | Key Ecosystem Characteristic | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Watershed Condition | Perennial Streams | Intermittent Streams | Streamflow | Surface Water Quality | Aquatic Biota Species Richness | Aquatic Biota Extent and Distribution | Springs and Seeps | Non-Riverine Wetlands | Groundwater Quantity | Groundwater Quality |
| *Plains of San Agustin Subbasin* | | | | | | | | | | | |
| Nester Draw | L | H | M | L | L | N | N | N | N | H | L |
| Y Canyon | L | N | N | L | L | N | N | M | N | H | L |
| Patterson Lake | L | H | H | L | L | L | H | L | N | H | L |
| *Elephant Butte Reservoir Subbasin* | | | | | | | | | | | |
| Headwaters Alamosa Creek | L | H | M | L | L | L | L | N | N | H | L |
| *Caballo Subbasin* | | | | | | | | | | | |
| Cuchillo Negro Creek | M | H | M | L | L | N | N | M | N | H | L |
| Palomas Creek-Rio Grande | M | M | H | L | L | L | H | M | H | H | L |
| Percha Creek | M | L | M | M | M | N | N | M | H | H | L |
| Caballo Reservoir | H | M | M | H | H | L | L | M | N | H | L |
| *El Paso-Las Cruces Subbasin* | | | | | | | | | | | |
| Cuervo Arroyo-Rio Grande | M | H | M | M | M | H | L | M | N | H | L |
| *Mimbres Subbasin* | | | | | | | | | | | |
| Gallinas Canyon-Mimbres River | M | M | H | H | H | M | H | M | H | H | L |
| Headwaters San Vincente Draw | M | M | M | N | L | H | L | M | N | H | L |

| Watershed Name | Key Ecosystem Characteristic | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Watershed Condition | Perennial Streams | Intermittent Streams | Streamflow | Surface Water Quality | Aquatic Biota Species Richness | Aquatic Biota Extent and Distribution | Springs and Seeps | Non-Riverine Wetlands | Groundwater Quantity | Groundwater Quality |
| Outlet San Vincente Draw | ND | M | H | N | L | N | N | M | N | H | L |
| Lampbright Draw | M | N | N | L | L | N | N | N | N | H | L |
| Lampbright Draw-Mimbres River | M | H | M | M | M | H | H | M | N | H | L |
| Macho Creek | L | N | N | L | L | N | N | N | N | H | L |
| Upper Seventysix Draw | ND | H | L | ND | L | N | N | M | N | H | L |
| Cow Spring Draw-Seventysix Draw | M | N | N | N | L | N | N | N | N | H | L |
| *Little Colorado Headwaters Subbasin* | | | | | | | | | | | |
| Coyote Creek | M | M | H | L | L | N | N | M | N | H | L |
| *Carrizo Wash Subbasin* | | | | | | | | | | | |
| Rito Creek | L | H | H | L | L | N | N | M | N | H | L |
| Upper Largo Creek | M | H | H | M | L | M | M | M | N | H | L |
| Agua Fria Creek | L | M | H | L | L | N | N | M | N | H | L |
| LA Draw-Cienega Amarilla | M | L | L | L | L | N | N | M | N | H | L |
| *Upper Gila Subbasin* | | | | | | | | | | | |

| Watershed Name | Key Ecosystem Characteristic | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Watershed Condition | Perennial Streams | Intermittent Streams | Streamflow | Surface Water Quality | Aquatic Biota Species Richness | Aquatic Biota Extent and Distribution | Springs and Seeps | Non-Riverine Wetlands | Groundwater Quantity | Groundwater Quality |
| Railroad Canyon | L | N | N | L | L | N | N | N | N | H | L |
| Corduroy Canyon | L | N | M | L | L | N | N | M | N | H | L |
| Beaver Creek | L | M | H | M | M | H | H | M | N | H | L |
| Headwaters East Fork Gila River | M | L | M | L | M | M | M | L | L | H | L |
| Middle Fork Gila River | M | L | L | M | M | M | H | M | L | H | L |
| West Fork Gila River | M | L | L | M | M | M | H | L | L | H | L |
| Outlet East Fork Gila River | M | M | M | M | M | M | H | M | L | H | L |
| Sapillo Creek | L | L | L | M | L | M | M | L | L | H | L |
| Sapillo Creek-Gila River | M | L | H | M | M | M | H | L | M | H | L |
| *Upper Gila-Mangas Subbasin* | | | | | | | | | | | |
| Bear Creek | M | H | L | L | L | L | H | M | N | H | L |
| Duck Creek | M | M | M | L | L | H | H | H | N | H | L |
| Mangas Creek | M | H | M | L | L | M | H | M | N | H | L |
| Sycamore Creek-Upper Gila River | M | M | M | H | M | M | H | M | M | H | L |
| Blue Creek | L | H | H | L | L | L | N | N | N | H | L |

| Watershed Name | Key Ecosystem Characteristic | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Watershed Condition | Perennial Streams | Intermittent Streams | Streamflow | Surface Water Quality | Aquatic Biota Species Richness | Aquatic Biota Extent and Distribution | Springs and Seeps | Non-Riverine Wetlands | Groundwater Quantity | Groundwater Quality |
| Blue Creek-Upper Gila River | M | H | L | M | M | M | H | M | M | H | L |
| Apache Creek-Gila River | M | M | H | M | L | H | H | M | N | H | L |
| *Animas Valley Subbasin* | | | | | | | | | | | |
| Headwaters Burro Cienega | M | N | N | H | L | N | N | H | N | H | L |
| Outlet Burro Cienega | ND | H | H | H | L | N | N | N | N | H | L |
| Lordsburg Draw | M | H | H | H | M | N | N | M | N | H | L |
| *San Francisco Subbasin* | | | | | | | | | | | |
| Headwaters Tularosa River | M | M | H | M | M | M | L | M | H | H | L |
| Outlet Tularosa River | M | H | M | M | M | M | H | L | H | H | L |
| Centerfire Creek-San Francisco River | M | M | M | VH | M | M | M | M | H | H | L |
| Deep Creek-San Francisco River | M | M | M | M | L | M | H | M | H | H | L |
| Pueblo Creek-San Francisco River | H | L | H | H | M | M | H | M | H | H | L |
| Upper Blue River | M | M | M | M | L | M | H | M | N | H | L |

| Watershed Name | Key Ecosystem Characteristic | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Watershed Condition | Perennial Streams | Intermittent Streams | Streamflow | Surface Water Quality | Aquatic Biota Species Richness | Aquatic Biota Extent and Distribution | Springs and Seeps | Non-Riverine Wetlands | Groundwater Quantity | Groundwater Quality |
| Lower Blue River | L | L | L | L | L | N | N | M | N | H | L |
| Mule Creek-San Francisco River | M | M | M | L | M | M | M | L | H | H | L |
| **Forest** | M | M | M | L-VH | M | M | M-H | M | H | H | L |
| **<u>Local Unit</u>** | | | | | | | | | | | |
| Little Colorado-San Agustin Fringe | M | M | M | L-VH | M | M | H | M | H | H | L |
| Apache | M | M | M | L-VH | M | M | M | M | H | H | L |
| Mogollon Front | M | M | M | L-H | M | M | H | M | H | H | L |
| Black Range | M | M | M | L-VH | M | L-M | M | M | H | H | L |
| Upper Gila | M | L | L | M | M | M | H | L | H | H | L |
| Lower Gila | M | M | L | L-H | L | M | H | M | L | H | L |

# Chapter 7. Riparian

## Introduction

Riparian areas are affected by the presence of surface and subsurface, perennial or intermittent, flowing or standing bodies of water. They are composed of distinctively different vegetative species than adjacent areas where water is more limited. In these systems, terrestrial and aquatic ecological processes are integrated. Riparian areas are defined by change and are adapted to disturbance. Because of variability in the amount, timing, distribution and duration of water availability in the Southwest, shifts in runoff, erosion, sedimentation, vegetation resistance to disturbance and resilience are site specific and episodic. This chapter includes a general description of riparian ecological response units (ERUs) occurring on the Gila NF, an analysis of key characteristics, a discussion of system drivers and stressors, an evaluation of risk, and summary of stakeholder input received during the assessment. Riparian ERUs are grouped based on similar dominant vegetative species which are:

- Cottonwood Group ERUs
  - Narrowleaf Cottonwood/Shrub
  - Sycamore-Fremont Cottonwood
  - Fremont Cottonwood/Shrub
  - Fremont Cottonwood-Oak
- Montane-Conifer Willow Group ERUs
  - Arizona Alder-Willow
  - Willow-Thinleaf Alder
  - Ponderosa Pine/Willow
  - Upper Montane Conifer/Willow
- Wetland (ciénega) ERU
  - Herbaceous Riparian
- Walnut-Evergreen Tree Group ERUs
  - Arizona Walnut
  - Walnut/Ponderosa Pine[38]
- Desert Willow Group ERU
  - Desert Willow

These groupings provide a framework for the analysis of most key characteristics, which include:

- Seral state proportion (structure)
- Ecological status (composition)
- Vegetative groundcover (function)
- Vegetation condition (function)
- Channel shape and function (function)
- Large woody debris (function)
- Flood frequency (process)[39]

[38] The official ERU name is Little Walnut/Ponderosa Pine. However, the species of walnut present on the Gila NF is Arizona walnut (*Juglans major* (Torr.) A. Heller) not little walnut (*Juglans microcarpa* Berl.).

[39] Soil loss was not modeled for riparian soils as it is for upland soils. Soil loss models are not capable reflecting the complexity of the sediment transport processes involved in streamside environments. While there are certainly some capable watershed models that could model sediment transport within riparian areas, assessment time frames do not allow for their use. Even if assessment time frames did allow for their use, the available data would likely restrict their use in some or all riparian ERUs and/or groups of ERUs.

Due to the available data and the methods employed to utilize that data, large woody debris is analyzed outside of the group concepts. Flood frequency is first discussed outside of the group concepts, but is ultimately related back to the individual ERUs and group concepts. In the next few sections, ecosystem services, data, and analysis approach are described relative to each characteristic. Subsequently, each group is described and analyzed in terms of the characteristics identified in the preceding paragraph, followed by the large woody debris and flood frequency analyses. The risk assessment, stakeholder input, data gaps and summary sections are included afterward.

## Ecosystem Services of Riparian Resources

Humans derive many benefits and enjoyment from the ecosystem services provided by the riparian resources on the Gila NF. Riparian zones contribute to provisioning and regulating services as they influence patterns of available water and nutrients, slow floodwaters, regulate stream temperatures, purify water, and contribute to the regulation of greenhouse gases and carbon storage. They provide a variety of supporting services as some of the greatest biodiversity occurs in riparian zones. One third of the Southwest's vascular plant species occur in riparian areas (Webb et al. 2007) and approximately 75 to 80 percent of all vertebrate species rely on riparian habitats despite the fact that they occupy a very small percentage of the landscape (Chaney et al. 1990; Riley 2005). Likewise, aquatic habitats and fish productivity are directly related to the health and function of riparian systems (Knutson and Naef 1997). They provide essential habitat for wildlife and aquatic species, including federally recognized and proposed threatened or endangered as well as sensitive wildlife and plant species. They also provide many cultural ecosystem services to society as they provide opportunities for recreation, personal enrichment, education and research.

## Data

To assess seral state proportion, the same datasets identified in the Upland Vegetation chapter were used with the exception of the dataset describing existing conditions. Instead of using the Midscale Existing Vegetation Mapping Project to describe current conditions, the 2016 Gila Riparian Existing Vegetation pilot project dataset is used. The watershed condition classification is used to assess vegetation condition, channel shape and function and large woody debris. The watershed condition classification is described in detail in the Water chapter. The USGS streamflow gage data used in the streamflow analysis within the Water chapter are also used to assess flood frequency as an ecological process and key characteristic for riparian.

A riparian Terrestrial Ecological Unit Inventory (TEUI) was completed for the Forest in the 1990s. Some riparian ecological units were also documented as part of TEUI mapping completed for landscape scale project planning during that time period. These completed inventories are part of the Gila NF's draft TEUI dataset which is described in greater detail in the Data section of the Upland Soils chapter. Riparian data collection and refinement of riparian ecological unit concepts are ongoing, but nearing completion. At present, there is no TEUI data documenting the Fremont Cottonwood/Shrub, Ponderosa Pine/Willow or Walnut/Ponderosa Pine ERUs. Completed surveys provide data summaries which are the primary information used to assess vegetative groundcover and ecological status. There are no TEUI data for lands that do not occur on National Forest System lands, therefore, these characteristics cannot be analyzed at the context scale. No other quantitative data exists to analyze these two characteristics for riparian.

To account for significant changes in conditions due to recent post-fire flood events that have occurred since the TEUI data were collected, pre and post-2011 satellite imagery was used to detect observable change in riparian canopy cover, erosion and/or sedimentation. While changes can be seen in the satellite imagery, there is no way to differentiate between erosion and sedimentation (hence "erosion and/or sedimentation"). It is however, very clear where there has been a reduction in riparian canopy cover, vegetative groundcover and changes in channel shape and function because of how significant these

events were. The year 2011 was chosen as a threshold because prior to that year, post-fire flood related impacts were localized, and not as widespread as they are now. Fires that occurred after the 2011 imagery was taken include the Wallow, Miller, Whitewater Baldy Complex and Silver Fires. An example illustrating changes observed via satellite imagery is provided in Figure 137 (pre-2011) and Figure 138 (post-2011). Reductions in riparian canopy cover and increases in unvegetated floodplain, indicative of either erosion or sedimentation are readily observed between the pre-2011 and post-2011 images. The results of the change detection are displayed in within each riparian group Table 127.

**Figure 137. The Meadows on the Middle Fork of the Gila River, 2011**

**Figure 138. The Meadows on the Middle Fork of the Gila River, post-2011**

**Table 127. Observable change in riparian canopy cover, erosion and/or sedimentation since 2011**

| Ecological Response Unit | Observable Change (% of Group or ERU) |
|---|---|
| Cottonwood Group ERUs | 22 |
| Narrowleaf Cottonwood/Shrub | 24 |
| Sycamore-Fremont Cottonwood | 24 |
| Fremont Cottonwood/Shrub | 3 |
| Fremont Cottonwood-Oak | 0 |
| Montane-Conifer Willow Group ERUs | 63 |
| Arizona Alder-Willow | 66 |
| Willow-Thinleaf Alder | 77 |
| Ponderosa Pine/Willow | 1 |
| Upper Montane Conifer/Willow | 30 |
| Wetland (cienega) ERU | 5 |
| Herbaceous Riparian | 5 |
| Walnut-Evergreen Tree Group ERU | 3 |
| Arizona Walnut | 3 |
| Walnut/Ponderosa Pine | 0 |
| Desert Willow Group ERU | 6 |
| Desert Willow | 6 |
| **Area Weighted Gila NF Riparian ERU Total** | **25** |

# Analysis Methods

## Seral State Proportion

Analysis methods for this characteristic are the same as for upland vegetation. However, trend is not assessed because no Vegetation Dynamics Development Tool (VDDT) models, as used in the Upland Vegetation analysis, have been developed for riparian ERUs.

## Ecological Status and Vegetative Groundcover

The analysis approach to the TEUI data, including how the reference and current condition are defined by the TEUI, is described in the Soils chapter. Departure categories are elevated to moderate where the change detection describes post-fire flooding impacts across 33 to 66 percent of the ERU or group's area. Departure is elevated to high where these changes have occurred over more than 66 percent of the ERU or group's area. Trend cannot be assessed as no quantitative monitoring data comparable to the TEUI currently exists.

The limitations associated with the analysis approach to ecological status, as discussed in the Upland Soils Chapter, remain true here, although to a lesser extent. If species diversity is high, but the same species are not present at each TEUI sample point location, this analysis methodology interprets that diversity as departure. Another factor that can contribute to site specific variability that may be contributing to departure is riparian soils. Riparian soils are highly diverse across both time and space. Not all soils have the same capacity to support riparian/wetland herbaceous species. Coarse textured soils that drain quickly are typically associated with lower ability to support herbaceous riparian species, while fine textured soils have a higher ability to do so. However, these soils may or may not support the same tree species, as tree roots access deeper soil layers than herbaceous species do.

However, the riparian analysis uses data summaries prepared for the completed surveys as previously described, which provide a more robust statistical basis than what time allows for the raw data used in the upland soils analysis; thus, departure ratings for ecological status in riparian ecosystems are associated with less uncertainty than upland systems. The greatest factor contributing to uncertainty is the size of the dataset. Smaller datasets are generally associated with greater uncertainty. All riparian ERUs have smaller datasets as compared to most of the upland ERUs. Another factor contributing to uncertainty is the quick response to changes in management or disturbance that occurs in riparian ecosystems, because of the higher plant available water in these systems as opposed to upland systems. Because changes can occur periodically and relatively rapidly, riparian datasets can become less accurate as time passes. The more recent the data, the less uncertainty.

### Vegetation Condition, Channel Shape and Function, and Large Woody Debris

Riparian/wetland vegetation condition, channel shape and function, and large (aka coarse) woody debris characteristics are assessed using those indicators or attributes from the Gila NF's watershed condition classification as described in the Water Chapter. While this classification information is directly applicable to subwatersheds ($6^{th}$ level HUC) and cannot be correlated precisely at the ERU scale, watersheds and their riparian ecosystems respond to large scale disturbances as a single unit. The classification information does provide a general sense of riparian conditions with regard to these indicators and attributes. As described in the next paragraph, the riparian/wetland vegetation condition indicator, is a qualitative measure of the more quantitative seral state proportion characteristic. The similarities and differences between these two analyses will be used as a point of comparison.

Indicator and attribute ratings of Functioning Properly serve as the reference condition, with Functioning at Risk and Impaired Function representing a moderate and high departure respectively. Riparian vegetation conditions that are Functioning Properly are defined as "native mid to late seral vegetation appropriate to the site's potential dominates the plant communities and is vigorous, healthy and diverse in age, structure, cover and composition on more than 80 percent of the riparian/wetland areas in the watershed. Sufficient reproduction of native species appropriate to the site is occurring to ensure sustainability. Mesic (i.e. riparian) herbaceous plant communities occupy most of their site potential. Vegetation is in dynamic equilibrium appropriate to the stream or wetland system" (Potyondy and Geier 2011). Ratings of Functioning at Risk are defined as "native vegetation demonstrates a moderate loss of vigor, reproduction or growth, or it changes in composition, especially in areas most susceptible to human impact. Areas displaying light to moderate impact to structure, reproduction, composition and cover may occupy 25 to 80 percent of the overall riparian area with only a few areas displaying significant impacts. Up to 25 percent of the species cover or composition occurs from early seral species and/or there exist some localized but relatively small areas where early seral species dominates, but the communities across the watershed are still dominated by mid to late seral vegetation. Xeric (i.e. upland) herbaceous communities exist where water relationships have been altered but they are relatively small and localized, generally are not contiguous across large areas and do not dominate across the watershed" (Potyondy and Geier 2011). Impaired Function ratings are defined by conditions described as Functioning Properly occurring on less than 25 percent of the riparian/wetland areas in the watershed, with shifts to upland species because of altered water relationships and limited reproduction of mid to late seral riparian species (Potyondy and Geier 2011).

Channel shape and function ratings of Functioning Properly indicate "channel width-to-depth ratios exhibit the range of conditions expected in the absence of human influence. Less than 5 percent of the stream channels show signs of widening. Channels are vertically stable, with isolated locations of aggradation (i.e. sedimentation) or degradation (i.e. downcutting), which would be expected in near natural conditions. The distribution of channels with floodplain connectivity is close to that fond in reference watersheds of similar size and geology" (Potyondy and Geier 2011). Functioning at Risk ratings indicate that "channel

width-to-depth ratios and vertical stability are maintained except where riparian vegetation has been disturbed. Between 5 and 25 percent of the stream channels have seen an increase in width-to-depth ratios (i.e. are widening). Channel degradation and/or aggradation are evident but limited to relatively small sections of the channel network. There is evidence of downcutting to the extent that some stream channels are no longer connected to their floodplain" (Potyondy and Geier 2011). Impaired Function ratings indicate that more than 25 percent of channels show signs of widening, "the size and extent of gullied sections of channels are extensive, currently increasing or have increased recently. Many streambanks show signs of erosion above what would be expected naturally. Channel aggradation and/or degradation are evident and widespread because of unstable stream-beds and banks." More than 50 percent of channels are "disconnected from their floodplain or are braided channels because of increased sediment loads" (Potyondy and Geier 2011).

Large woody debris ratings of Functioning Properly describe aquatic and riparian systems where wood is an important functional component and that woody is present and continues to be recruited at near natural rates. Functioning at Risk ratings indicate wood is present, but recruitment is less than natural rates because of riparian management activities. Impaired Function ratings indicate wood is lacking and resulting in poor riparian and aquatic habitat conditions. These poor conditions may manifest themselves as unstable banks, inadequate pool formation and microclimate maintenance (Potyondy and Geier 2011).

Not all subwatersheds contribute the same number of acres to the Forest, nor do they all contain the same riparian ERUs or proportions thereof. Indicator and attribute ratings were area weighted to each ERU to approximate and describe variability in conditions. The group totals are based on the individual ERU ratings and their respective contributions to the total number of riparian acres. The watershed condition classification information was updated in 2015 to reflect post-fire and flooding events that have occurred; therefore it is not necessary to use the change detection to modify the analysis results as those changes are reflected in the classification information.

Approximately 40 percent of subwatersheds intersecting the Gila NF boundary are considered Functioning Properly with respect to the riparian/wetland vegetation indicator. 49 percent are Functioning at Risk, and 11 percent are Impaired Function. However, water is a limiting factor and not all subwatersheds contain riparian/wetland vegetation nor have the potential to do so. Approximately 48 percent of subwatersheds were identified in the watershed condition classification as being limited by water in their potential to support riparian/wetland vegetation. In these subwatersheds, these indicator scores were given a lesser weight so they did not influence the overall condition classification.

## Flood Frequency

Flood flows are often described in terms of return intervals. Return intervals describe the likelihood that a flood of a certain magnitude will occur. A flood with a two-year return interval has a 50 percent chance of occurring in any given year. A flood with a 100-year return interval has a one percent chance of occurring in any given year. Flood frequency analyses can include variables of magnitude, timing and duration. The flood frequency analysis presented here relies on daily streamflow data from six USGS gages[40] located on Mogollon Creek and the San Francisco, Gila and Mimbres Rivers, the streamflow analysis conducted in the

[40] All streamflow gages used in this analysis lie within the plan area. One additional streamflow gage occurs within the context area on the Gila River near Virden, New Mexico. This gage was not analyzed as the difference in contributing watershed area between the Virden and Redrock gages is relatively small.

Water Chapter, and the USGS PeakFQ model (v7.1)[41] available at http://water.usgs.gov/software/PeakFQ/.[42]

Studies evaluating flood history in the Southwest over the last 5,000 years have concluded that the largest floods cluster into distinct time periods that related to regional and global climatic fluctuations. Episodes with increased frequency of high magnitude floods coincide with cool, wet periods whereas dramatic decreases in frequency and magnitude occur during warm periods (Ely et al.1993; Ely 1997). The only streamflow reconstruction available for the Forest was conducted for the Upper Gila River using tree-ring data. In this study, the "Upper Gila River" includes the Upper Gila, Upper Gila-Mangas and San Francisco subbasins (4th level watersheds) of the context area defined in the Water Chapter. The reconstruction concludes that a defining characteristic of area streams is wide ranging differences between streamflow events that do not occur very often. Moreover, these differences increased in the 20th century (Meko and Graybill 1995). This creates a high level of uncertainty in departure analyses related to flood frequency.

There were no instrumental records kept prior to the arrival of Europeans. In fact, instrumental streamflow records from the plan area are limited to the last 25 to 87 years, depending on the gage. Given that area hydrology is the product of many natural and human caused changes over a much longer time period (McLean 1981), this is a very small dataset. Furthermore, to differentiate between reference and current conditions and approximate departure and trend requires this record be divided into a reference and current time period. A subset of the current time period (2000-2014) is analyzed for the purposes of approximating recent trends. The rationale behind establishing these time periods is described in further detail in the Water Chapter, where the same time periods are used to assess the streamflow characteristic.

Changes in flood frequency are most likely to occur where streamflow patterns are altered. Therefore, departure in flood frequency is ultimately determined by departure in streamflow. The Water Chapter determined departure in streamflow at the watershed (5th level) scale. These results were area weighted to the riparian ERUs, with the departure rating representing the largest percentage of the ERU or group.

## Cottonwood Group

The cottonwood group includes Narrowleaf Cottonwood/Shrub, Sycamore-Fremont Cottonwood, Fremont Cottonwood/Shrub, and Fremont Cottonwood/Oak riparian ERUs.

[41] "Bulletin 17B (B17B) of the Interagency Advisory Committee on Water Data (IACWD; 1982) codifies the standard methodology for conducting flood-frequency studies in the United States. B17B specifies that annual peak-flow data are to be fit to a log-Pearson Type III distribution. Specific methods are also prescribed for improving skew estimates using regional skew information, tests for high and low outliers, adjustments for low outliers and zero flows, and procedures for incorporating historical flood information. The authors of B17B identified various needs for methodological improvement and recommended additional study. In response to these needs, changes include adoption of a generalized method-of-moments estimator donated the Expected Moments Algorithm (EMA) (Cohn and others, 1997) and a generalized version of the Grubbs-Beck test for low outliers (Cohn and others, 2013). The USGS has implemented these changes in the PeakFQ program." (USGS 2013).

[42] This model calculates the magnitude of flood flows expected with various return intervals. It does not provide for the analysis of actual flood flows, nor does it provide for analysis of the timing or duration of those flows. To accomplish that level of analysis requires instantaneous data, not daily data. Assessment time frames and the limited period of record associated with instantaneous data (1990-present) do not allow for such analysis. Other studies that have included analysis of the actual occurrence and frequency, magnitude and duration of flood flows are referenced, as is the watershed condition classification's water quantity indicator as it describes alterations to the natural hydrograph.

Narrowleaf Cottonwood/Shrub (Figure 139) covers approximately 60,613 acres within the context area. This ERU is the 3rd largest riparian ERU in the context area and the largest riparian type on the Forest, containing 22,681 acres. It has the widest elevational and climatic range of any riparian ERU on the Forest. Within the context area, it is typically found at elevations ranging from 1,900 to 10,000 feet. On the Gila NF, it is mapped between 4,880 and 9,160 feet. Riparian species commonly found in the Narrowleaf Cottonwood/Shrub ERU include Fremont cottonwood (*Populus fremontii* S. Watson), narrowleaf cottonwood (*P. angustifolia* James) and lanceleaf cottonwood (*P. × acuminata* Rydb. (pro sp.) [*angustifolia × deltoides*]), boxelder (*Acer negundo* L.), willow species (*Salix* spp. L.), Arizona alder (*Alnus oblongifolia* Torr.), and Arizona walnut (*Juglans major* (Torr.) A. Heller).

**Figure 139. Narrowleaf cottonwood/shrub ERU (Photo by M. Wahlberg)**

Sycamore-Fremont Cottonwood (Figure 140) covers approximately 46,059 acres within the context area. This ERU is the 4th largest riparian ERU in the context area and the 3rd largest on the Forest containing roughly 6,427 acres. Within the context area, it is typically found at elevations ranging from 1,400 to 7,700 feet. On the Gila NF, it is mapped between 4,160 and 6,520 feet. The primary cottonwood species is Fremont cottonwood, while narrowleaf cottonwood occurs occasionally. Other riparian species commonly found include Arizona sycamore (*Platanus wrightii* S. Watson), boxelder, velvet ash (*Fraxinus velutina* Torr.), Arizona walnut, and willow species.

**Figure 140. Sycamore-Fremont cottonwood ERU (Photo by L.J. WhiteTrifaro)**

Fremont Cottonwood/Shrub (Figure 141) covers approximately 116,189 acres within the context area. This ERU is the largest riparian ERU in the context area and the 6th largest on the Gila NF, containing roughly 2,059 acres. Within the context area, it is typically found at elevations ranging from 1,000 to 7,600 feet. On the Gila NF, it is mapped between 5,040 and 7,160 feet. Some areas of this ERU are dominated by Gooding's willow (*Salix gooddingii* C.R. Ball) and velvet ash but have the potential for cottonwood regeneration. Other riparian species commonly found include willow species, boxelder, and desert willow (*Chilopsis linearis* (Cav.) Sweet). This ERU also supports a mesquite bosque subtype.

**Figure 141. Fremont cottonwood/shrub ERU (Photo by L.J. WhiteTrifaro)**

Fremont Cottonwood/Oak (Figure 142) covers approximately 2,159 acres within the context area. This ERU is the 10th largest riparian ERU in the context area and the smallest riparian type on the Gila at approximately 85 acres. Within the context area, it is typically found at elevations ranging from 2,200 to 7,500 feet. Oak species include Emory oak and Sonoran scrub oak (*Quercus turbinella* Greene). Other riparian species commonly found include Arizona sycamore and velvet ash.

The majority of the cottonwood group is located in the central and western portion of the context area and the northwestern and southeastern portions of the Forest. Figure 143 and Figure 144 display the general locations of the cottonwood group within the context area and Gila NF.

**Figure 142. Fremont cottonwood/oak ERU (Photo @ A. Schneider, www.swcoloradowildflowers.com)**

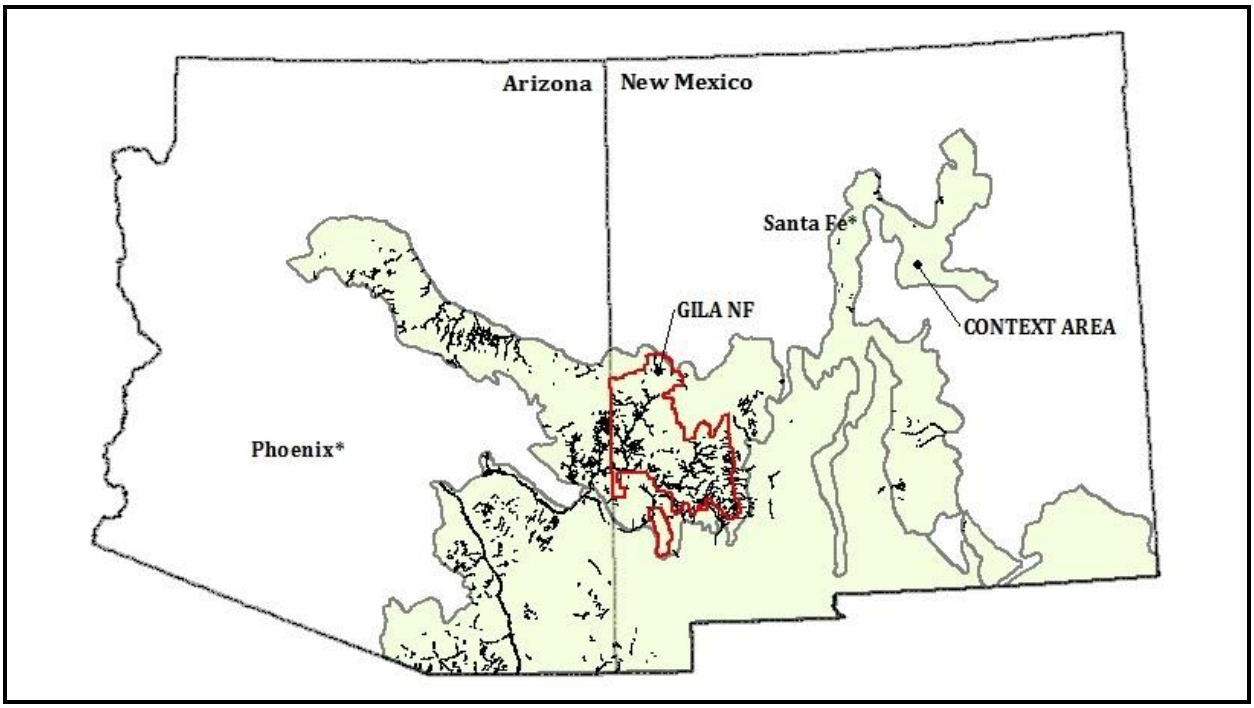



**Figure 143. General location of the cottonwood group of riparian ERUs within the context area**

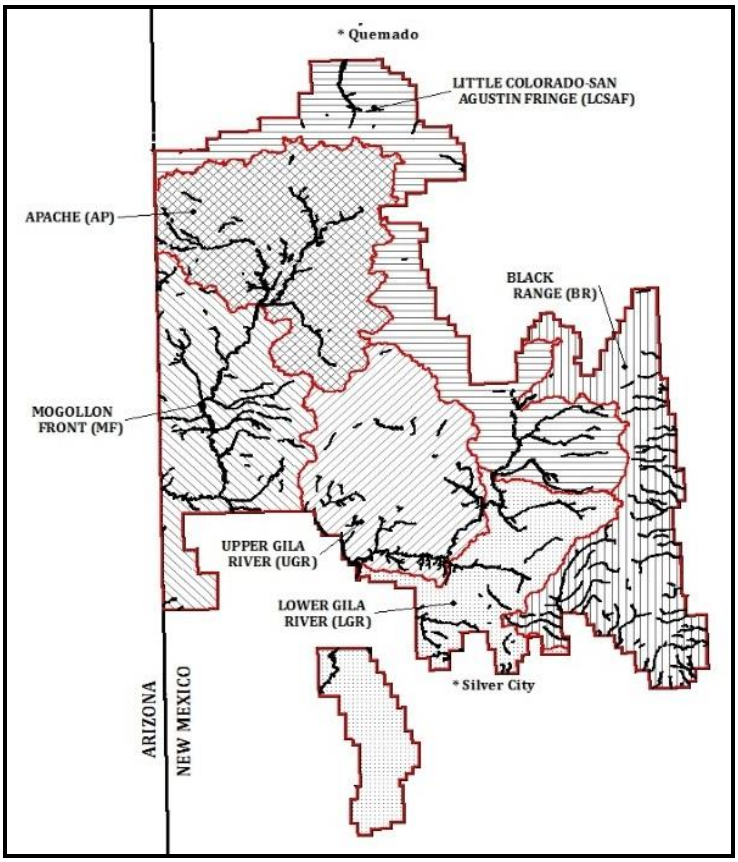



**Figure 144. General location of the cottonwood group of riparian ERUs within the Gila NF and the six local units.**

Note: Local units are the polygons interior to the Forest boundary with names in callout labels

As displayed in Table 128, this group is fairly well distributed across the Forest, but the majority is located in the Black Range and Mogollon Front local units. The Fremont Cottonwood-Oak ERU occurs only in the Mogollon Front local unit.

**Table 128. Local unit contributions to the cottonwood group of ERUs**

| Cottonwood Group ERUs | Gila NF Local Units | | | | | | | | | | | | Gila NF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| Narrowleaf Cottonwood/Shrub | 3,280 | 14.5 | 6,184 | 27.3 | 4,147 | 18.3 | 3,260 | 14.4 | 2,330 | 10.3 | 3,479 | 15.3 | 22,681 |
| Sycamore-Fremont Cottonwood | 142 | 2.2 | 0 | 0.0 | 0 | 0.0 | 1,078 | 16.8 | 3,557 | 55.3 | 1,650 | 25.7 | 6,427 |
| Fremont Cottonwood/Shrub | 154 | 7.5 | 1,016 | 49.3 | 0 | 0.0 | 48 | 2.3 | 826 | 40.1 | 15 | 0.7 | 2,059 |
| Fremont Cottonwood-Oak | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 85 | 100.0 | 0 | 0.0 | 85 |
| CWG Group Total | 3,576 | 11.4 | 7,200 | 23.0 | 4,147 | 13.3 | 4,386 | 14.0 | 6,798 | 21.8 | 5,144 | 16.5 | 31,252 |

## Spatial Niche

The cottonwood group is the largest riparian group in both the context area (225,020 acres) and Forest (31,252 acres) (Table 129). This group has a greater proportional representation (0.54) on Forest than in the context area with Narrowleaf Cottonwood/Shrub and Sycamore-Fremont Cottonwood ERUs also having greater proportional representation on Forest. Fremont Cottonwood/Shrub is the exception with a greater proportional representation within the context area (-0.50) than on Forest. Fremont Cottonwood-Oak has equal representation (0.00) within both the context area and Forest. The Gila NF has a high level of responsibility for maintaining the ecological integrity of these riparian communities.

**Table 129. Riparian ERUs represented in the cottonwood group**

| Cottonwood Group ERUs | Total ERU Area on Gila NF | | | Total ERU Area within Context Area | | | Gila NF's Contribution to Total ERU within Context Area | |
|---|---|---|---|---|---|---|---|---|
| | acres | % Gila NF | % departure from reference | acres | % Context Area | % departure from reference | from Gila NF | representation index |
| Narrowleaf Cottonwood/Shrub | 22,681 | 0.7 | 44 | 60,613 | 0.09 | 8 | 37.4 | 0.77 |
| Sycamore-Fremont Cottonwood | 6,427 | 0.2 | 40 | 46,059 | 0.07 | 29 | 14 | 0.48 |
| Fremont Cottonwood/Shrub | 2,059 | 0.06 | 38 | 116,189 | 0.18 | 70 | 1.8 | -0.50 |
| Fremont Cottonwood-Oak | 85 | 0.003 | 4 | 2,159 | 0.003 | 39 | 3.9 | 0.00 |
| Group Total | 31,252 | 0.01 | 42 | 225,020 | 0.003 | 49 | 13.9 | 0.54 |

Approximately 26 percent of the Fremont Cottonwood/Shrub ERU contains designated critical habitat for one or more species, with an additional four percent proposed critical habitat. In Narrowleaf Cottonwood/Shrub the percentages are 18 (designated) and 14 (proposed) percent and in Sycamore-Fremont Cottonwood it is 41 percent (designated) and 12 percent (proposed). The Fremont Cottonwood/Oak does not contain designated or proposed critical habitat. As a whole, 20 percent of this group contains designated critical habitat with an additional 11 percent proposed.

Thirty three percent of Narrowleaf Cottonwood/Shrub, 14 percent of Sycamore-Fremont Cottonwood and five percent of Fremont Cottonwood/Shrub are located in designated wilderness areas. Another 12 percent of Sycamore-Fremont Cottonwood is located in the Lower San Francisco Wilderness Study Area. The Fremont Cottonwood/Oak ERU is located entirely within the Hell Hole Wilderness Study Area. A total of 22 percent of this group occurs in designated wilderness. Over 10,600 acres of riparian are currently excluded from livestock grazing, including 210 acres of springs and wetland areas. Exclosures are not consistently mapped in the available geospatial data, and how much of the total excluded acres are represented by the cottonwood group ERUs has not been quantified.

## Key Characteristics

### *Seral State Proportion (Vegetation Structure) –Reference and Current Conditions*

Seral state proportion is the percent of ERU in each seral state, as described in the Upland Vegetation chapter. Under reference conditions (RC) (Table 130) the majority of the CWG was made up of an understory of all size shrubs with a closed canopy and open overstory of all size trees (seral state B). These riparian communities also had a large representation of large trees with closed canopy characteristics (seral state C) as well as a good representation of shrub and tree regeneration (seral state A).

**Table 130. Area-weighted seral state make-up of the cottonwood group under reference (RC) and current conditions for both the Gila NF and context area**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to Reference† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | context area | Gila NF | context area |
| A | Early-seral: Recently burned, sparsely vegetated, all herbaceous dominance types, and < 10% tree cover and < 10% shrub cover; Native shrub dominance types, and all shrub size classes, shrub cover < 25%; Native tree dominance types, and tree diameter 0-4.9", all tree cover classes | 25 | 34 | 74 | 25 | 25 |
| B | Mid-seral: Native shrub dominance types, and all shrub size classes, shrub cover > 25%; Native tree dominance types, and tree diameter∂ > 5", tree cover < 25% | 50 | 8 | 15 | 8 | 15 |
| C | Late-seral: Native tree dominance types, and tree diameter > 5" tree cover > 25% | 25 | 58 | 11 | 25 | 11 |
| D | Upland dominance types, and types dominated by exotic vegetation, and various *(occurs on contemporary landscapes only)* | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 100 | 58 | 51 |

**Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 58) = 42 or MODERATE; and Context Area = (100 – 51) = 49 or MODERATE**

‡ USDA FS 2016d; LANDFIRE 2008d

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

∂ Diameter is at diameter at breast height (dbh) or at rood collar (drc)

With more than 33 percent, but less than 66 percent departure from the reference condition, departure in seral state proportion is categorized as moderate for the CWG at the context, Forest and local unit scales as illustrated in Figure 145.

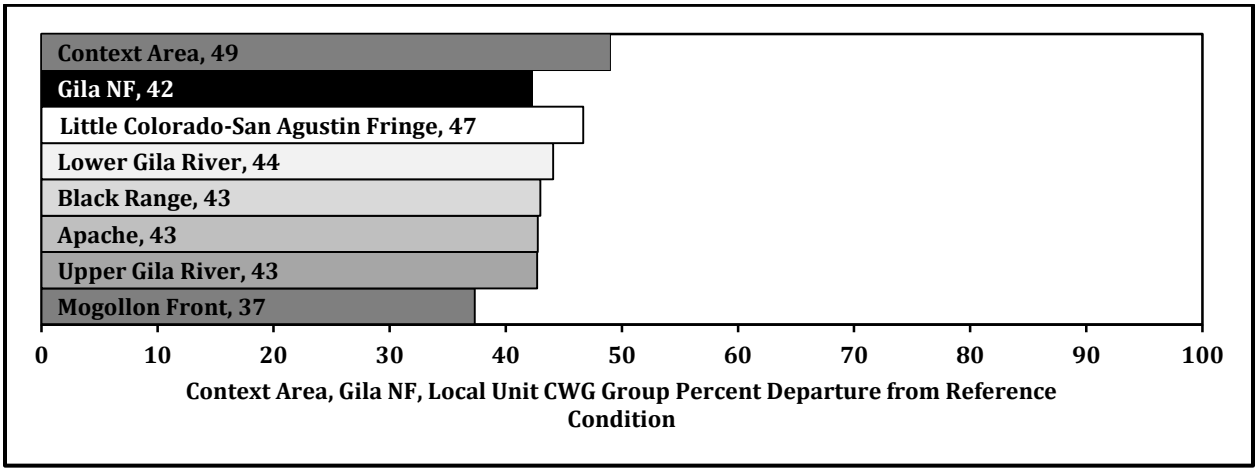



**Figure 145. Area-weighted variations in seral state departure from reference condition for cottonwood-willow group at the context area, Forest and local unit scales**

## *Ecological Status*

Ecological status is a vegetative and soil characteristic that describes canopy cover by species (composition). It is an important indicator of nutrient cycling status and overall riparian function. Different riparian species have different adaptations that allow them to persist in the relatively high-frequency disturbance environment they occupy. Some produce large numbers of small seeds that are easily dispersed by wind and water to colonize seedbeds prepared by flood events. Others can re-sprout after fire, flood or partial consumption by herbivores. These species can also colonize new areas as their broken branches take root and grow in suitable conditions. Some can withstand weeks of saturated conditions, withstand some fire and are resistant to some diseases. Most riparian species have more than one of these adaptations, while some may be less able to withstand disturbance. Diverse species composition allows riparian vegetation communities to maintain themselves over a range of climatic conditions and provides for recovery after disturbance. The following figure (Figure 146) illustrates the variability in ecological status across ERUs in this group based on the TEUI data. The draft Gila NF TEUI does not include documentation in Fremont Cottonwood-Oak ERU.

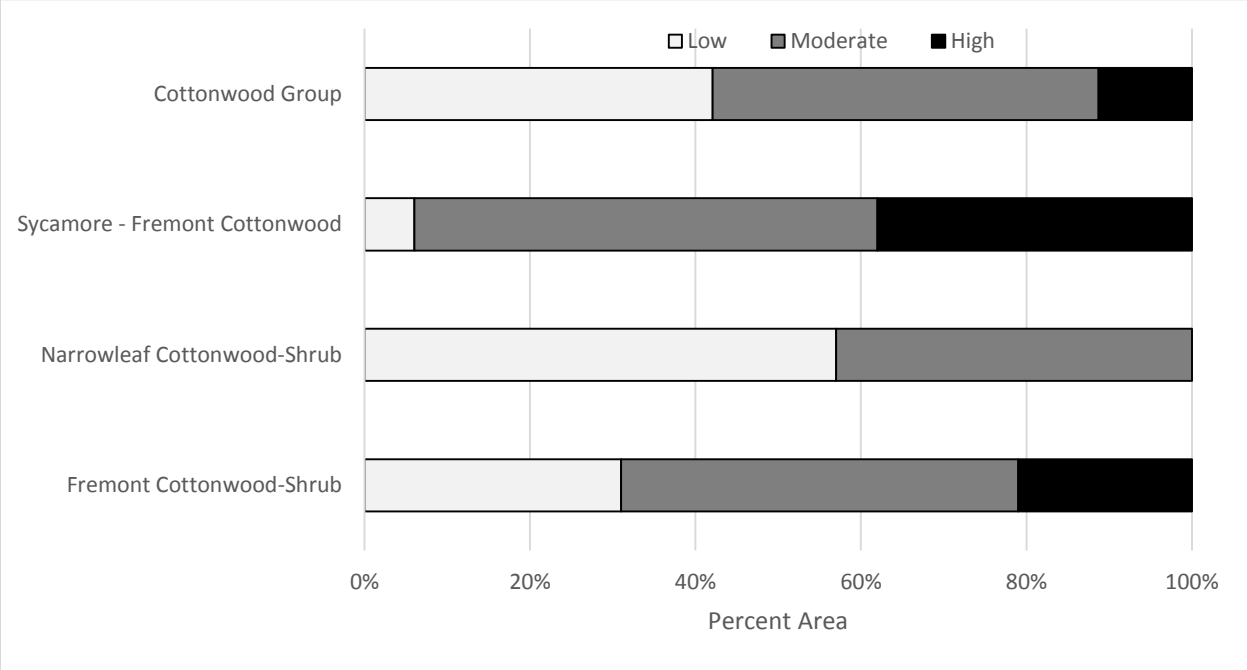



**Figure 146. Plan scale variability in ecological status departure for the cottonwood group and its ERUs**

With more than 50 percent of its area in low departure, ecological status departure is categorized as low in Narrowleaf Cottonwood/Shrub overall, even though just over 40 percent of its area is in moderate departure. Departure in Fremont Cottonwood/Shrub, Sycamore-Fremont Cottonwood and the cottonwood group as a whole is moderate overall, with most of their area in that departure category (Figure 146). Where departure is moderate, there is typically less canopy cover of riparian tree, shrub and grass species and a higher proportion of canopy cover associated with forb species.

Non-native, disturbance adapted species that have been documented in the TEUI and have naturalized in these systems include but are not limited to: Kentucky bluegrass, sweetclovers, mullein and dandelion. These naturalized species are now part of the potential natural vegetation community. Most occur at low levels, but in some places Kentucky bluegrass has largely replaced the native grasses, sedges and/or rushes in the understory community. This grass does not have the deep, dense root system that native riparian species do and does not provide for streambank or floodplain stability.

Noxious weed species documented at low levels in these systems by the TEUI include, but may not be limited to cheatgrass and saltcedar. Saltcedar control and eradication along the Gila and San Francisco Rivers and their tributaries is ongoing (see System Drivers and Stressors Chapter). With less than 33 percent of any given ERU or the group identified in the change detection as having reduced riparian canopy or, departure is not modified from the TEUI analysis.

It is probable that factors identified by the watershed condition classification as contributing to departure of vegetation condition and function (see discussion under Vegetation Condition and Function subheading) also contribute to ecological status departure in the cottonwood group ERUs.

### *Vegetative Groundcover*

Vegetative groundcover includes the basal area, litter, microbiotic crusts, lichens and mosses. Basal area is the area covered by tree trunks and stems of shrubs, forbs and graminoid species where they meet the ground. Litter includes all coarse woody and finer plant debris, a half inch or more in depth (USDA FS 1986a). Litter less than this depth is not considered effective in supporting soil stability. In upland systems, vegetative groundcover plays a critical role in soil stability as it reduces the raindrop impact energy responsible for detachment of soil particles, limits the movement of detached particles and prevents the concentration of surface runoff that can lead to rill and gully erosion. It is also an important indicator of nutrient cycling status. The contributions of vegetative groundcover to soil stability remain important in riparian zones, but of additional importance is the surface roughness it contributes. Surface roughness is important to slowing flood waters, thereby reducing erosion potential. In riparian areas, microbiotic crusts, lichens and mosses may add to biodiversity, but are not typically significant contributors to stability of the system. The following figure (Figure 147) illustrates the variability in conditions across ERUs in this group with TEUI documentation.

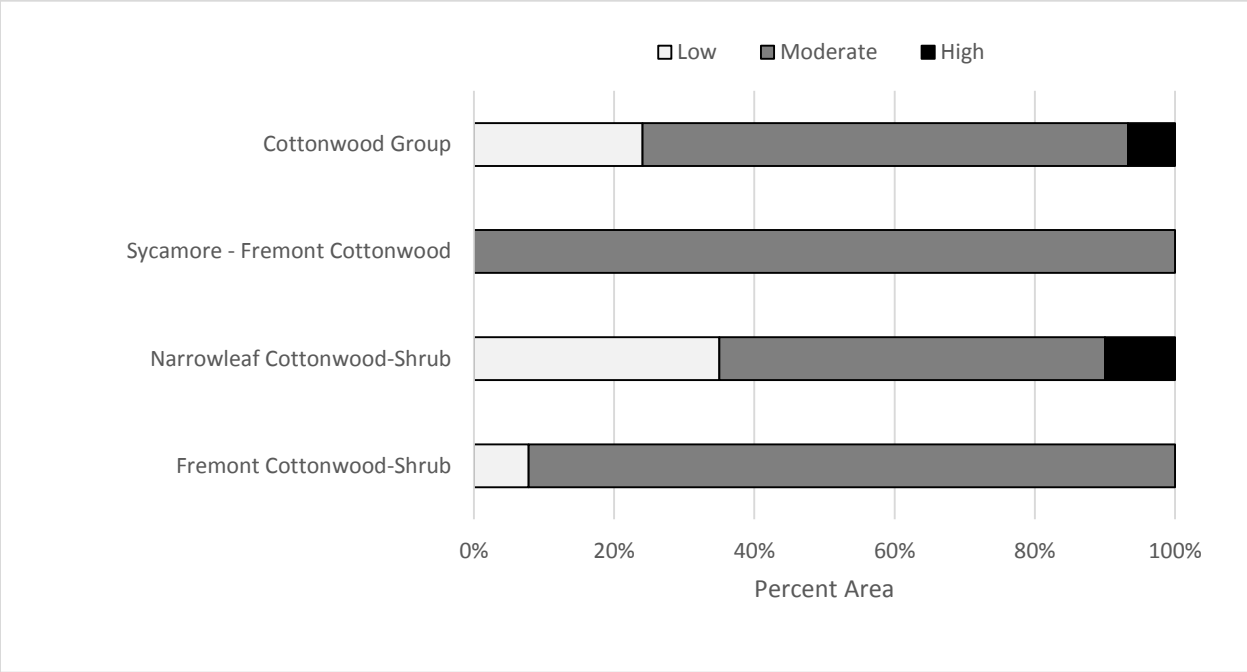



**Figure 147. Area weighted vegetative groundcover departure**

All ERUs and the cottonwood group as a whole are moderately departed in terms of vegetative groundcover, with the majority of their area being represented by the moderate departure category (Figure 147). However, groundcover in riparian systems is highly variable across time and space because of natural cycles of flooding which relocate and redistribute litter, and can remove basal area. Under

reference conditions, vegetative groundcover ranges from 20 to 70 percent. Under current conditions, it ranges from 10 to 60 percent. It is probable that factors identified by the watershed condition classification as contributing to departure of vegetation condition and function (see discussion in the next subsection) also contribute to departure in the cottonwood group ERUs.

### *Vegetation Condition and Function*

Healthy, diverse riparian and wetland vegetation is critical to overall ecosystem integrity. Above and below ground portions of these plants provide for flood control, floodplain and streambank stability, water quality protection, and wildlife and aquatic habitat. Riparian areas that provide multi-storied, dense canopy cover adjacent to more open upland systems support some of the greatest biodiversity (Webb et al. 2007). Table 131 displays current riparian/wetland vegetation conditions for the cottonwood group ERUs in terms of Functioning Properly, Functioning at Risk or Impaired Function. Fremont Cottonwood/Oak ERU is not included due to the small number of acres (85) mapped on the Forest.

**Table 131. Current riparian/wetland vegetation conditions at the plan scale for cottonwood group ERUs**

| Ecological Response Unit | Percent of ERU by Subwatershed Indicator Rating | | |
|---|---|---|---|
| | Functioning Properly | Functioning at Risk | Impaired Function |
| Fremont Cottonwood/Shrub | 24 | 64 | 12 |
| Narrowleaf Cottonwood/Shrub | 23 | 64 | 13 |
| Sycamore-Fremont Cottonwood | 42 | 51 | 6 |
| **Area Weighted Group Total** | **28** | **61** | **11** |

All individual ERUs and the group as a whole are considered moderately departed with most subwatersheds containing ERUs in this group rated as Functioning at Risk with respect to riparian/wetland vegetation condition and function (Table 131). This is roughly consistent with the seral state proportion analysis. Reasons for departure are site specific, but include recent extents of high and moderate burn severity and post-fire flooding effects, as well as those related to older fires, such as the Bear (2006), Pigeon (1994) and Divide (1989) Fires. Other reasons cited in the watershed condition classification rationales include roads, drought, drying of the system attributed to irrigation diversions, and trespass livestock. In some cases, elk and current livestock grazing management contribute to departure. All of these stressors are discussed in further detail in the System Drivers and Stressors Chapter.

### *Channel Shape and Function*

This characteristic includes vertical stability, width to depth ratios and floodplain connectivity which play important roles in maintaining groundwater connections, stream temperatures and vegetation characteristics, as well as influencing flood and sediment transport processes. Table 132 summarizes the attribute ratings for each ERU based on the contributing area of subwatersheds containing each ERU. Fremont Cottonwood-Oak is not included due reasons previously stated.

**Table 132. Channel shape and function conditions at the plan scale for cottonwood group ERUs**

| Ecological Response Unit | Percent of ERU by Subwatershed Indicator Rating | | |
|---|---|---|---|
| | Functioning Properly | Functioning at Risk | Impaired Function |
| Fremont Cottonwood/Shrub | 34 | 42 | 24 |
| Narrowleaf Cottonwood/Shrub | 28 | 41 | 31 |
| Sycamore-Fremont Cottonwood | 54 | 25 | 21 |
| **Area Weighted Group Total** | **35** | **37** | **28** |

All ERUs and the group as a whole are moderately departed from the reference condition (Functioning Properly), with most subwatersheds containing ERUs in this group rated as Functioning at Risk with respect to channel shape and function. As documented in the classification information, rationales attribute most of this departure to post-fire flooding and roads. These stressors are discussed in more detail in the System Drivers and Stressors Chapter.

## Montane-Conifer Willow Group

The montane-conifer willow group includes Arizona Alder-Willow, Willow-Thinleaf Alder, Ponderosa Pine/Willow, and Upper Montane Conifer/Willow ERUs.

Arizona Alder-Willow (Figure 148) covers approximately 4,523 acres within the context area. This ERU is the 9th largest riparian ERU in the context area and the 4th largest on the Gila NF, containing roughly 3,222 acres. Within the context area, it is typically found at elevations ranging from 3,330 to 9,900 feet. It is mapped on the Gila NF between 4,700 to 8,920 feet. While both Arizona alder and willow species are indicative of this ERU, some areas of may contain only one species or the other. Common willow species include red willow (*Salix laevigata* Bebb) and arroyo willow (*S. lasiolepis* Benth). Other riparian species commonly found include Arizona walnut, velvet ash, and Rocky Mountain maple (*Acer glabrum* Torr.).

**Figure 148. Arizona alder-willow ERU**

Willow-Thinleaf Alder (Figure 149) covers approximately 7,091 acres within the context area. This ERU is the 6th largest riparian ERU in the context area and 8th largest on the Gila NF, containing roughly 1,054 acres. Within the context area, it is typically found at elevations ranging from 5,400 to 11,900 feet. On the Forest, it is mapped between 6,240 and 9,520 feet. While both thinleaf alder (*Alnus incana* (L.) Moench subsp. *tenuifolia* (Nutt.) Breitung) and willow species are indicative of this unit, some locations may contain only one species or the other. Common willow species include dewystem willow (*S. irrorata* Andersson), Drummond's willow (*S. drummondiana* Barratt ex Hook.), park willow (*S. monticola* Bebb, and grayleaf willow (*Salix glauca* L.).

**Figure 149. Willow-thinleaf alder ERU (Photo by L.J. WhiteTrifaro)**

Ponderosa Pine/Willow (Figure 150) covers approximately 6,339 acres within the context area. This ERU is the 7th largest riparian ERU in the context area and the 9th largest on the Forest, containing 862 acres. Within the context area, it is typically found at elevations ranging from 4,500 to 9,700 feet. On the Gila NF, it is mapped between 5,380 and 8,360 feet. It is typified by an overstory of ponderosa pine with an understory of shrub-form willow species. As a result of the pine overstory, this unit is particularly hard to distinguish from pine-oak systems of similar structure via remote sensing applications, and therefore is believed to be under-represented in the Regional Riparian Mapping Project (RMAP) and therefore the ERU map. Other riparian species commonly found include Arizona walnut, boxelder, and velvet ash.

**Figure 150. Ponderosa pine/willow ERU (Photo by D. Cress)**

Upper Montane Conifer/Willow (Figure 151) covers approximately 1,343 acres within the context area. This ERU is the 11th largest riparian ERU in the context area and the 10th largest on Forest, containing roughly 670 acres. Within the context area, it is typically found at elevations ranging from 6,100 to 11,400 feet. On the Forest, it is mapped between 6,750 and 9,160 feet. Conifer species include spruce, subalpine fir, white fir, and Douglas fir. Quaking aspen can be present, or even a co-dominant species. Other riparian species commonly found include thinleaf alder and boxelder.

**Figure 151. Upper montane conifer/willow ERU (Photo by L.J. WhiteTrifaro)**

The majority of the montane-conifer willow group is located in the central, western and eastern portions of the context area, and the western and southeastern portions of the Forest. Figure 152 and Figure 153 display the general locations of the montane-conifer willow group within the context area and Gila NF.

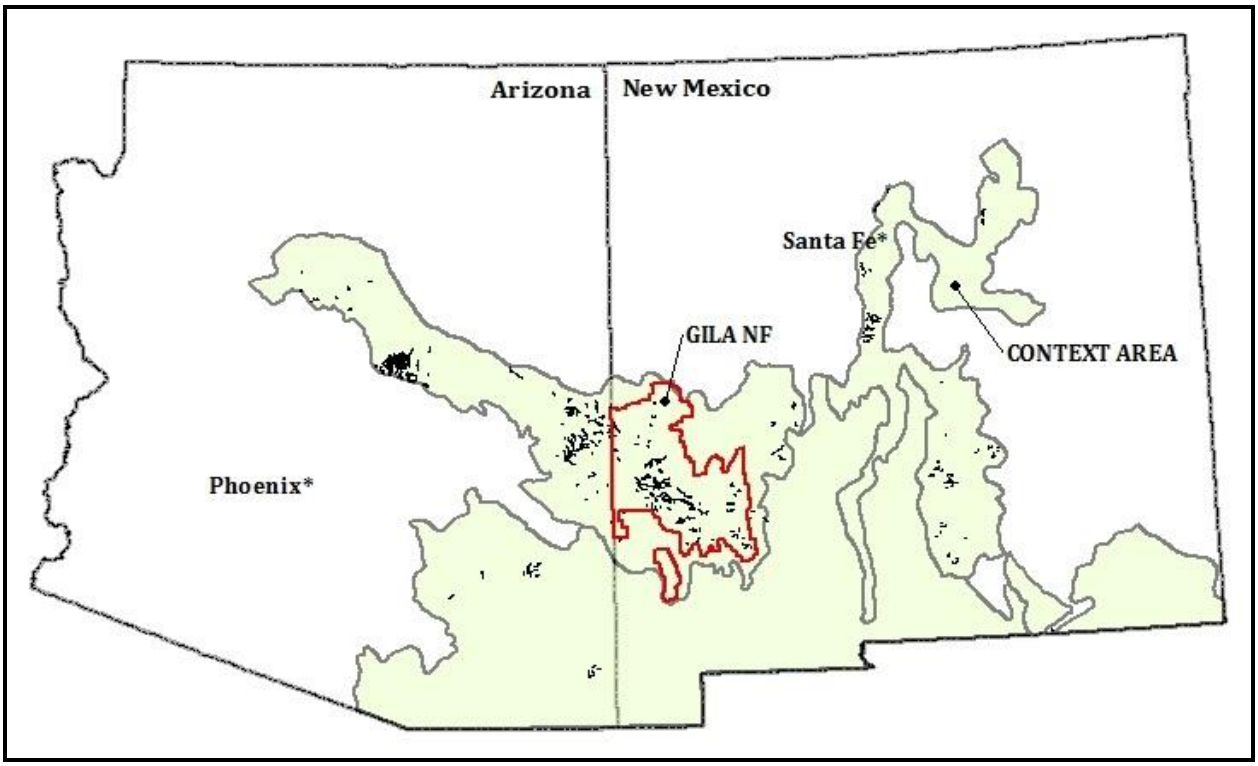



**Figure 152. General location of the montane-conifer willow group of riparian ERUs within the context area**

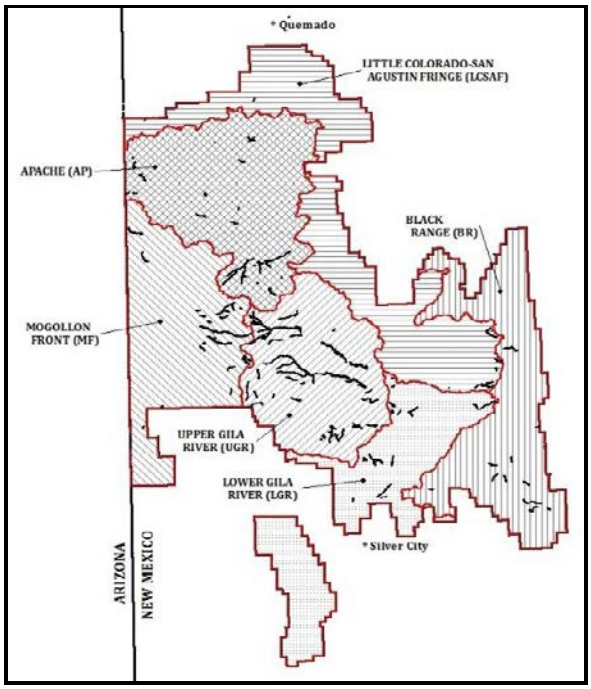



**Figure 153. General location of the montane-conifer willow group of riparian ERUs within the Gila NF and the six local units**

Note: Local units are the polygons interior to the Forest boundary with names in callout labels

As displayed in Table 133, the majority of this ERU group is located in the Upper Gila River and Apache local units.

**Table 133. Local unit contributions to the montane-conifer willow group of ERUs**

| Montane-Conifer Willow ERUs | Gila NF Local Units | | | | | | | | | | | | Gila NF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| Arizona Alder-Willow | 207 | 6.4 | 283 | 8.8 | 0 | 0.0 | 317 | 9.8 | 530 | 16.4 | 1,885 | 58.5 | 3,222 |
| Willow-Thinleaf Alder | 66 | 6.3 | 19 | 1.8 | 3 | 0.3 | 0 | 0.0 | 110 | 10.4 | 857 | 81.3 | 1,054 |
| Ponderosa Pine/Willow | 794 | 92.1 | 0 | 0.0 | 6 | 0.7 | 0 | 0.0 | 62 | 7.2 | 0 | 0.0 | 862 |
| Upper Montane Conifer/Willow | 49 | 7.3 | 41 | 6.1 | 349 | 52.1 | 148 | 22.1 | 52 | 7.8 | 31 | 4.6 | 670 |
| Group Total | 1,116 | 19.2 | 343 | 5.9 | 358 | 6.2 | 465 | 8.0 | 754 | 13.0 | 2,773 | 47.7 | 5,808 |

## Spatial Niche

Individually, and as a group, these riparian communities have greater proportional representation on the Forest than in the context area (Table 134). The Gila NF has a high level of responsibility for maintaining the ecological integrity of these riparian communities.

**Table 134. Riparian ERUs represented in the montane-conifer willow group**

| Montane Conifer-Willow Group ERUs | Total ERU Area on Gila NF | | | Total ERU Area within Context Area | | | Gila NF's Contribution to Total ERU within Context Area | |
|---|---|---|---|---|---|---|---|---|
| | acres | % of Gila NF | % departure | acres | % of Context Area | % departure | from Gila NF | proportional representation |
| Arizona Alder-Willow | 3,222 | 0.1 | 46 | 4,523 | 0.01 | 45 | 71.2 | 0.82 |
| Willow-Thinleaf Alder | 1,054 | 0.03 | 40 | 7,091 | 0.01 | 42 | 14.9 | 0.50 |
| Ponderosa Pine/Willow | 862 | 0.03 | 47 | 6,339 | 0.01 | 61 | 13.6 | 0.50 |
| Upper Montane Conifer/Willow | 670 | 0.02 | 33 | 1,343 | 0.002 | 56 | 49.9 | 0.82 |
| Group Total | 5,808 | 0.002 | 44 | 19,296 | 0.0003 | 50 | 30.1 | 0.74 |

Approximately eight percent of the Arizona Alder-Willow ERU contains designated critical habitat for one or more species, with an additional 32 percent proposed critical habitat. In Willow-Thinleaf Alder the percentages are 6 (designated) and 47 (proposed) percent. There is currently no designated critical habitat associated with the Upper Montane Conifer/Willow ERU, but 47 percent of it is proposed critical habitat. There is no designated or proposed critical habitat in Ponderosa Pine/Willow. As a whole, eight percent of this group contains designated critical habitat with an additional 39 percent proposed.

Sixty one percent of Arizona Alder-Willow, 55 percent of Upper Montane Conifer/Willow and 63 percent of Willow-Thinleaf Alder are located in designated wilderness areas. Ponderosa Pine/Willow is not mapped

in designated wilderness areas. A total of 67 percent of this group occurs in designated wilderness. None of these ERUs occur in Wilderness Study Areas.

Total riparian acres not being grazed by livestock was disclosed in the cottonwood group analysis. Exclosures are not consistently mapped in the available geospatial data, and how much of the excluded acres are represented by the montane-conifer willow group ERUs has not been quantified.

## Key Characteristics

### *Seral State Proportion (Vegetation Structure)*

Under reference conditions (Table 135) the majority of the montane-conifer willow group was made up of early and mid-seral states (seral states A and B). Currently, within both the Forest and context area there is an over representation of seral state B, with an under representation of seral state A (regeneration and recruitment).

**Table 135. Area-weighted seral state make-up of the montane-conifer willow group ERUs under reference (RC) and current conditions for both the Gila NF and context area**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to Reference† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | context area | Gila NF | context area |
| A | Early-seral: Recently burned, all corresponding herb types; all shrub dominance types, shrub cover < 25%; all tree dominance types, < 5" dbh/drc (< 5m height), all cover classes | 65 | 21 | 15 | 21 | 15 |
| B | Mid to late-seral: All shrub dominance types, ≥ 25% canopy cover; all tree dominance types, ≥ 5" dbh/drc (≥ 5m height), all cover classes | 35 | 79 | 85 | 35 | 35 |
| C | Upland dominance types and exotic vegetation, various *(occurs on contemporary landscapes only)* | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 100 | 56 | 50 |
| **Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 56) = 44 or MODERATE; and Context Area = (100 – 50) = 50 or MODERATE** | | | | | | |

‡ USDA FS 2016e; LANDFIRE 2007g

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

At the local unit scale, departure ranges from a low of 38 percent in Upper Gila River, to a high of 61 percent in Lower Gila River (Figure 154). All of the local units, Forest and context area are moderately departed from reference conditions with respect to seral state proportion.

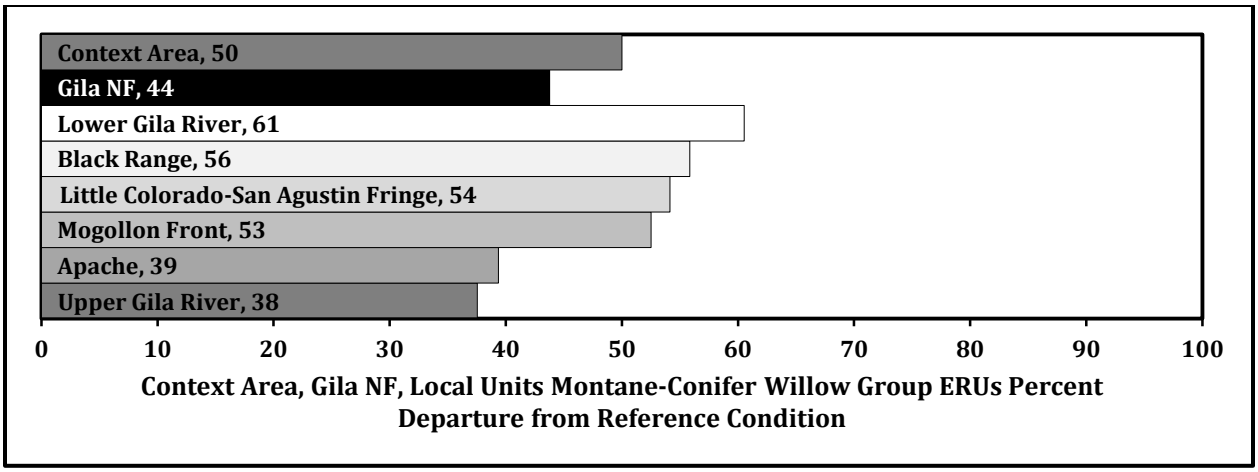



**Figure 154. Area-weighted variations in departure from reference condition for montane-conifer willow group at the context area, Forest and local unit scales**

### *Ecological Status*

The following figure illustrates the variability in ecological status conditions across ERUs in this group. Ponderosa Pine-Willow is not included as there is no documentation in the draft TEUI to support analysis of this characteristic for this ERU.

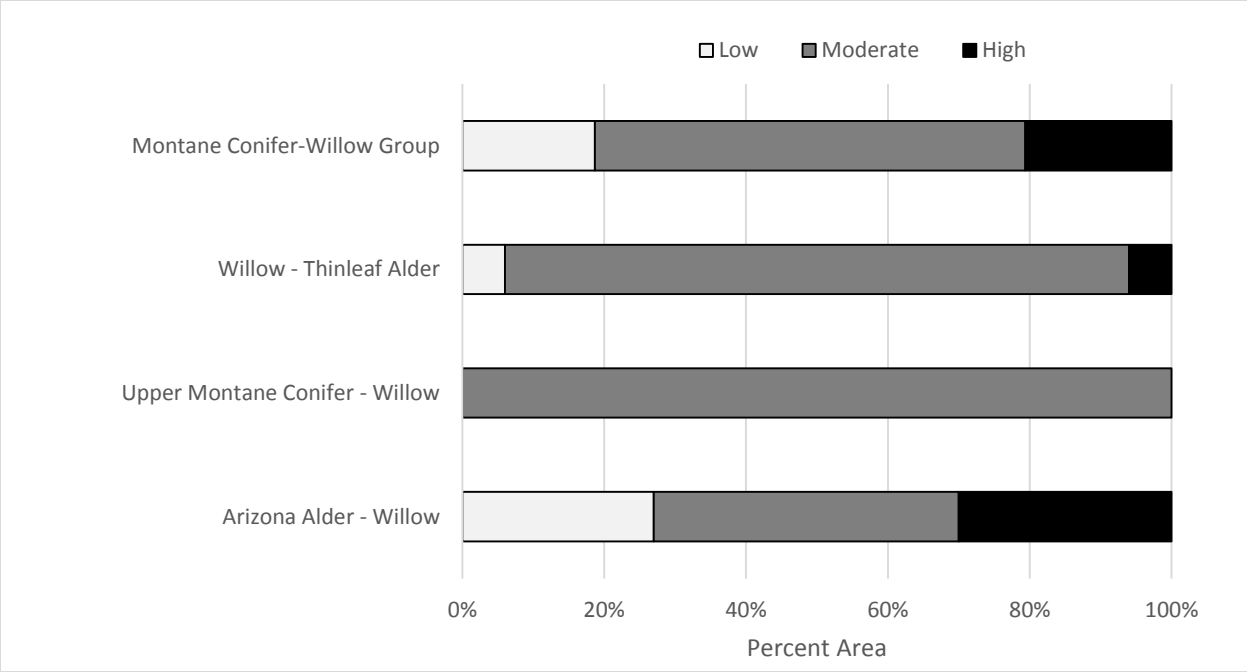



**Figure 155. Plan area ecological status departure for the montane conifer willow group and its individual ERUs**

Based solely on the TEUI information, all ERUs in this group are moderately departed in terms of ecological status, with the moderate departure category representing the largest percentage of each ERU area. However, with 77 percent of the Willow-Thinleaf Alder and 66 percent of the Arizona Alder-Willow identified in the change detection (see Data and Analysis Methods) as experiencing significant loss of vegetative cover since 2011 due to post-fire flooding, the departure rating for these two ERUs is modified to high. The Upper Montane Conifer/Willow ERU, remains moderately departed overall, but is within three

percent of being considered in high departure (Table 127). While regeneration of willows is a reasonable expectation, alders have not been observed as reliable re-sprouters on the Gila NF, and climatic and streamflow conditions supporting successful germination and seedling establishment do not occur every year (see System Drivers and Stressors). Ecological status departure remains moderate for the group as a whole, although it is very close to the thresholds that would place it in high departure (Table 127).

Prior to the large scale post-fire flooding that has occurred, departure in ecological status was due to fewer co-dominant riparian species, such as cottonwoods, under current conditions as opposed to reference conditions. There were also fewer willows, and less grass cover under current conditions as opposed to reference. As with the cottonwood group, Kentucky bluegrass has replaced the native riparian grasses in some places within the montane conifer/willow group, but it is present in fewer instances. Again, sweetclovers, dandelion and a few other non-native species have naturalized in these ERUs but are generally present at low levels. Noxious species documented by the TEUI at low levels in these systems include cheatgrass and saltcedar, although these tend to be present at the lower end of this ERUs elevational climatic gradient, where cottonwoods begin to increase in dominance.

Where fire impacts did not occur in these ERUs, the causal factors documented in the watershed condition classification, as discussed in the cottonwood group analysis, also apply here.

### *Vegetative Groundcover*

The following figure (Figure 156) illustrates the variability in ecological status conditions across montane-conifer willow ERUs with representation in the draft TEUI data.

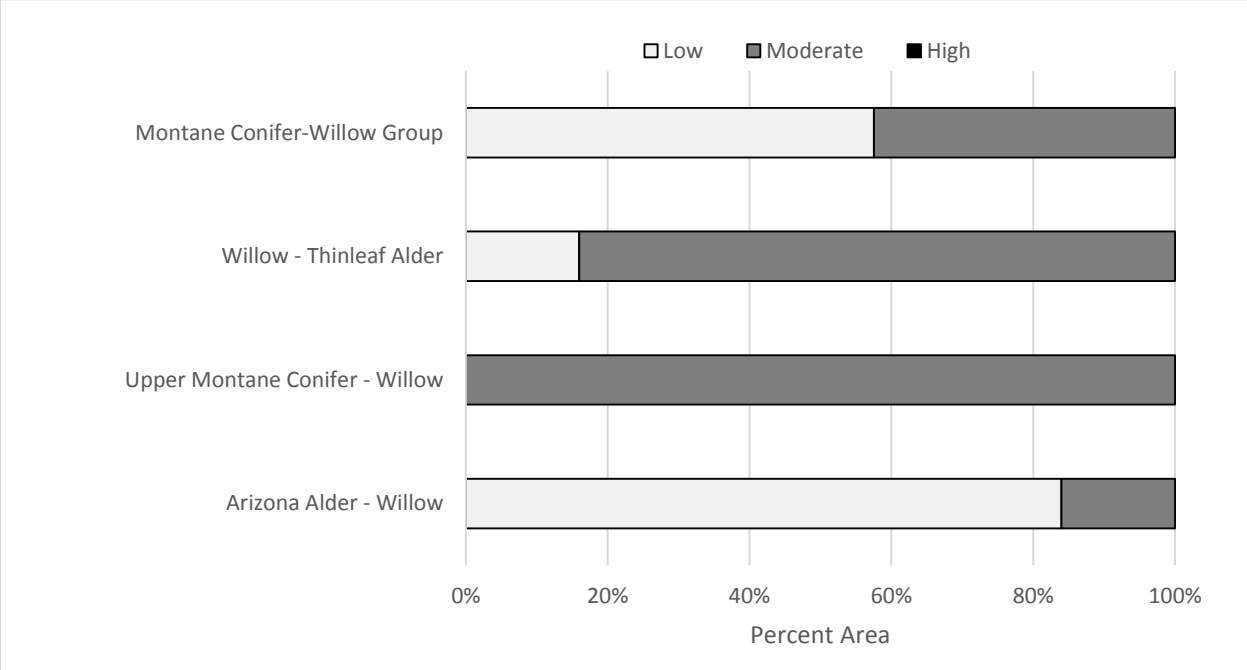



**Figure 156. Plan area vegetative groundcover departure for the montane-conifer willow group and its individual ERUs**

Based only on the TEUI data, vegetative groundcover is moderately departed in Willow-Thinleaf Alder and Upper Montane Conifer/Willow, with the largest percentage of their respective area being represented by the moderate departure category. Likewise, overall ERU departure in Arizona Alder-Willow is low with more than 80 percent of its area being represented by the low departure category. Because Arizona Alder-Willow makes up most of this group, the group as a whole is also in low departure. As with ecological

status, these vegetative groundcover results are modified based on the change detection (see Data and Analysis Methods), moving Willow-Thinleaf Alder and Arizona Alder-Willow to high departure, and the group as a whole to high departure.

Prior to recent high and moderate burn severities in the upper watersheds and subsequent flooding, where vegetative groundcover departure occurred in these ERUs, it reflected reductions in both plant basal area and litter under current conditions. Where fire impacts did not occur in these ERUs, the causal factors documented by the watershed condition classification, as discussed in the cottonwood group analysis, also apply here.

### *Vegetation Condition and Function*

Table 136 displays current riparian/wetland vegetation conditions for the montane conifer-willow group ERUs in terms of Functioning Properly, Functioning at Risk or Impaired Function.

**Table 136. Current riparian/wetland vegetation conditions within the plan area for montane-conifer willow group ERUs**

| Ecological Response Unit | Percent of ERU by Subwatershed Indicator Rating | | |
|---|---|---|---|
| | Functioning Properly | Functioning at Risk | Impaired Function |
| Arizona Alder-Willow | 11 | 59 | 29 |
| Ponderosa Pine/Willow | 2 | 58 | 40 |
| Upper Montane Conifer/Willow | 25 | 75 | 0 |
| Willow-Thinleaf Alder | <1 | 61 | 39 |
| **Area Weighted Group Total** | **15** | **53** | **30** |

All ERUs in this group are moderately departed for vegetation condition and function with the largest percentage of each ERU area being represented by subwatersheds with Functioning at Risk ratings. This is consistent with the seral state proportion departure results. All of the factors identified as contributing to departure in this characteristic for the cottonwood group also apply here. However, high and moderate burn severities and post-fire flooding are the primary reason for departure within the portions of these ERUs that occur within wilderness.

### *Channel Shape and Function*

Table 137 displays current channel shape and function conditions for the montane-conifer willow group ERUs in terms of Functioning Properly, Functioning at Risk or Impaired Function.

**Table 137. Channel shape and function conditions within the plan area for montane-conifer willow group ERUs**

| Ecological Response Unit | Percent of ERU by Subwatershed Indicator Rating | | |
|---|---|---|---|
| | Functioning Properly | Functioning at Risk | Impaired Function |
| Arizona Alder-Willow | 17 | 35 | 46 |
| Ponderosa Pine/Willow | 2 | 98 | 0 |
| Upper Montane Conifer/Willow | 29 | 23 | 48 |
| Willow-Thinleaf Alder | <1 | 15 | 85 |
| **Area Weighted Group Total** | **19** | **38** | **44** |

Most ERUs in the group as a whole are highly departed with respect to channel shape and function, with the largest percentage of each ERU area being represented by subwatersheds with Impaired Function ratings. Ponderosa Pine/Willow is the exception, demonstrating moderate departure, which reflects less recent post-fire effects to channel shape and function as compared to the other ERUs. As with this

characteristic in the cottonwood group, extents of high and moderate burn severity and post-fire flooding impacts, as well as roads are the primary factors contributing to departure. Extents of high and moderate burn severity and post-fire alterations to flow have the largest explanatory value for departure in the montane-conifer willow group. Roads have less explanatory value for departure where this group occurs in wilderness.

## Wetland (Ciénega) Group

The wetland (ciénega) group is represented by a single ERU: Herbaceous Riparian (Figure 157). This ERU covers approximately 161,391 acres within the context area. This ERU is the 2nd largest riparian ERU in the context area and the 5th largest on the Gila NF containing roughly 2,485 acres. Within the context area, it is found at nearly all elevations, ranging from 2,100 to over 12,000 feet. On the Gila NF, it is mapped at elevations between 5,880 and 9,440 feet. It supports a whole host of riparian and wetland herbaceous species depending on landscape position[43], elevation and climatic factors. Non-native Kentucky and Canada bluegrass have become naturalized within this system (White 2002). This group is scattered throughout most of the context area and the Forest. Figure 158 and Figure 159 display the general locations within the context area and Gila NF.

**Figure 157. Herbaceous Riparian ERU (Photo by L.J. WhiteTrifaro)**

[43] Unlike the other riparian groups and ERUs, this group and ERU may occur in valley bottoms along stream corridors, or in upland positions.

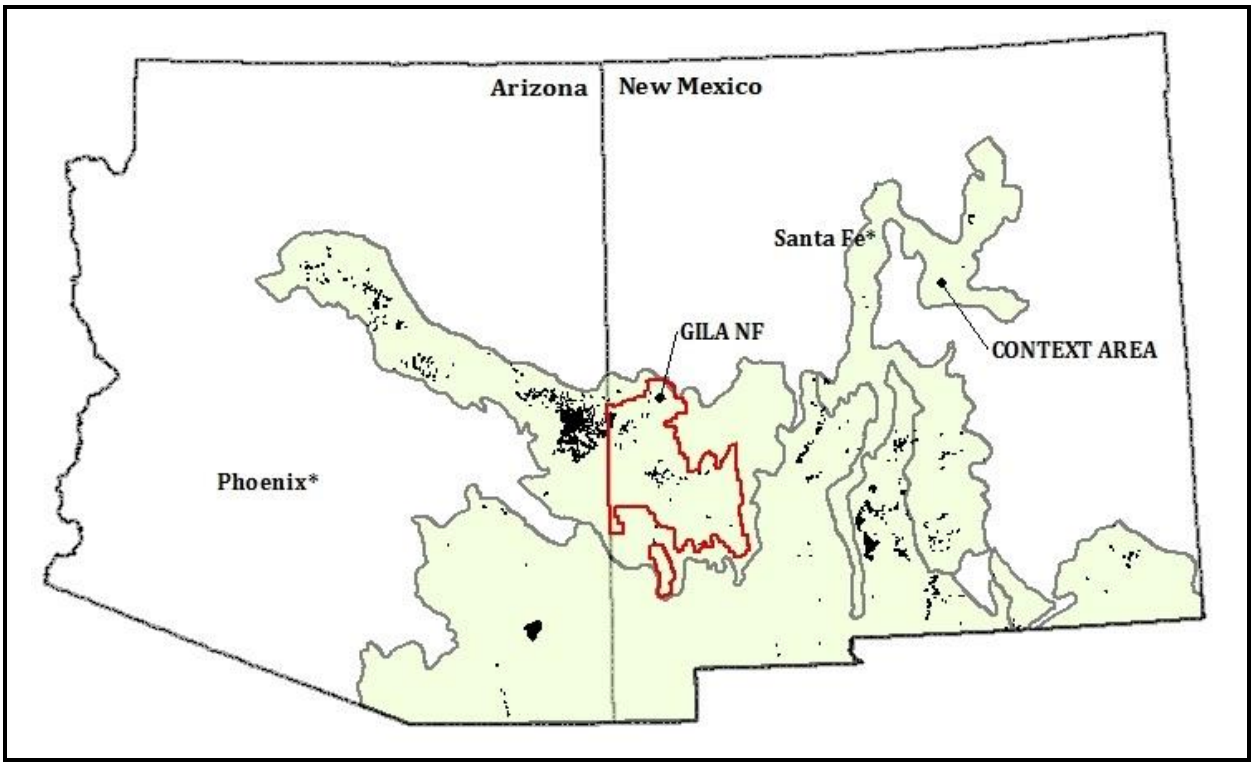



**Figure 158. General location of Herbaceous riparian ERU within the context area**

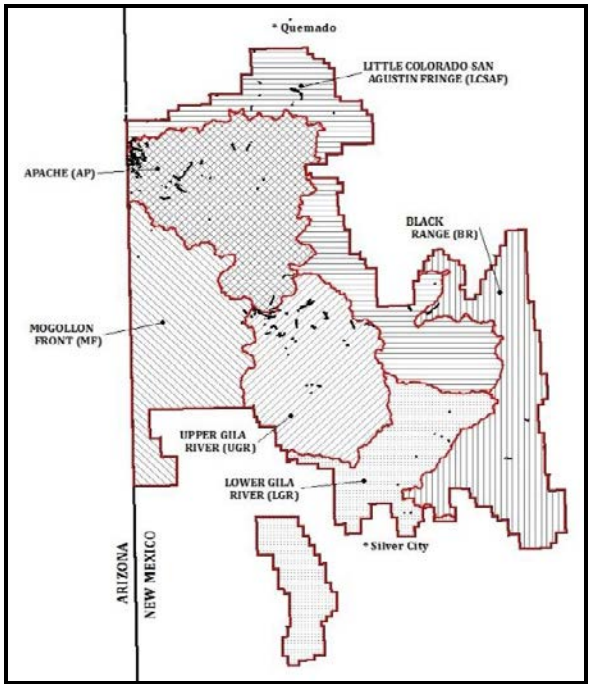



**Figure 159. General location of Herbaceous-wetland riparian within the Gila NF and the six local units**

Note: Local units are the polygons interior to the Forest boundary with names in callout labels

As displayed in Table 138 the majority of this ERU is located in the Apache and Upper Gila River local units.

**Table 138. Local unit contributions to the Herbaceous Riparian ERU**

| Wetland (ciénega) Group | Gila NF Local Units | | | | | | | | | | | | Gila NF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| Herbaceous Riparian ERU | 1,126 | 45.3 | 74 | 3.0 | 185 | 7.4 | 63 | 2.5 | 47 | 1.9 | 990 | 39.8 | 2,485 |

## Spatial Niche

The Herbaceous Riparian ERU has a greater proportional representation in the context area than on the Forest (Table 139). This does not mean that the Forest has a lesser responsibility to restore and/or maintain ecological integrity in these systems, just fewer opportunities.

**Table 139. Riparian ERUs represented in the wetland (ciénega) group.**

| Wetland (ciénega) Group | Total ERU Area on Gila NF | | | Total ERU Area within Context Area | | | Gila NF's Contribution to Total ERU within Context Area | |
|---|---|---|---|---|---|---|---|---|
| | acres | % of Gila NF | % departure | acres | % of Context Area | % departure | from Gila NF | proportional representation |
| Herbaceous Riparian ERU | 2,485 | 0.08 | no data | 161,391 | 0.3 | no data | 1.5 | -0.58 |

There are no areas in the Herbaceous Riparian that are designated or proposed critical habitat for any species. Eight percent of it is located within the Gila Wilderness, but it is also found in the Aldo Leopold Wilderness. No occurrences of this ERU are found within Wilderness Study Areas. Total riparian acres not being grazed by livestock was disclosed in the cottonwood group analysis. Exclosures are not consistently mapped in the available geospatial data, and how much of the excluded acres are represented by the Herbaceous Riparian ERU has not been quantified.

## Key Characteristics

### *Seral State Proportion (Vegetation Structure)*

Under reference conditions (Table 140) the majority of the wetland (ciénega) group was made up of a grass, forb and shrub state (seral state B, C). Currently, within the Forest there has developed a seral state dominated by trees (seral state D). The seral state successional pattern within the context area fairly closely follows the Gila NF.

**Table 140. Seral state make-up of the wetland (ciénega) group ERU under reference (RC) and current conditions for both the Gila NF and context area (CA)**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | context area | Gila NF | context area |
| A | Early-seral: Recently burned, sparsely vegetated | 15 | 0 | 12 | 0 | 12 |
| B,C | Mid-seral: Grass/forb and all corresponding shrub types and all cover classes | 85 | 87 | 81 | 85 | 81 |
| D | Upland dominance types, and types dominated by exotic vegetation, and various *(occurs on contemporary landscapes only ...)* | 0 | 13 | 7 | 0 | 0 |
| Total | | 100 | 100 | 100 | 85 | 93 |
| **Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 85) = 15 or LOW; and Context Area = (100 – 93) = 7 or LOW** | | | | | | |

‡ LANDFIRE 2003; USDA FS 2008a
† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)
† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

Within the Forest, at the local unit scale, departure ranges from a low of 15% in Apache, Black Range and Little Colorado-San Agustin Fringe to a high of 81% in Mogollon Front (Figure 160). The context area departure is low.

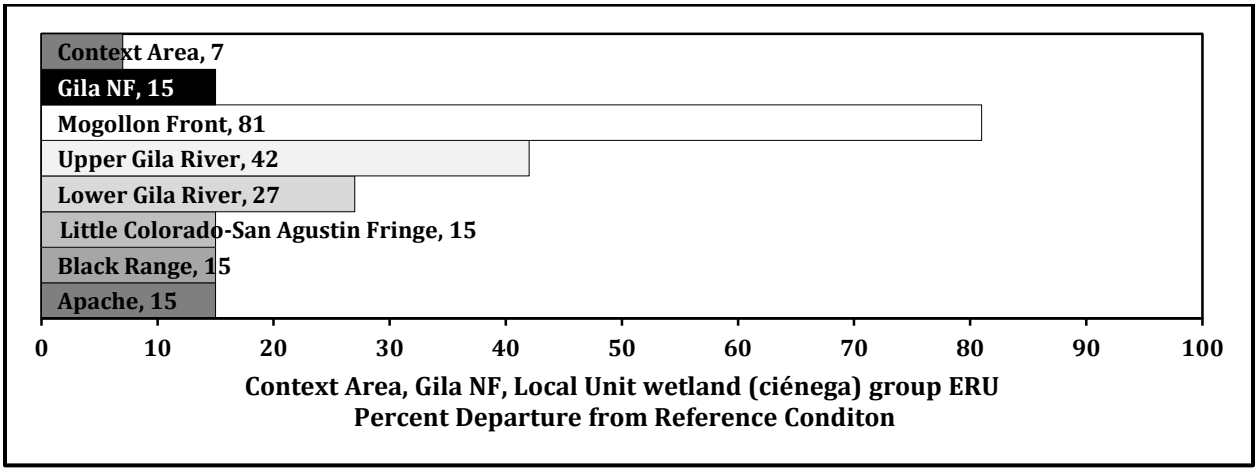



**Figure 160. Variations in departure from reference condition for wetland (ciénega) group at the context area, Forest and local unit scales**

## *Ecological Status*

Ecological status conditions described by the TEUI data in the Herbaceous Wetland ERU are evenly split between moderate (50 percent) and high departure (50 percent). Kentucky bluegrass has displaced the native riparian/wetland herbaceous community in places, and where those native species remain present, their canopy cover is lower than under reference conditions. This grass does not have the deep, dense root system that native riparian species do and does not provide for streambank or floodplain stability. Therefore, this displacement of the native species reduces channel stability where this ERU occurs along streams. Again, non-native sweetclovers and dandelion have naturalized and are present at relatively low levels. No noxious species have been documented in the TEUI data. All the factors described first in the cottonwood group analysis also apply here. However, extents of high and moderate burn severity and post-fire is not a factor contributing to ecological status departure in this ERU or group.

### *Vegetative Groundcover*

Vegetative groundcover departure in Herbaceous Riparian is described by this analysis method as low. However, portions of this ERU are in a gullied phase, as documented by the TEUI. This merits a closer look at the data. While the total vegetative groundcover indicates low departure, there is a large reduction in litter and a corresponding increase in basal area between the reference and current condition. This increased basal area is indicative of grass species in sod-bound growth forms. The basal area of sod-bound grasses is not as effective in maintaining site stability or productivity as grasses that are not. Productivity is also negatively impacted by the reduction in litter. In this case, the analysis methods fail to capture the actual departure in vegetative groundcover, which should be categorized as high. All the factors described first in the cottonwood group analysis also apply here. However, extents of high and moderate burn severity and post-fire is not a factor contributing to vegetative groundcover departure in this ERU or group.

### *Vegetation Condition and Function*

With respect to vegetation condition, nine percent of the Herbaceous Riparian ERU is represented by subwatersheds that are Functioning Properly, 88 percent Functioning at Risk and three percent Impaired Function, giving the ERU a moderate departure overall based only on the watershed condition classification information. This is not consistent with the seral state proportion departure, which is low. While this may be a demonstration of the limitations associated with applying a watershed scale dataset to the ERU scale, or the qualitative nature of the watershed scale dataset, there are other factors that may provide greater explanatory value for what appears to be a disagreement. The riparian/wetland vegetation indicator does not only consider recent burns as differentiating factors between early seral and other seral states as does the model used to assess the seral state proportion characteristics. It also provides consideration for water relationships, which is a measure of risk (see indicator rating definitions in Analysis Methods) Thus, where this ERU occurs along streams, channel downcutting, disconnection from the floodplain, and altered surface-groundwater interactions observed by the interdisciplinary team that conducted the classification are reflected as departure.

### *Channel Shape and Function*

This characteristic applies only to those portions of this ERU that exist along stream corridors. Thirty eight of the Herbaceous Riparian ERU is represented by subwatersheds that are Functioning Properly, 33 percent Functioning at Risk and 30 percent Impaired Function giving this ERU a low departure rating overall. However, it is very close to the thresholds being used in this assessment. The differences between departure categories are small enough that it is likely well within the margin of error introduced by using watershed scale data at the ERU scale. No matter the departure category assigned here, there is a high degree of uncertainty. Based the displacement of native riparian/wetland species with non-native species that do not adequately provide for stream bank and floodplain stability (moderate-high ecological status departure), high vegetative groundcover departure, and notes associated with the TEUI data that identify portions of this ERU as being in a gullied phase, departure in channel shape and function is categorized as moderate to high, rather than low. Causal factors contributing to departure are those previously identified for other riparian groups, with fire and associated alterations in streamflow having the least relevance here, and historic livestock grazing having the most. Current livestock grazing may have realized improvements over historic conditions, but current livestock management and elk slow the natural rate of recovery that this system would experience without their presence.

## Walnut-Evergreen Tree Group

The Walnut-Evergreen Tree Group includes the Arizona Walnut[44] (Figure 161) and Walnut/Ponderosa Pine ERUs. Arizona Walnut covers approximately 6,632 acres within the context area. This ERU is the 8th largest riparian ERU in the context area and the 7th largest on Forest, containing roughly 1,655 acres. Within the context area, it is typically found at elevations ranging from 4,000 to 8,300 feet. On the Gila NF, this ERU has been mapped between 4,160 and 8,000 feet. This highly diverse ERU occurs in dryer drainages than other riparian types and often includes species such as willows, boxelder, ponderosa pine, piñon pines, junipers, and various species of oak.

**Figure 161. Arizona walnut ERU (Photo by M. Wahlberg)**

Most Arizona Walnut is located in the central and western portions of the context area, and the western and southern portions of the Forest. Figure 162 and Figure 163 display general locations within the context area and Gila NF.

[44] RMAP includes approximately 370 acres of the Little Walnut-Ponderosa Pine ERU. However, little walnut is not known to occur on the Gila NF. Arizona walnut is the only walnut species known to occur on the Forest. These acres are included in the Arizona Walnut ERU analysis. The Little Walnut/Ponderosa Pine ERU is also lacking documentation in the Gila's draft TEUI.

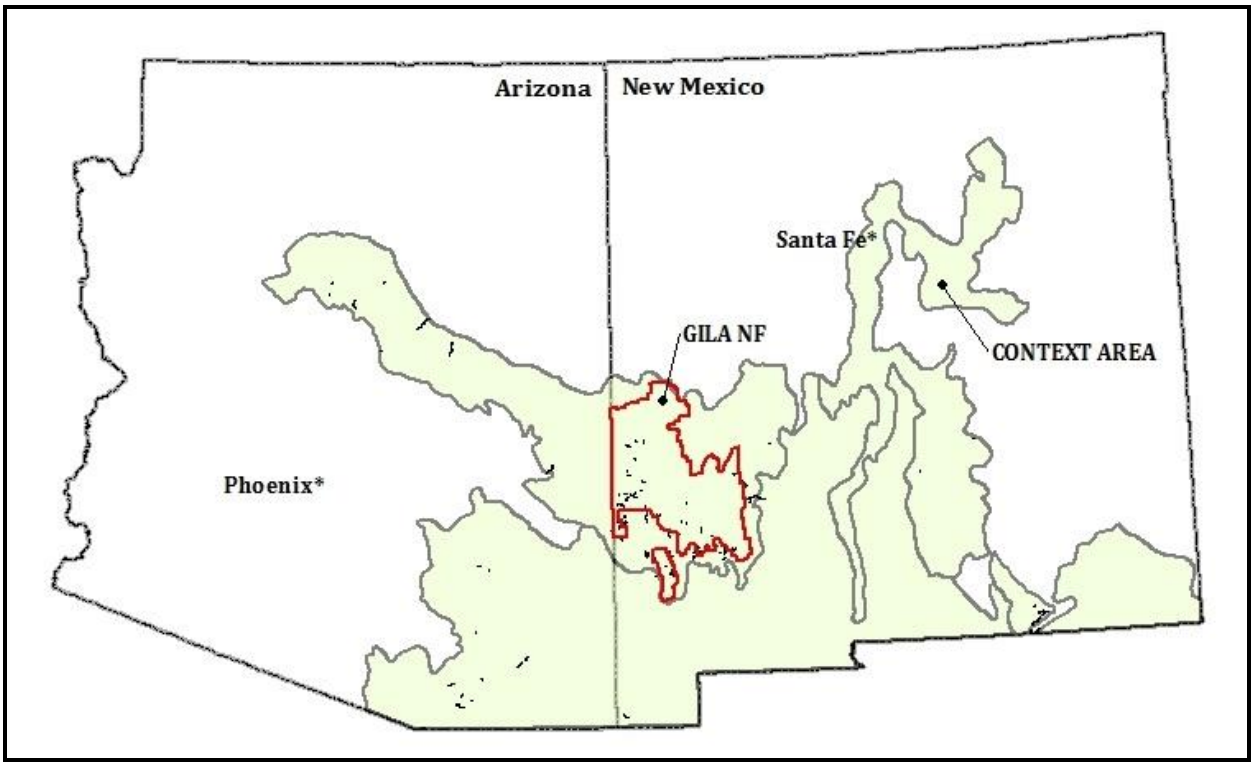



**Figure 162. General location of the walnut-evergreen tree group of riparian ERUs within the context area**

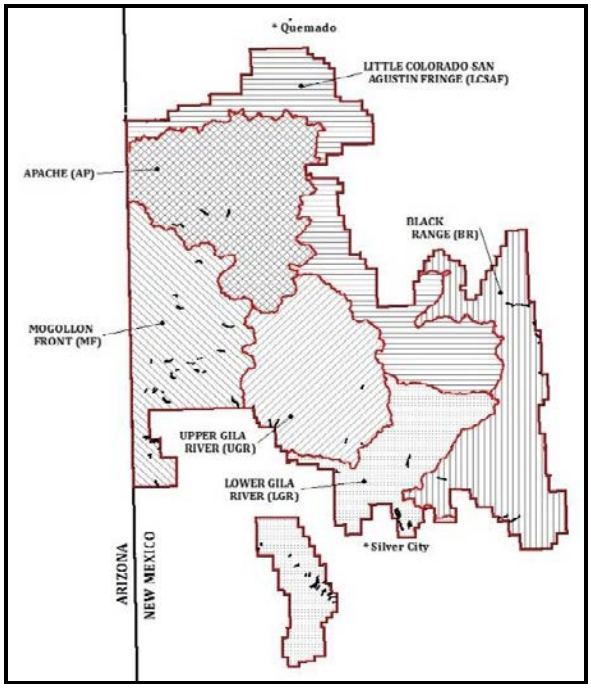



**Figure 163. General location of the walnut-evergreen tree group of riparian ERUs within the Gila NF and the six local units**

Note: Local units are the polygons interior to the Forest boundary with names in callout labels

As displayed in Table 141, the majority of this ERU is located in the Lower Gila River and Mogollon Front local units.

**Table 141. Local unit contributions to the walnut-evergreen tree group of ERUs**

| Walnut-Evergreen Tree Group | Gila NF Local Units | | | | | | | | | | | | Gila NF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| Arizona walnut ERU | 125 | 7.6 | 301 | 18.2 | 0 | 0.0 | 612 | 37.0 | 523 | 31.6 | 94 | 5.7 | 1,655 |

## *Spatial Niche*

The walnut-evergreen tree group of ERUs is the smallest riparian group in both the context area at 6,632 acres and Forest at 1,655 acres (Table 142). Arizona walnut has a greater proportional representation on the Forest (0.67) than in the context area. The Gila NF has a high level of responsibility for maintaining the ecological integrity of these riparian communities.

**Table 142. Riparian ERUs represented in the Arizona walnut ERU**

| Walnut-Evergreen Tree Group | Total ERU Area on Gila NF | | | Total ERU Area within Context Area | | | Gila NF's Contribution to Total ERU within Context Area | |
|---|---|---|---|---|---|---|---|---|
| | acres | % of Gila NF | % departure | acres | % of Context | % departure | from Gila NF | proportional representation |
| Arizona walnut ERU | 1,655 | 0.05 | 49 | 6,632 | 0.01 | 38 | 25.6 | 0.67 |

Nine percent of Arizona Walnut is within designated wilderness areas with one percent occurring in the Hell Hole and Lower San Francisco Wilderness Study Areas. None of the Walnut/Ponderosa Pine occurs in designated wilderness or Wilderness Study Areas.

# Key Characteristics

## *Seral State Proportion (Vegetation Structure)*

Under reference conditions (Table 143) the majority of the walnut-evergreen tree group was made up of an understory of all size shrubs with a closed canopy and open overstory of all size trees (seral state B). These riparian communities also had a large representation of large trees with closed canopy characteristics (seral state C) as with as a good representation of shrub and tree regeneration (seral state A).

**Table 143. Seral state make-up of the walnut-evergreen tree group ERU under reference (RC) and current conditions for both the Gila NF and context area**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to Reference† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | context area | Gila NF | context area |
| A | Early-seral: Recently burned, sparsely vegetated, all herbaceous dominance types, and < 10% tree cover and < 10% shrub cover; Native shrub dominance types, and all shrub size classes, shrub cover < 25%; Native tree dominance types, and tree 0-4.9" dbh/drc, all tree cover classes | 25 | 38 | 63 | 25 | 25 |
| B | Mid-seral: Native shrub dominance types, and all shrub size classes, shrub cover > 25%; Native tree dominance types, and tree > 5" dbh/drc, tree cover < 25% | 50 | 1 | 23 | 1 | 23 |
| C | High-seral: Native tree dominance types, and tree > 5" dbh/drc, tree cover > 25% | 25 | 60 | 15 | 25 | 25 |
| D | Upland dominance types, and types dominated by exotic vegetation, and various *(occurs on contemporary landscapes only)* | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 100 | 51 | 62 |

**Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 51) = 49 or MODERATE; and Context Area = (100 – 62) = 38 or MODERATE**

‡ USDA FS 2016f; LANDFIRE 2008d

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

At the local unit scale, departure ranges from a low of 27 percent in Mogollon Front, to a high of 50 percent in Lower Gila River (Figure 164). The context area, Forest and most local units are associated with a moderate departure from the reference condition. Departure is low in the Mogollon Front local unit, and the Little Colorado-San Agustin Fringe does not contain either of the two ERUs in this group.

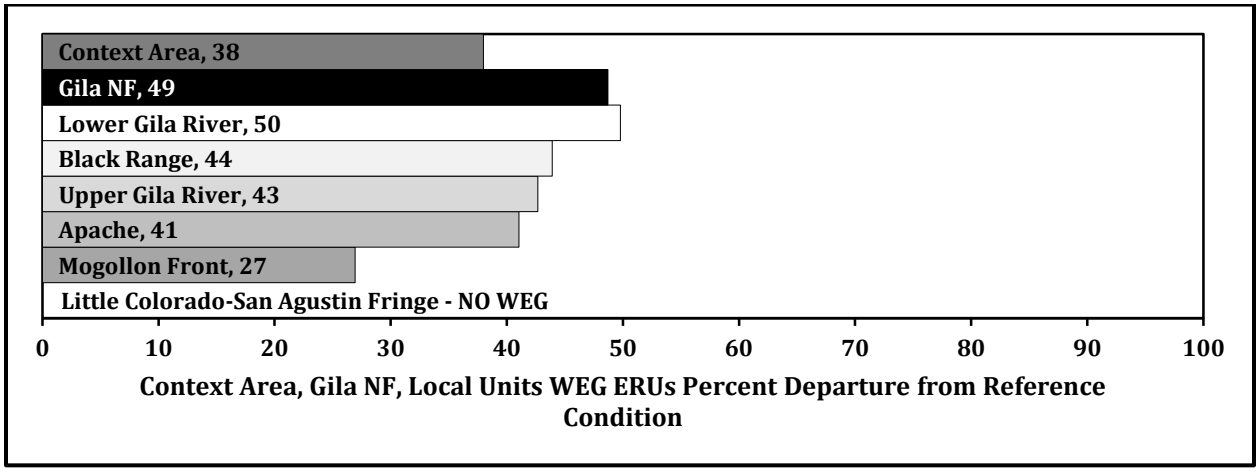



**Figure 164. Area-weighted variations in seral state departure from reference condition for walnut-evergreen tree group at the context area, Forest and local unit scales**

## *Ecological Status*

According to the TEUI data, ecological status in the Arizona Walnut ERU is low. There is no TEUI information for the Walnut/Ponderosa Pine ERU. Kentucky bluegrass is present in some areas near the upper end of this group's elevational-climatic gradient. Native grasses tend to be present in slightly lower amounts

under current conditions. Some non-natives, such as dandelion have naturalized and have been documented at low levels. No noxious weed species have been documented by the TEUI. Field observations not associated with the TEUI indicate some instances of this ERU are experiencing drought related die-off of mature Arizona walnut, with little or no regeneration of this species taking place.

### *Vegetative Groundcover*

Vegetative groundcover departure in Arizona Walnut is low.

### *Vegetation Condition and Function*

With respect to vegetation condition, 23 percent of the Arizona Walnut[45] ERU area is represented by subwatersheds that are Functioning Properly, 73 percent Functioning at Risk and four percent Impaired Function. Overall, departure for the walnut-evergreen tree group is moderate. This is consistent with the seral state proportion departure for the group. However, most instances of this ERU occur in watersheds where riparian and aquatic indicators received a lower weight (see Water Chapter) because all or the majority of streams are ephemeral in nature.

### *Channel Shape and Function*

With respect to channel shape and function, 20 percent of the Arizona Walnut ERU area is represented by subwatersheds that are Functioning Properly, 63 percent Functioning at Risk and 17 percent Impaired Function. Overall, departure is moderate. Again, most of these systems are associated with watersheds dominated by ephemeral channels, where channel shape and function received a lower weight in the overall classification.

## Desert Willow Group

The desert willow group includes only one ERU (Figure 165): Desert willow. Desert willow covers approximately 24,331 acres within the context area. This ERU is the 5th largest riparian ERU in the context area. The Gila NF contains roughly 8,929 acres, making it the 2nd largest riparian type on the Forest. In the context area, it is typically found at elevations ranging from 1,300 to 6,900 feet, often along ephemeral and drier reaches of interrupted alluvial channels. On the Gila NF, it is mapped between 4,320 and 6,720 feet. Other riparian species commonly found in this ERU include netleaf hackberry (*Celtis laevigata* Willd. var. *reticulata* (Torr.) L.D. Benson) and velvet mesquite (*Prosopis velutina* Wooton).

**Figure 165. Desert willow ERU (Photo by M. Wahlberg)**

Most of this group is located in the central and southwestern portion of the context area, and the southern portion (primarily Burro Mtns.) of the Forest. Figure 166 and Figure 167 display the general locations of the DWG within the context area and Gila NF.

[45] While there is equivalent data in the watershed condition classification for the acres mapped as Walnut-Ponderosa Pine, their inclusion would not change departure and trend for the group because of the relatively small acreage associated with this ERU. This footnote also applies to the channel shape and function analysis.

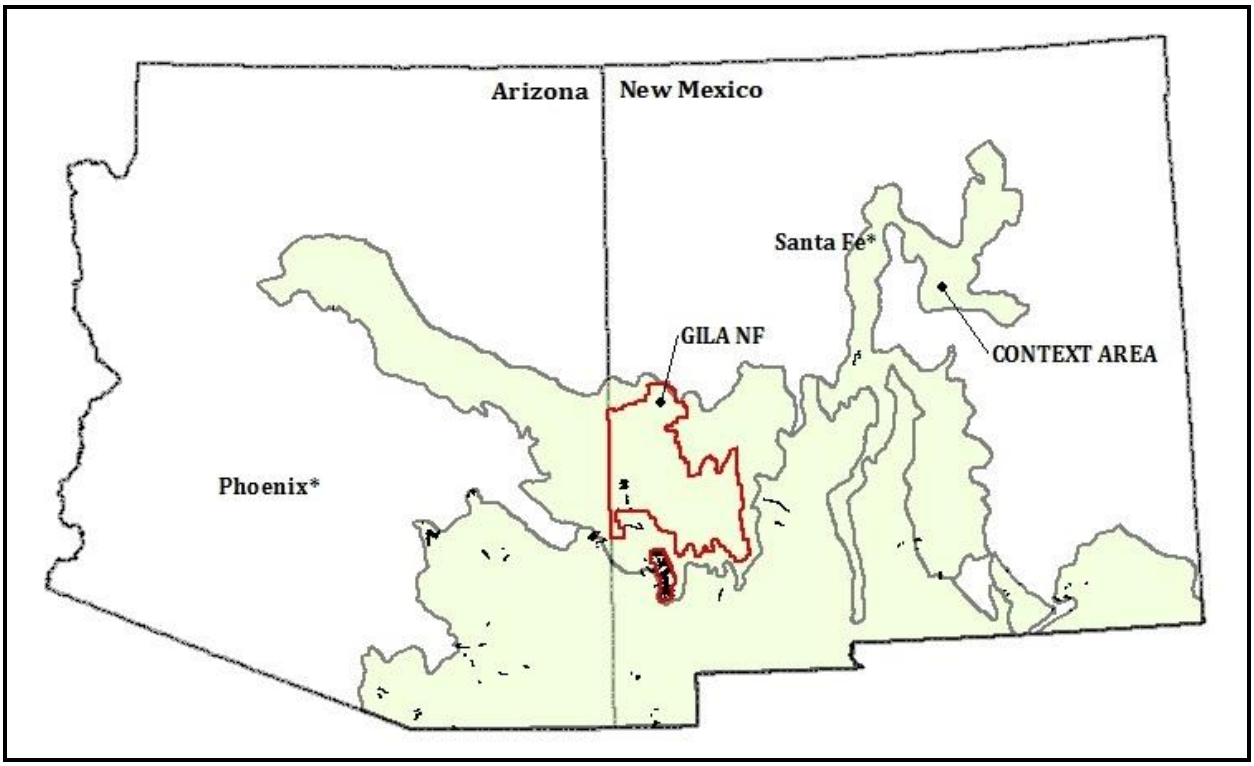



**Figure 166. General location of the desert willow ERU within the context area**

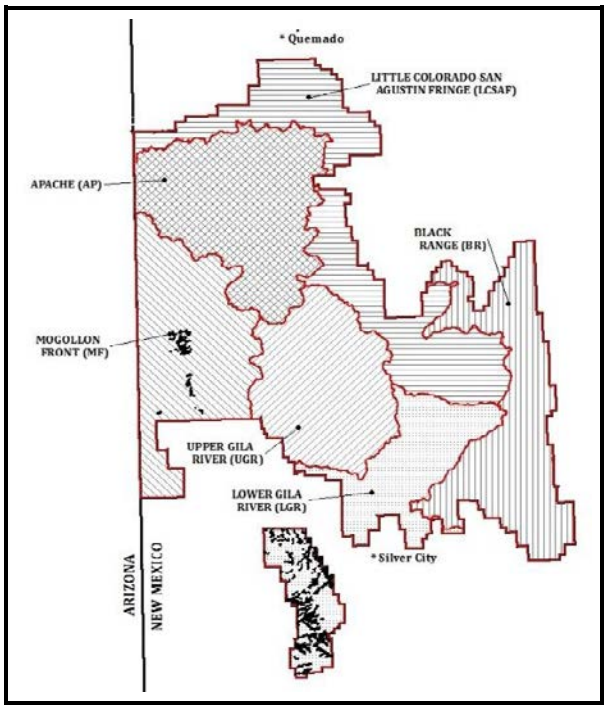



**Figure 167. General location of the desert willow riparian ERU within the Gila NF and the six local units**

Note: Local units are the polygons interior to the Forest boundary with names in callout labels

As displayed in Table 144, this ERU only occurs in the Lower Gila River and Mogollon Front local units, with the majority occurring in Lower Gila River.

**Table 144. Local unit contributions to the desert willow group of ERUs**

| Desert Willow Group | Gila NF Local Units | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | Black Range | | Little Colorado-San Agustin Fringe | | Lower Gila River | | Mogollon Front | | Upper Gila River | | |
| | acres | % | acres | % | acres | % | acres | % | acres | % | acres | % | |
| Desert Willow | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 7,331 | 82.1 | 1,598 | 17.9 | 0 | 0.0 | 8,929 |

## Spatial Niche

The desert willow group is the 4th largest riparian group in the context area at 24,331 acres and the 2nd largest riparian group on the Forest at 8,929 acres (Table 145). The Desert willow ERU has a greater proportional representation on the Forest than in the context area.

**Table 145. Riparian ERUs represented in the desert willow group**

| Desert Willow Group ERU | Total ERU Area on Gila NF | | | Total ERU Area within CA | | | Gila NF's Contribution to Total ERU within CA | |
|---|---|---|---|---|---|---|---|---|
| | acres | % Gila NF | % departure from reference | acres | % Context Area | % departure from reference | from Gila NF | proportional representation |
| Desert willow | 8,929 | 0.3 | 35 | 24,331 | 0.05 | 60 | 36.7 | 0.71 |

This ERU lies entirely outside of designated wilderness or Wilderness Study Areas, does not contain designated or proposed critical habitat.

## Key Characteristics

### *Seral State Proportion (Vegetation Structure)*

Under reference conditions (Table 146) the majority of the desert willow group was represented by early and mid-seral states (seral states A, B and C). Currently, within the Forest the majority seral states are C and E. Within the context area the majority state is early seral state A.

**Table 146. Seral state make-up of the desert willow group under reference (RC) and current conditions for both the Gila NF and context area**

| Seral State | Seral State Structure, Composition and Cover Class Description‡ | Percent Proportion | | | Similarity Values to RC† | |
|---|---|---|---|---|---|---|
| | | RC | current condition | | | |
| | | | Gila NF | context area | Gila NF | context area |
| A | Low-seral: Recently burned, sparsely vegetated, all herbaceous and shrub dominance types, and < 10% tree cover and < 10% shrub cover | 20 | 17 | 77 | 17 | 20 |
| B | Mid-seral: Native shrub dominance types with cover 25/30-50/60% and trees < 5" dbh/drc with cover ≥ 25/30 | 15 | 13 | 3 | 13 | 3 |
| C | Mid-seral: Native shrub dominance all size classes and trees < 5" dbh/drc with cover < 25/30% | 40 | 22 | 4 | 22 | 4 |
| D | Late-seral: Native tree dominance types, trees > 5" dbh/drc, and tree cover < 50/60% | 20 | 8 | 8 | 8 | 8 |
| E | Late-seral: Native shrub dominance all size classes and trees ≥ 5" dbh/drc with cover ≥ 50/60% | 5 | 40 | 8 | 5 | 5 |
| F | Upland dominance types, and various types dominated by exotic vegetation (occurs on contemporary landscapes only …) | 0 | 0 | 0 | 0 | 0 |
| Total | | 100 | 100 | 100 | 65 | 40 |

**Departure Index Rating† = 100 – ∑ similarity values: Gila NF = (100 – 65) = 35 or MODERATE; and Context Area = (100 – 40) = 60 or MODERATE**

‡ LANDFIRE 2005c; USDA FS 2016g

† Similarity value is the lesser of the two proportions (Gila NF to RC and Context Area to RC) for a seral state. Departure was calculated using the Czekanowski coefficient (Czekanowski 1913, as cited in Kent and Coker 1992, page 93)

† Departure index ratings from RC: 0 to 33% = Low, 34 to 66% = Moderate, and 67 to 100% = High

Departure is moderate across the context area, and for the Forest as a whole; while departure is moderate in the Lower Gila River where most of this ERU occurs, it is low in Mogollon Front (Figure 168).

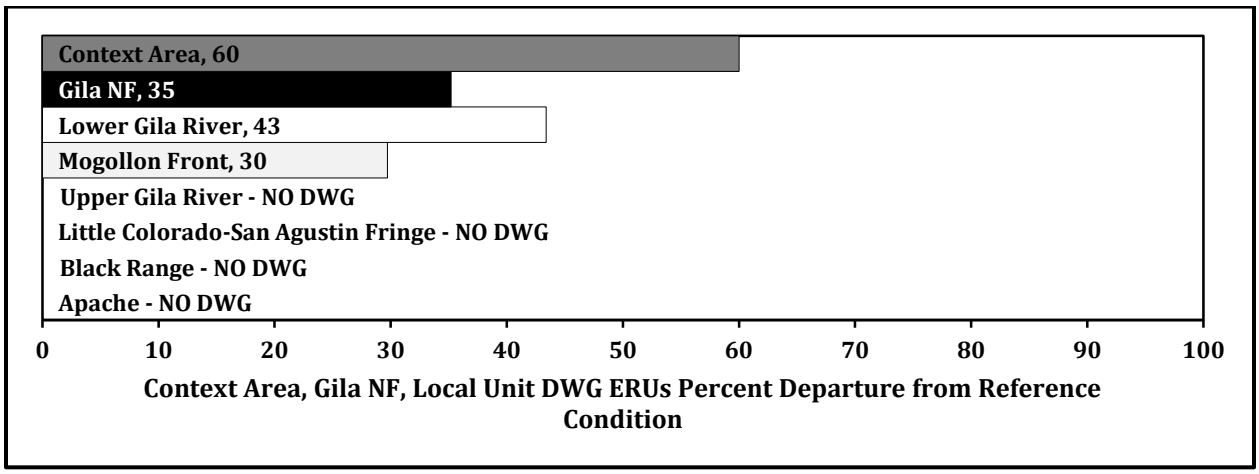



**Figure 168. Area-weighted variations in departure from reference condition for desert willow group at the context area, Forest and local unit scales**

## *Ecological Status*

Ecological status departure in Desert Willow is moderate. The TEUI documents less desert willow, Apache plume, netleaf hackberry and perennial grass species canopy cover under current conditions as opposed to reference, with an increase in oak and shrub species. This ERU is strictly associated with ephemeral channels at the lower end of the Forest's elevational-climatic gradient in the Lower Gila and Mogollon

Front local units. Although the vegetation present in this ERU is adapted to drier conditions, field observations not associated with the TEUI indicate recent years of drought have contributed to poor vigor and death in some instances.

### *Vegetative Groundcover*

According to the TEUI data, vegetative groundcover departure in the Desert Willow is low.

### *Vegetation Condition and Function*

With respect to vegetation condition and function, 26 percent of subwatersheds containing Desert Willow are Functioning Properly, 61 percent Functioning at Risk and 13 percent Impaired Function. Overall, there is moderate departure which is consistent with the Forest scale seral state proportion analysis and also a reflection of ecological status departure.

### *Channel Shape and Function*

With respect to channel shape and function, 13 percent of subwatersheds containing Desert Willow are Functioning Properly, 71 percent Functioning at Risk and 16 percent Impaired Function. Using the watershed condition classification, departure is moderate. That said, this truly does represent the limitations of using a watershed scale dataset at the ERU scale. Desert Willow depends mainly on subsurface water and is associated with ephemeral channels, which tend to be wide, open, sandy washes. These washes have naturally unstable banks and can transport relatively large volumes of sediment. Although many of these washes contain roads, or have been used for off-road vehicle travel, impacts to channel shape and function are minimal given the natural instability of the streambed and bank material. In reality, channel shape and function departure is low.

## Large Woody Debris

Large woody debris (LWD) is important for creating habitat in streams. Large wood influences channel shape and function, creates pools and waterfalls and affects channel width and depth. Many aquatic species use pools formed by large wood as habitat and for cover. These pools are particularly important in semi-arid regions, such as the Southwest, as they provide refugia for aquatic species during periods of low streamflow. The presence of large wood in streams contributes to slowing flood waters and affects patterns of transport and deposition of sediment and nutrients. LWD in the riparian zone also provides habitat for mammals, birds, reptiles, amphibians and insects. It is important to the cottonwood group, however, LWD does not carry the same degree of importance in all riparian and stream systems.

The LWD rating is associated with aquatic and riparian systems that evolved with wood near the streams and reflects the presence and continued recruitment of LWD at near natural rates. Subwatersheds rated as Functioning at Risk may still have LWD present, but it is not being recruited at natural rates due to riparian management activities. Impaired Function rating should contain wood, but no longer does resulting in poor riparian and aquatic conditions (Potyondy and Geier 2011). Because a LWD attribute rating was not considered applicable in more than 90 percent of subwatersheds, this ecosystem characteristic is analyzed for overall riparian acres, excluding the Herbaceous Riparian ERU, which did not evolve with wood near the streams. On an area weighted basis, approximately 63 percent of the Forest's riparian areas, in which large woody debris is an important component of riparian function, are rated Functioning Properly and 37 percent are Functioning at Risk. There are no Impaired Function ratings. This characteristic is considered to be in low departure overall.

## Flood Frequency

Floods of varying magnitudes have occurred throughout the reference and current time periods. Floods are a natural characteristic of streamflow, and are ecologically important to the condition and function of riparian and aquatic ecosystems. Flows important for maintaining floodplains are those that overflow the

channel banks and allow for soil moisture and local groundwater recharge, as well as redistribution and deposition of sediment. These flows are also important to defining channel shape. Flows important for regeneration of riparian species and maintenance of age-class diversity are those that remove older individuals and create conditions suitable for germination. Those conditions vary by species, but the timing between those flows and seed dispersal is critical. These flows also maintain the properties of the streambed material. (Gori et al. 2014; Naiman et al. 2005). Although there are other factors involved in the persistence of native fishes, natural flow regimes tend to favor native aquatic species over non-natives (Propst et al. 2008).

Peak FQ results (see Analysis Methods subsection near the beginning of this chapter) characterizing the full period of record at each gage are displayed in Table 147, which is followed by a discussion of departure and trend. Recall that flood flows are described in terms of return intervals, which describe the likelihood of a flood of a certain magnitude will occur. For example, a flood with a two year return interval has a 50 percent chance of occurring in any given year while a flood with a 100 year return interval has a one percent chance of occurring in any given year.

**Table 147. Magnitude and return interval for Mogollon Creek and the San Francisco, Gila and Mimbres Rivers, entire period of record**

| USGS Gage Name | Period of Record | 2-Year Return Interval (cfs) | 5-Year Return Interval (cfs) | 10-Year Return Interval (cfs) | 25-Year Return Interval (cfs) | 50-Year Return Interval (cfs) | 100-Year Return Interval (cfs) | 500-Year Return Interval (cfs) |
|---|---|---|---|---|---|---|---|---|
| San Francisco River near Reserve, NM | 1960-2014 | 774 | 2,041 | 3,504 | 6,397 | 9,573 | 13,890 | 30,370 |
| San Francisco River near Glenwood, NM | 1928-2014 | 2,627 | 6,420 | 10,190 | 16,630 | 22,770 | 30,180 | 53,150 |
| Mogollon Creek near Cliff, NM | 1968-2014 | 827 | 2,613 | 4,731 | 8,862 | 13,250 | 18,990 | 39,080 |
| Gila River near Gila, NM | 1928-2014 | 2,062 | 6,194 | 11,240 | 21,700 | 33,500 | 49,790 | 113,100 |
| Gila River near Redrock, NM | 1931-2014 | 5,952 | 13,090 | 19,370 | 28,960 | 37,260 | 46,480 | 71,590 |
| Mimbres River at Mimbres, NM | 1979-2012 | 570 | 1,793 | 3,140 | 5,549 | 7,893 | 10,730 | 19,400 |

The results of the PeakFQ modeling demonstrate a decline in the magnitude of flood flows associated with all return intervals over the current time period and the subset of the current time period at San Francisco near Reserve, Mimbres and Gila near Redrock. Post-2000 flows for the two year return interval are 11 percent of reference for San Francisco at Reserve, 25 percent of reference at Mimbres and 72 percent of reference at Gila near Redrock. The 25 year return interval is 18, 24 and 77 percent of reference and the 100 year return interval is 11, 26 and 78 percent of reference for each of these gages respectively.

In contrast to these three gages, the San Francisco near Glenwood, Gila near Gila and Mogollon Creek generally demonstrate an increasing trend in the magnitude of the flows associated with all return intervals except the two-year return interval. Changes in flow for this interval are mixed, and relatively small as opposed to the 48 to 55 percent increase associated with the 25 year return interval and the 56 to 61 percent increase associated with the 100 year return interval.

These results generally support the conclusions of the streamflow analysis presented in the Water Chapter and may have implications for flood frequency as an ecological process. Reductions or increases in the magnitude of the flows associated with return intervals might signal a departure from the flood frequency characteristics that native riparian systems are adapted to. However, some of this is likely due to the period of record at San Francisco near Reserve, Mimbres and Mogollon Creek gages as the reference time period includes only the relatively wet 1980s but does not include the drought of the 1950s. On the other hand, the Gila River Geomorphology Study, which included a flood frequency analysis, determined that the streamflow patterns at the San Francisco near Reserve could not be explained by precipitation (England 2002).

The Water Chapter also includes an analysis of monthly streamflow variables which demonstrates decreases in average streamflow in the winter and spring months (December-May) and a shift to earlier and shorter periods of peak snowmelt runoff. These changes have enormous ecological implications for riparian and aquatic systems. Recruitment of important vegetative components, like cottonwood, requires spring flood events be synchronized with seed dispersal. Changes in the timing of these floods also have implications for biological processes of many aquatic organisms.

There have been significant and widespread post-fire flood events over the last few years that have impacted riparian and aquatic communities. These impacts include changes in the abundance and composition of aquatic species and riparian vegetation, as well as changes in the physical characteristics of stream channels and patterns of streamflow. In some areas, benefits have been realized as non-native fish species did not survive the flooding, while native species did. In other areas, all fish, including natives, were removed from the stream system (Chapter 6 Water).

The removal of riparian vegetation due to fire induced changes in peak flows has negative, but potentially short-term impacts to stream temperatures and aquatic habitat. The duration of these impacts will depend on successful reestablishment of riparian vegetation communities. Reestablishment of willows has been observed in many areas. Additionally, changes in the physical characteristics of stream channels may represent long term alterations in streamflow and flood frequency. Considering the compounding factor of climate change, the reestablishment of riparian communities that resemble what existed previously, may or may not occur.

Table 148 displays departure in flood frequency for the Gila NF riparian ERUs and groups.

**Table 148. Departure in flood frequency for the Gila NF riparian ERUs and groups**

| Ecological Response Unit | Departure Category |
|---|---|
| Cottonwood Group ERUs | Moderate |
| Narrowleaf Cottonwood/Shrub | Moderate |
| Sycamore-Fremont Cottonwood | High |
| Fremont Cottonwood/Shrub | Moderate |
| Fremont Cottonwood-Oak | Moderate |
| Montane-Conifer Willow Group ERUs | Moderate |
| Arizona Alder-Willow | Moderate |
| Willow-Thinleaf Alder | Moderate |
| Ponderosa Pine/Willow | Moderate |
| Upper Montane Conifer/Willow | Low |
| Wetland (cienega) ERU | High |
| Herbaceous Riparian | High |
| Walnut-Evergreen Tree Group ERUs | Low |
| Arizona Walnut | Low |
| Walnut/Ponderosa Pine | Low |
| Desert Willow Group ERU | Low |
| Desert Willow | Low |

Flood frequency departure is low in those ERUs and groups associated with ephemeral channels. The primary reason it is low for the Upper Montane Conifer/Willow is that most of this ERU is located in the Headwaters East Fork Gila River watershed (5$^{th}$ level) which has seen some flow alterations since the Silver Fire, but not nearly to the extent of other watersheds. For streamside occurrences of the Herbaceous Riparian ERU where they occur in the wilderness, extents of high and moderate burn severity and post-fire alterations to streamflow are responsible for departure in flood frequency. However, most of the Herbaceous Riparian ERU is located outside wilderness areas and in the Apache local unit. Here, the causal factors for departure have been discussed in the analysis of other characteristics in that ERU. Likewise, the same factors that contribute to departure of other key characteristics in the remaining ERUs also contribute to departure in flood frequency.

## Riparian System Drivers and Stressors

Every system driver and stressor discussed within the System Drivers and Stressors chapter apply to riparian ecosystems and characteristics analyzed. Climate and streamflow are the primary system drivers. Streamflow is assessed as an ecosystem characteristic in the Water Chapter. The System Drivers and Stressors Chapter describes the historic and current status of the other system drivers and stressors, and their relationships with riparian ecosystems. This section identifies two additional drivers and stressors that are not discussed in that chapter: soil and upland watershed condition. Riparian soil is an additional system driver. Upland watershed condition can be a system driver or stressor depending on whether or not conditions are within the natural range of variability. This section focuses on describing the influence of soil and upland watershed condition on riparian characteristics.

Riparian soils are a system driver. Streamside riparian soils tend to have greater variability across space and time than upland soils because of the influence of streamflow. Sediment, organic matter and nutrients are deposited, redistributed or removed periodically as a result of flooding. This creates a three-dimensional mosaic of soils with different physical properties (e.g. soil texture and particle size class), and therefore different hydrologic properties (e.g. water holding capacity and infiltration capacity). The

hydrological properties of riparian soils are a major determiner of the potential natural community composition[46], vegetative establishment and colonization, nutrient cycling pathways, the amount and duration of water availability, streambank and channel stability, and groundwater recharge.

In general, erosion and sedimentation rates within Gila NF riparian zones are naturally greater than the rate of soil formation. This results in weakly developed soils that can also be highly productive because of the influx of nutrients and organic matter associated with floodwaters. The Herbaceous Wetland ERU is an exception to this generality as this ERU can be found in streamside environments, but also occurs as wet meadows in upland areas. Both of these environments typically produce well developed soils with considerable organic matter content. This is due to the greater natural stability of both streamside and upland occurrences of this ERU created by the dense, fibrous root systems characteristic of herbaceous riparian species. Landform and landscape position also contribute to greater natural stability of upland herbaceous wetlands.

Upland watershed condition is important to the stability, quality and abundance of riparian (and aquatic) ecosystems through its influence on the supply of sediment, water and nutrients to the streams along which riparian corridors exist (Brooks et al. 2003). It is a system driver when conditions are within the natural range of variability, and a stressor when it is outside that range. Watershed condition is analyzed as a key ecosystem characteristic in the Water Chapter.

## Risk

Risk to the ecological integrity of riparian ecosystem characteristics analyzed in this chapter is assessed for each ERU and group using the matrix displayed in Table 149

Table 149. Because there are no data to assess trend, risk is a direct interpretation of departure. Results of this risk assessment are displayed in Table 150, with “L” meaning low risk, “M” moderate risk, “H” high risk and “ND” meaning there was insufficient data to assess departure for that characteristic in that ERU or group. While not displayed in the risk results, a moderate or greater watershed vulnerability to climate change elevates risk one category. This is the case for all Gila NF watersheds (see System Drivers and Stressors Chapter).

**Table 149. Risk matrix for riparian ecosystem characteristics**

| Departure | Trend Toward Reference | Trend Unknown or Static | Trend Away from Reference |
|---|---|---|---|
| High | Risk Addressed | High Risk | Very High Risk |
| Moderate | Risk Addressed | Moderate Risk | High Risk |
| Low | Low Risk | Low Risk | Moderate Risk |

[46] Woody riparian vegetation such as cottonwood, willow, and sycamore prefer coarse textured soils that drain relatively quickly. Herbaceous riparian vegetation, such as sedges and rushes, tolerate longer periods of saturation and are typically associated with finer textured soils that have higher soil water holding capacities and do not drain as quickly.

**Table 150 . ERU and group risk by ecosystem characteristic**

| Ecological Response Unit and Riparian ERU Groups | Key Ecosystem Characteristic | | | | | |
|---|---|---|---|---|---|---|
| | Seral State Proportion | Ecological Status | Vegetative Groundcover | Vegetation Condition/ Function | Channel Shape and Function | Flood Frequency |
| **Cottonwood Group (CWG) ERUs** | M | M | M | M | M | M |
| Narrowleaf Cottonwood/Shrub | M | L | M | M | M | M |
| Sycamore-Fremont Cottonwood | M | M | M | M | M | H |
| Fremont Cottonwood/Shrub | M | M | M | M | M | M |
| Fremont Cottonwood-Oak | M | ND | ND | M | M | M |
| **Montane-Conifer Willow Group ERUs** | M | H | H | M | H | M |
| Arizona Alder-Willow | M | H | H | M | H | M |
| Willow-Thinleaf Alder | M | H | H | M | H | M |
| Ponderosa Pine/Willow | M | ND | ND | M | M | M |
| Upper Montane Conifer/Willow | M | M | H | M | H | M |
| **Wetland (cienega) Group ERU** | | | | | | |
| Herbaceous Riparian | L | M-H | H | M | M-H | H |
| **Walnut-Evergreen Tree Group ERUs** | M | L | L | M | M | L |
| Arizona Walnut | M | L | L | M | M | L |
| Walnut/Ponderosa Pine | M | ND | ND | M | M | L |
| **Desert Willow Group ERU** | | | | | | |
| Desert Willow | M | M | L | M | L | L |

Seral state proportion is the only ecosystem characteristic analysis that relies on data that can and did assess departure at the local unit scale. Seral state proportion risk for the local units and the Forest as a whole are assessing the same risk matrix used for the ERU and groups (Table 149). “None” indicates that particular ERU does not occur within that particular local unit. These results are displayed in the table below (Table 151).

**Table 151. Seral state proportion risk by local unit**

| Local Unit and Key Ecosystem Characteristic | Risk Rating | | | | |
|---|---|---|---|---|---|
| | Cottonwood Group | Montane - Conifer Willow Group | Wetland (Ciénega) Group | Walnut-Evergreen Tree Group | Desert Willow Group |
| **Apache** | M | M | L | M | None |
| **Little Colorado Headwaters-San Agustin Fringe** | M | M | L | None | None |
| **Mogollon Front** | M | M | H | L | L |
| **Black Range** | M | M | M | M | None |
| **Upper Gila River** | M | M | M | M | None |
| **Lower Gila River** | M | M | L | M | M |
| **Gila NF** | M | M | L | M | M |

Because fire frequency departure was not able to be calculated given the sparse information in the scientific literature regarding a reference condition for that characteristic, risk is not analyzed beyond the ERU or group. For the remaining characteristics, risk is assessed using the same matrix (Table 149) and displayed by the percent of each local unit and the Forest within each risk category. These results are displayed in the table below (Table 152).

**Table 152. Local unit and Forest risk for ecosystem characteristics other than seral state proportion**

| Ecosystem Characteristic | Local Unit and Percent in each Risk Category (L=Low, M=Moderate, H=High) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apache | | | Little Colorado Headwaters-San Agustin Fringe | | | Mogollon Front | | | Black Range | | | Upper Gila River | | | Lower Gila River | | | Gila NF | | |
| | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H | L | M | H |
| Ecological Status | 56 | 6 | 24 | 88 | 7 | 4 | 29 | 62 | 7 | 82 | 13 | 5 | 40 | 19 | 41 | 28 | 67 | 3 | 48 | 39 | 12 |
| Vegetative Groundcover | <1 | 60 | 24 | 0 | 96 | 4 | 22 | 70 | 7 | 4 | 91 | 5 | 1 | 57 | 41 | 59 | 35 | 3 | 19 | 67 | 12 |
| Vegetation Condition/ Function | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 0 |
| Channel Shape and Function | 0 | 76 | 24 | 0 | 86 | 14 | 16 | 76 | 8 | 0 | 95 | 5 | 0 | 58 | 42 | 57 | 39 | 4 | 17 | 71 | 13 |
| Flood Frequency | 35 | 36 | 29 | 56 | 19 | 25 | 27 | 36 | 38 | 49 | 11 | 40 | 0 | 100 | 0 | 44 | 55 | 1 | 34 | 50 | 19 |
| Large Woody Debris | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 63 | 37 | 0 |

Note: Where percents to not equal 100 is indicative of an ERU that did not have data to describe that particular characteristic

## Stakeholder Input

Riparian resources area of great concern to the Gila NF and the public. Community members hold diverse perceptions of what healthy riparian systems should be like, but is largely united in their belief that the Forest is neglecting and/or mismanaging these areas. Most of the public input received during the assessment on the riparian topic was focused on livestock grazing effects, although some are concerned about negative impacts resulting from roads, recreation, fire, poor upland watershed conditions, streamflow diversions and other constructed features along streams that support riparian communities. Salt cedar is also a concern.

There are those that believe that our riparian areas have been damaged by the exclusion of livestock and are concerned that overgrown vegetation negatively effects the ability of water to move downstream and the ability of wildlife to navigate along the stream corridor. They have observed a decrease in species diversity, reduced aesthetics, and an increase of fire danger. Some believe that excluding riparian areas from livestock is not justified, scientifically or otherwise. Others point to the ability of sound grazing practices to invigorate riparian vegetation.

On the other hand, there are those that believe all riparian areas should be excluded from livestock grazing and motorized travel because these activities reduce ecological and aesthetic values. They have observed an improvement in riparian areas that have been excluded. However, some believe the Gila NF has been negligent in riparian monitoring, maintaining exclosures and enforcing the rules. Others recognize a connection between upland watershed management and riparian conditions, but do not believe that the Forest adequately recognizes this connection. Setbacks related to post-fire effects, climate change and related changes in streamflow have been observed. There is also concern about negative impacts to riparian communities resulting from an Arizona Water Settlement Act diversion, including the loss of the natural flooding regime.

## Data Gaps

Despite the ecological importance of riparian areas, the Forest has relatively little on the ground inventory and/or monitoring data related to key ecosystem characteristics of riparian. Such monitoring data could better inform management of these areas and provide a means for evaluating whether management is contributing to ecological integrity and sustainability, or not.

## Summary

This assessment reviews the best available information at watershed, ERU, and Forest levels, as well as the broader landscape, to assess the ecological integrity of the Forest's riparian resources under current Forest Plan direction. Ecosystem integrity was assessed by evaluating key characteristics including: seral state proportion (vegetation structure), ecological status (vegetation composition), vegetation condition (function), vegetative groundcover (function), channel shape and function (function and connectivity), large woody debris (function), and flood frequency (process).

These areas on the Gila NF are a focal point for humans, terrestrial wildlife, and livestock activities, as well as species that are obligate-dependence on wetland, riparian and aquatic habitats. Therefore, both demand and impacts are high. Under the current climatic regime and Forest management, risk to riparian ecological integrity ranges from low to high, with most characteristics being at moderate risk at most scales. Primary stressors that have compromised the ecological integrity of riparian resources are altered fire regimes, upland watershed condition, as a result of high and moderate severity fire, and associated alterations in streamflow and flood frequency. Roads and trails and herbivory are also factors contributing risk.

Climate change is an emerging stressor that elevates this risk, making what was a moderate risk into a high risk. Because of the scarcity of water resources in the Southwest, the Forest has a major responsibility for management and maintenance of the ecological integrity and sustainability of these systems. Local, state and regional demand for water, coupled with climate change increases risk associated with Forest water resources, and therefore riparian ecosystems. While climatic conditions, drought and water allocation are outside the scope of Forest management, the Forest can look for opportunities to monitor climate change influences and reduce the risk to riparian ecosystems by considering the key characteristic status identified at the project level. Riparian systems that have high ecological integrity are more resistant and resilient to natural and human caused disturbances, or alterations in those disturbance regimes.

# Chapter 8. At-Risk Species

## Introduction

This chapter focuses on identifying federally recognized threatened, endangered, proposed, and candidate species, as well as potential species of conservation concern (SCC). Additionally, these species will be evaluated to determine conditions and trends of species and their habitat, as well as risk to persistence on the Gila NF. This chapter also documents information gaps relevant to at-risk species that may be filled through inventories, plan monitoring, or research. Other species of interest on the Gila NF, such as popular game species, are addressed in Chapter 11. Multiple Uses and their Economic Contributions.

Under the National Forest Management Act, the Forest Service is directed to:

> *"provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet multiple-use objectives, and within the multiple-use objectives of a land management plan adopted pursuant to this section [of this Act], provide, where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan."* (NFMA, 16 U.S.C. 1604(g)(3)(B))

To meet this objective, the 2012 Planning Rule adopts a complementary ecosystem and species- specific approach to maintaining species diversity, known as coarse-filter/fine-filter (36 CFR § 219.9). The premise behind this approach is that native species evolved and adapted within limits established by natural landforms, vegetation, and disturbance patterns prior to extensive human alteration. Therefore, maintaining or restoring ecological conditions and functions similar to those under which native species evolved, offers the best assurance against losses of biological diversity and maintains habitats for the majority of species in an area. However, for some species, this approach may not be adequate, either because the reference condition is not achievable or non-habitat risks to species viability.

The fine-filter approach recognizes that for some species, ecological condition or additional specific habitat features (key ecosystem characteristics) are required, and these may not be met by the coarse-filter approach. To determine which animal and plant species may require this approach, the Gila NF has identified federally listed threatened, endangered, proposed, and candidate species and developed a list of potential SCC that occur within the plan area. This list will be used to develop specific plan components that ensure continued species diversity in the plan area. Maintaining species that are vulnerable to decline within the Gila NF will maintain diversity on the Forest and thus, comply with the NFMA diversity requirement.

Plant and animal species are highly dependent on the function of ecosystems with specific conditions, such as local soil, air, water, aspect, elevation, precipitation, etc., which create areas favorable for particular species. The most important direct drivers of biodiversity loss and ecosystem service changes are habitat change (e.g., land use changes, physical modification of rivers, or water withdrawal from rivers), climate change, invasive species, overexploitation, and pollution (MEA 2005). This chapter builds on reference and current ecological conditions of other terrestrial and aquatic ecological resources assessed in this plan. It relies heavily on descriptions of current ecological conditions described within the terrestrial vegetation types, known as ecological response units (ERUs) (Ecological Integrity Chapter 1), on the Gila NF and the Integration and Risk Assessment of these ERUs. Additional information can be found in the Upland Vegetation (Chapter 2) and Riparian Vegetation (Chapter 7) chapters of this assessment report.

## Federally Recognized Species

The Endangered Species Act (Act; 16 U.S.C. Sec. 1531-1544), administered by the U.S. Fish and Wildlife Service (FWS), recognizes imperiled species and provides for their protection and recovery. Table 153 identifies the 12 federally endangered, 10 threatened, two proposed threatened species, one candidate species, and two experimental non-essential population species listed for the four counties (Catron, Grant, Hidalgo, and Sierra) of the Gila NF (USDI FWS 2016). However, only four endangered species (Southwestern willow flycatcher, Gila chub, Loach minnow, and Spikedace), one non-essential experimental species (Mexican gray wolf), seven threatened species (Chiricahua leopard frog, Mexican spotted owl, Yellow-billed cuckoo, Chihuahua chub, Gila trout, Narrow-headed gartersnake, and Northern Mexican gartersnake), and two proposed threatened species (Headwater chub and Roundtail chub) are found within the planning area.

Eight endangered (Least tern, Gila topminnow, Rio Grande silvery minnow, Todsen's pennyroyal, Jaguar, Lesser long-nosed bat, Mexican long-nosed bat, and New Mexico meadow jumping mouse), three threatened (Beautiful shiner, Zuni fleabane, and New Mexican ridge-nosed rattlesnake), the one candidate species (Sprague's Pipit), and one experimental non-essential species (Northern Aplomado falcon) are listed for the four counties, but do not occur on the Gila NF and will not be carried forward in the assessment analysis. In the case of the Gila topminnow and beautiful shiner, these two species have been completely removed and no longer occur on the Gila NF.

Section 4 of the Endangered Species Act requires the FWS to identify and protect all lands, water, and air necessary to recover an endangered species; this is known as critical habitat. Critical habitats are areas that are needed for life processes, including space for individual and population growth and for normal behavior; cover or shelter; food, water, air; light, minerals, or other nutritional or physiological requirements; sites for breeding and rearing offspring; and habitats that are protected from disturbances or are representative of historical geographical and ecological distributions of a species. The Chiricahua leopard frog, Mexican spotted owl, southwestern willow flycatcher, Gila chub, Loach minnow, and Spikedace have final designated critical habitat, while Yellow-billed cuckoo, Narrow-headed gartersnake, and Northern Mexican gartersnake all have proposed critical habitat designated on the Gila NF. Critical habitat is described more in Chapter 13 Designated Areas.

Section 7 of the Endangered Species Act requires federal agencies to ensure actions they authorize, fund, or carry out are not likely to destroy or adversely modify designated critical habitat. Section 7 of the Act also requires that any federal agency that carries out, permits, licenses, funds, or otherwise authorizes activities that may affect a listed species must consult with the Fish and Wildlife Service to ensure that its actions are not likely to jeopardize the continued existence of any listed species.

**Table 153. Federally listed threatened or endangered species listed for the four-county area (Catron, Grant, Hidalgo, and Sierra) of the Gila National Forest.**

Note: An asterisk (*) denotes species carried forward as federally listed species for the Gila NF.

| Common Name | Scientific Name | Federal Status | Critical Habitat on Gila NF |
|---|---|---|---|
| **Amphibians and Reptiles** | | | |
| Chiricahua leopard frog* | *Lithobates chiricahuensis* | Threatened | Yes |
| Narrow-headed gartersnake* | *Thamnophis rufipunctatus* | Threatened | Proposed |

| Common Name | Scientific Name | Federal Status | Critical Habitat on Gila NF |
|---|---|---|---|
| New Mexican ridge-nosed rattlesnake | *Crotalus willardi obscurus* | Threatened | No |
| Northern Mexican gartersnake* | *Thamnophis eques megalops* | Threatened | Proposed |
| **Birds** | | | |
| Least tern | *Sterna antillarum* | Endangered | No |
| Mexican spotted owl* | *Strix occidentalis lucida* | Threatened | Yes |
| Northern aplomado falcon | *Falco femoralis septentrionalis* | Experimental population , Non-essential | No |
| Southwestern willow flycatcher* | *Empidonax traillii extimus* | Endangered | Yes |
| Sprague's pipit | *Anthus spragueii* | Candidate | No |
| Western yellow-billed cuckoo* | *Coccyzus americanus occidentalis* | Threatened | Proposed |
| **Fishes** | | | |
| Beautiful shiner | *Cyprinella formosa* | Threatened | No |
| Chihuahua chub* | *Gila nigrescens* | Threatened | No |
| Gila chub* | *Gila intermedia* | Endangered | Yes |
| Gila topminnow | *Poeciliopsis occidentalis* | Endangered | No |
| Gila trout* | *Oncorhynchus gilae* | Threatened | No |
| Headwater chub* | *Gila nigra* | Proposed Threatened | No |
| Loach minnow* | *Tiaroga cobitis* | Endangered | Yes |
| Rio Grande silvery minnow | *Hybognathus amarus* | Endangered | No |
| Roundtail chub* | *Gila robusta* | Proposed Threatened | No |
| Spikedace* | *Meda fulgida* | Endangered | Yes |
| **Flowering Plants** | | | |
| Todsen's pennyroyal | *Hedeoma todsenii* | Endangered | No |
| Zuni fleabane | *Erigeron rhizomatus* | Threatened | No |
| **Mammals** | | | |

| Common Name | Scientific Name | Federal Status | Critical Habitat on Gila NF |
|---|---|---|---|
| Mexican Gray wolf* | *Canis lupus baileyi* | Experimental, Non-Essential population | No |
| Jaguar | *Panthera onca* | Endangered | No |
| Lesser long-nosed bat | *Leptonycteris curasoae yerbabuenae* | Endangered | No |
| Mexican long-nosed bat | *Leptonycteris nivalis* | Endangered | No |
| New Mexican meadow jumping mouse | *Zapus hudsonius luteus* | Endangered | No |

## Potential Species of Conservation Concern

A species of conservation concern (SCC) is defined in the 2012 Planning Rule as "a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The guidance provided in the final directives for the 2012 planning regulations (Forest Service Handbook [FSH] 1909.12 – Land Management Planning, Chapter 10) is used to develop the SCC list for the Gila NF.

1. All potential SCCs ***must meet*** the following mandatory requirements for their identification as SCC:
   - The species is native to, and known to occur in, the plan area. A species is known to occur in a plan area if, at the time of plan development, the best available scientific information indicates that a species is established or is becoming established in the plan area.
   - The best available scientific information about the species indicates substantial concern about the species' capability to persist over the long term in the plan area. See FSH 1909.12, zero code, section 07, for guidance on best available scientific information.

2. A species ***should not*** be identified as a potential SCC if:
   - The species is secure and its continued long-term persistence in the plan area is not at risk based on knowledge of its abundance, distribution, lack of threats to persistence, trends in habitat, or responses to management.
   - There is insufficient scientific information available to conclude there is a substantial concern about a species' capability to persist in the plan area over the long-term that species cannot be identified as a species of conservation concern.
   - Its occurrence is thought to be "accidental," well outside its current range. A species with an individual occurrences in a plan area that are merely "accidental" or "transient," or are well outside the species' existing range at the time of plan development, is not established or becoming established in the plan area. If the range of a species is changing so that what is becoming its "normal" range includes the plan area, an individual occurrence should not be considered transient or accidental.

### Species to Consider when Identifying Potential Species of Conservation Concern

1. Species native to and known to occur in the planning area.

2. Species in the following categories must be considered:
   a. Species with status ranks of G/T1 or G/T2 on the NatureServe ranking system (see below). These species are expected to be included unless it can be demonstrated and documented that known threats for these species are not currently present or relevant in the plan area.

   b. Species that were removed within the past 5 years from the Federal list of threatened or endangered species, and other delisted species that the regulatory agency still monitors.

3. Species in the following categories should be considered:
   a. Species with status ranks of G/T3 or S1 or S2 on the NatureServe ranking system (see below).

b. Species listed as threatened or endangered by relevant States, federally recognized Tribes, or Alaska Native Corporations.

c. Species identified by Federal, State, federally recognized Tribes, or Alaska Native Corporations as a high priority for conservation

d. Species identified as species of conservation concern in adjoining National Forest System plan areas (including plan areas across regional boundaries).

e. Species that have been petitioned for Federal listing and for which a positive"90-day finding" has been made.

f. Species for which the best available scientific information indicates there is local conservation concern about the species' capability to persist over the long-term in the plan area due to:

    i. Significant threats, caused by stressors on and off the plan area, to populations or the ecological conditions they depend upon (habitat). These threats include climate change.

    ii. Declining trends in populations or habitat in the plan area.

    iii. Restricted ranges (with corresponding narrow endemics, disjunct populations, or species at the edge of their range).

    iv. Low population numbers or restricted ecological conditions (habitat) within the plan area.

## NatureServe Conservation Status Ranks

NatureServe conservation status ranks are based on a scale of one to five, ranging from critically imperiled (G1) to demonstrably secure (G5). Status is assessed and documented at three distinct geographic scales–global (G), national (N), and State/province (S). The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (Table 154). (http://www.natureserve.org/explorer/ranking.htm).

**Table 154. NatureServe Ranking Descriptions**

| Status Rank | Status Rank Definition |
|---|---|
| 1 | Species is Critically Imperiled<br>At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors. |
| 2 | Species is Imperiled<br>At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors. |
| 3 | Species is Vulnerable<br>At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors. |
| 4 | Species is Apparently Secure<br>At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors. |
| 5 | Species is Secure<br>At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats. |
| Infraspecific taxa refer to subspecies, varieties, and other designations below the level of the species. The status of infraspecific taxa (subspecies or varieties) are indicated by a T-rank following the species' global rank. Rules for assigning T-ranks follow the same principles outlined above. For example, the global rank of a critically imperiled subspecies of an otherwise widespread and common species would be G5T1.<br>Migratory bird species are assigned a B or N-rank as part of their state (S) rank. B refers to "Breeding" and N refers to "Non-breeding" populations. For example, the rank of a species that is globally common but migratory and commonly only winters in the state would have a rank of G5/S1B,S4N. | |

## Evaluating Relevant Information for At-Risk Species

Potential species of conservation concern were evaluated and information on each species was gathered and evaluated from several sources representing the Best Available Scientific Information (BASI) to determine risk to each species. Both the Planning Rule and final directives mandate the use of BASI for each resource parameter evaluated in this assessment.

According to NatureServe (NatureServe 2015), there are more than 7,000 unique animal, plant, and fungi species found in New Mexico. In developing the Gila NF potential SCC list, species records were exported from NatureServe for all species occurring in the four counties (Catron, Grant, Hidalgo, and Sierra) in which the Gila NF occurs. Species with status ranks of G or T 1, 2, or 3 and S 1 and 2 are species that have been identified by state natural heritage programs, the U.S. Fish and Wildlife Service, the International Union for Conservation of Nature, the Canadian Wildlife Service, and others as facing possible risk of extinction. To this list, we also included:

- Species that are identified as recently delisted or have a positive 90-day finding in New Mexico by the USFWS;
- Species listed as threatened or endangered by New Mexico Department of Game and Fish (NMDGF) (BISON-M 2015) and State Forestry Division (NM EMNRD 2015a);

- Species on the Southwestern Regional Forester's Sensitive Species List (USDA FS 2013c);
- Species identified as those of greatest conservation need by the New Mexico Comprehensive Wildlife Conservation Strategy (NMDGF 2006, 2016b);
- Rare plants as identified by the New Mexico Rare Plants Technical Council (NMRPTC 1999);
- Birds of Conservation Concern List by the USFWS (USDI FWS 2015a);

This list of approximately 1,266 species formed the initial basis of the potential SCC list within the four counties in which the Gila NF occurs, and was comprised of 332 vascular and non-vascular plants, 390 invertebrates, and 544 vertebrates, which included 20 amphibians, 54 reptiles, 54 fish, 99 mammals, and 317 birds.

The next part of the process involved removing species with rankings of G/T 4 or 5, and S 3-5 from the potential SCC list, unless the species was listed as state threatened or endangered. Then we identified which of these species actually occur on the Gila NF (FSH 1909.12, 12.52c (1)). Where possible, published location information was used to filter out species that were not reported within the Gila NF itself.

Internal databases (USDA FS 2014b), breeding bird species survey data (Shook et al. 2015), and museum databases, including Arctos Collection Management Information System (Arctos 2016), Biota Information System of New Mexico (BISON-M 2016), Breeding Bird Survey data (Sauer et al. 2014); Natural Heritage New Mexico (Natural Heritage NM 2016), NatureServe (2016), New Mexico Rare Plant Technical Council (NMRPTC 1999), Southwest Environmental Information Network (SEINet 2016) were queried for Forest-specific observations.

In addition to the databases and lists cited above, Forest Service biologists at the Gila NF Supervisor's Office and ranger districts, as well as the Southwestern Regional Office were consulted in the development of the potential SCC list. Subject matter experts were interviewed via personal communications. Staff at Natural Heritage New Mexico (R. McCollough); New Mexico Department of Game and Fish (C. Hayes, J. Dominguez, K. Rodden, D. Propst (retired)); New Mexico State Forestry Division state botanist (D. Roth); Western New Mexico University (R. Jennings, D. Zimmerman Emeritus Professor); U.S. Fish and Wildlife Service (M. Christman); and others were able to review internal records and databases or rely on agency specialists to further filter the list.

While compiling relevant species information, several sources of data that appeared to fill gaps in the BASI were encountered. Citizen science is a growing movement in conservation and allows volunteers to collect and submit data to online databases including eBird (eBird 2016), iNaturalist (iNaturalist 2016), and BugGuide.Net (BugGuide 2016). These resources were used where it was possible to verify observations.

For highly visible and high-interest species information (e.g. birds), reliable collections and observation data were readily available. Additionally, the current Forest Plan requires monitoring for management indicator species, Region 3 sensitive species, and federally listed species. For many other species, however, this information was simply not available. In many cases there was little known about species (life history, habitat needs, etc.), other than they occur on the Gila NF. This lack of information pertained primarily to insect species such as a mayfly (*Leucrocuta petersi*) and a notodontid moth (*Oligocentria delicata*) which were not carried forward. There were also species not carried forward since they were thought to be "vagrants", or birds that stray far outside of their expected breeding, wintering, or migrating range so that they are considered accidental, such as elegant trogon (*Trogon elegans*) and Harris's hawk (*Parabuteo unicinctus*).

From the initial 1,266 potential SCC identified for the four county area encompassing the Gila NF, and several species listed by the State of New Mexico, 99 species are reliably documented on the Gila NF and meets one or more criteria for potential SCC in the directives (Table 155).

**Table 155. Species known to occur in the plan area and carried forward for consideration as potential species of conservation concern.**

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| **Amphibians** | | | |
| Arizona toad | *Anaxyrus microscaphus* | CN, RF, G4/S2? | Ryan et al. 2015 |
| **Birds** | | | |
| Abert's Towhee | *Melozone aberti* | CN, G3G4/S1B,S1N, RF, S | Natural Heritage NM 2015, BISON-M 2016, Shook et al. 2015 |
| American Goldfinch | *Spinus tristis* | G5/S2B,S5N | NatureServe 2016, BISON-M 2016 |
| American Peregrine Falcon | *Falco peregrinus anatum* | CN, G4T4/S2B,S3N, RF, S | USDA FS Gila NF 2016a, Natural Heritage NM 2015 |
| Bald Eagle | *Haliaeetus leucocephalus* | CN, G5/S1B,S4N, RF, S | USDA FS Gila NF, 2016a |
| Bank Swallow | *Riparia riparia* | CN, G5/S2B,S5N | BISON-M 2016 |
| Bell's Vireo | *Vireo bellii* | CN, G5/S2B,S3N, RF, S | Natural Heritage NM 2015, Shook et al. 2015 |
| Black Swift | *Cypseloides niger* | CN, G4/S2B,S2N | BISON-M 2016, NatureServe 2016 |
| Blue-throated Hummingbird | *Lampornis clemenciae* | G5/S2B,S2N | BISON-M 2016, NatureServe 2016 |
| Common Blackhawk | *Buteogallus anthracinus* | CN, G4G5/S2B,S3N, RF, S | BISON-M 2016, Natural Heritage NM 2015, USDA FS Gila NF 2016a, Sauer et al. 2014 |
| Eastern bluebird | *Sialia sialis* | G5/S2B,S2N | BISON-M 2016, NatureServe 2016 |

[47] CN = Identified as a species of greatest conservation need in the New Mexico Comprehensive Wildlife Conservation Strategy Report; PF= Federally petitioned for listing; NatureServe Ranking - Global (G), Taxonomic (T), State (S), Breeding (B), Non-breeding (N), Not Ranked (NR), or Uncertainty on ranking (?); RF = Regional Forester's Sensitive Species List; and S = State-listed as threatened or endangered. NatureServe codes futher described in Table 154.

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Ferruginous Hawk | *Buteo regalis* | CN, G4/S2B,S4N | BISON-M 2016 |
| Gila Woodpecker | *Melanerpes uropygialis* | CN, G5/S2B,S2N, RF, S | Natural Heritage NM 2015, NatureServe 2016, Sauer et al. 2014, Shook et al. 2015 |
| Lincoln's Sparrow | *Melospiza lincolnii* | G5/S2B,S5N | NatureServe 2016, BISON-M 2016 |
| Marsh Wren | *Cistothorus palustris* | G5/S1B,S5N | NatureServe 2016, BISON-M 2016 |
| Northern Goshawk | *Accipiter gentilis* | CN, G5/S2B,S3N, RF | NatureServe 2016, Natural Heritage NM 2015, USDA FS Gila NF 2016a, Shook et al. 2015 |
| Northern Harrier | *Circus cyaneus* | CN, G5/S2B,S5N | NatureServe 2016, BISON-M 2016 |
| Osprey | *Pandion haliaetus* | CN, G5/S2B,S4N | NatureServe 2016, BISON-M 2016 |
| Ring-necked Duck | *Aythya collaris* | G5/S1B,S4N | NatureServe 2016, BISON-M 2016 |
| Savannah Sparrow | *Passerculus sandwichensis* | G5/S2B,S5N | NatureServe 2016, BISON-M 2016 |
| Wilson's Phalarope | *Phalaropus tricolor* | CN, G5/S2B,S4N | NatureServe 2016, BISON-M 2016 |
| Wilson's Warbler | *Cardellina pusilla* | G5/S2B,S4N | NatureServe 2016, BISON-M 2016 |
| **Fish** | | | |
| Desert Sucker | *Catostomus clarkii* | CN, G3G4/S2, RF | USDA FS Gila NF 2016a, Natural Heritage NM 2015, NMED SWQB 2015c, NatureServe 2016, FishNET 2015 |
| Rio Grande cutthroat trout | *Oncorhychus clarkii virginalis* | CN, G4/T3/S2, RF | USDA FS Gila NF 2016a, Natural Heritage NM 2015, NMED SWQB 2015c, NatureServe 2016, FishNET 2015 |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Rio Grande sucker | *Catostomus plebeius* | CN, G3G4/S2, PF, RF | USDA FS Gila NF 2016a, Natural Heritage NM 2015, NMED SWQB 2015c, NatureServe 2016, FishNET 2015 |
| Sonora Sucker | *Catostomus insignis* | CN, G3G4/S2, RF | USDA FS Gila NF 2016a, Natural Heritage NM 2015, NMED SWQB 2015c, NatureServe 2016, FishNET 2015 |
| **Invertebrates** | | | |
| "Gila" May Fly | *Lachlania dencyanna* | CN, G1/SNR, RF | NatureServe 2016, BISON-M 2016 |
| A Stonefly | *Capnia caryi* | CN, G1/SNR, RF | NatureServe 2016, BISON-M 2016, Bauman and Jacobi 2002 |
| Arizona Snaketail | *Ophiogomphus arizonicus* | CN, G2G3/SNR | NatureServe 2016, BISON-M 2016, IUCN 2016 |
| Bearded Mountainsnail | *Oreohelix barbata* | CN, G1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Black Range Mountainsnail | *Oreohelix metcalfei acutidiscus* | CN, G2/T1/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Black Range Mountainsnail | *Oreohelix metcalfei hermosensis* | CN, G2/T1T2/SNR | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Black Range Woodlandsnail | *Ashmunella cockerelli* | G1/T1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Cockerell Holospira Snail | *Holospira cockerelli* | CN, G1/S1 | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Cross Snaggletooth | *Gastrocopta quadridens* | G2G3/S4 | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Dashed Ringtail | *Erpetogomphus heterodon* | CN, G2G4/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, IUCN 2016 |
| Dry Creek Woodlandsnail | *Ashmunella tetrodon tetrodon* | G3/T3/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Four-spotted Skipperling Skipper | *Piruna polingii* | CN, G3/SNR | Natural Heritage NM 2016, BISON-M 2016, NatureServe 2016, Zimmerman 2001 |
| Gila Springsnail | *Pyrgulopsis gilae* | CN, G2/S2, RF, S | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, IUCN 2016, USDA FS Gila NF 2016a |
| Iron Creek Woodlandsnail | *Ashmunella mendax* | CN, G1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Marsh Slug Snail | *Deroceras heterura* | CN, G1G2/SNR | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Mineral Creek Mountainsnail | *Oreohelix pilsbryi* | CN, G1/S1, RF, S | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Morgan Creek Mountainsnail | *Oreohelix swopei* | G1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| New Mexico Hot Springsnail | *Pyrgulopsis thermalis* | CN, G1/S1, RF, S | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, IUCN 2016, USDA FS Gila NF 2016a |
| Nitrocris Fritillary Butterfly | *Speyeria nokomis nitocris* | CN, G3/T3/SNR | Natural Heritage NM 2016, BISON-M 2016, NatureServe 2016, Zimmerman 2001 |
| No Common Name Snail | *Ashmunella cockerelli argenticola* | G1/T1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| No Common Name Snail | *Ashmunella cockerelli perobtusa* | G1/T1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| No Common Name Snail | *Ashmunella tetrodon animorum* | G3/T3/S3, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| No Common Name Snail | *Ashmunella tetrodon inermis* | G3/T2/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| No Common Name Snail | *Ashmunella tetrodon mutator* | G3/T2/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| No Common Name Snail | *Oreohelix metcalfei radiata* | CN, G2/T2/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| No Common Name (Black Range mountainsnail) | *Oreohelix metcalfei concentrica* | CN, G2/SNR, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Silver Creek Woodlandsnail | *Ashmunella binneyi* | CN, G1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Sonoran Snaggletooth Snail | *Gastrocopta prototypus* | CN, G1/SNR | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| Stonefly | *Taenionema jacobii* | CN, G2/SNR | NatureServe 2016, BISON-M 2016, Stewart 2009 |
| Tiger Moth | *Alexicles aspersa* | CN, G1G2/SNR | NatureServe 2016, BISON-M 2016, Metzler 2014 |
| Whitewater Creek Woodlandsnail | *Ashmunella danielsi* | G1/S1, RF | Natural Heritage NM 2015, BISON-M 2016, NatureServe 2016, Metcalfe and Smartt 1997 |
| **Plants** | | | |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Cliff Brittlebush | *Apacheria chiricahuensis* | G2/S2 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Davidson's Cliff Carrot | *Pteryxia davidsonii* | G2/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Gila Thistle | *Cirsium gilense* | G3G5Q/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Goodding's Bladderpod | *Lesquerella gooddingii* | G3?/S3 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Gooding's Onion | *Allium gooddingii* | G4/S1, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Greene Milkweed | *Asclepias uncialis* ssp. *uncialis* | G3G4/T2T3/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Heartleaf Groundsel | *Packera cardamine (=Senecio cardamine)* | G3/S3, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Hess's Fleabane | *Erigeron hessii* | G1/S1, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Horned Spurge | *Euphorbia brachycera* | G5/S2 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Metcalfe's Groundsel | *Packera neomexicana* var. *metcalfei* | G5/T3?Q/S3? | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Metcalfe's Penstemon | *Penstemon metcalfei* | G1/S1, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Mimbres Figwort | *Scrophularia macrantha* | G2/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Mogollon Clover | *Trifolium neurophyllum* | G2/S2 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Mogollon Death Camas | *Zigadenus mogollonensis* | G3/S3 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Mogollon Hawkweed | *Hieracium brevipilum (=H. fendleri* var. *mogollense)* | G4/T2?/S2?, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Mogollon Whitlowgrass (Draba) | *Draba mogollonica* | G3/S3 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Mt. Graham Beardtongue | *Penstemon deaveri* | G3?/S3? | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| New Mexican Gumweed | *Grindelia arizonica* var. *neomexicana* | G4/T3?/SNR | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| New Mexico Groundsel | *Packera quaerens* | G2/S2 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Nutrioso Milkvetch | *Astragalus nutriosensis* | G3?/SNR | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999, Isely 1998 |
| Pinos Altos Flame Flower | *Talinum humile* | G2/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Porsild's Starwort | *Stellaria porsildii* | G1/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Silver Mock Orange | *Philadelphus argenteus* | G5?Q/S1? | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Threadleaf Giant-hyssop | *Agastache rupestris* | G3?/S3? | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Villous Groundcover Milkvetch | *Astragalus humistratus* var. *crispulus* | G4G5/T3?/SNR, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| White Mountain Groundsel | *Packera cynthioides* | G3?/S3? | NatureServe 2016, SEINet 2016, NMRPTC 1999 |
| Winn Falls Fleabane | *Erigeron scopulinus* | G3?/S3? | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |

| Common Name | Scientific Name | Rationale for Consideration[47] | Source(s) for Presence |
|---|---|---|---|
| Wooton's Hawthorn | *Crataegus wootoniana* | G2/S2, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Wright's Catchfly (campion) | *Silene wrightii* | G3/S2 | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Wright's Dogweed | *Adenophyllum wrightii* var. *wrightii* | G1?/S1, RF | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| Yellow Lady's-Slipper | *Cypripedium parviflorum* var. *pubescens* | G5/T5/S2?, RF, S | NatureServe 2016, Natural Heritage NM 2015, SEINet 2016, NMRPTC 1999 |
| **Mammals** | | | |
| Arizona Gray Squirrel | *Sciurus arizonensis arizonensis* | CN, G4/S2, RF | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015 |
| Arizona Montane Vole | *Microtus montanus arizonensis* | CN, G5/T4/S1, RF, S | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015, Frey 1995 |
| Bighorn Sheep | *Ovis canadensis* | CN, G4/S1 | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015 |
| Gunnison's Prairie Dog (prairie population) | *Cynomys gunnisoni* | CN, G5/S2, RF | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015 |
| Hooded Skunk | *Mephitis macroura* | G5/S2, RF | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015 |
| Spotted Bat | *Euderma maculatum* | RF, S | NatureServe 2016, BISON-M 2016, Natural Heritage NM 2015 |
| White-nosed Coati | *Nasua narica* | CN, G5/S2 | NatureServe 2016, BISON-M, 2016, Natural Heritage NM 2015 |

## Identify species that are at risk of persisting over the long term in the plan area.

The next step of the SCC analysis process determined which species can be removed from the potential SCC list because it is secure and its continued long-term persistence in the plan area is not at risk. Criteria for this removal step were: (1) “transient” (e.g. northern harrier) or “vagrant” (e.g. elegant trogon) species (also called “accidental” species) are species that have been documented to use the Gila NF only occasionally for foraging; (2) species inhabit areas not known to be affected by threats; (3) there is insufficient information to evaluate whether or not the species is at risk for persistence within the plan area; (4) species has a stable to upward population or habitat trend on the Gila NF; or (5) is a “game” species according to NMDGF meaning that the population is secure enough to withstand harvest, and as such its population is secure.

Based on knowledge of the species' abundance, distribution, lack of threats to persistence, trends in habitat, or responses to management, 52 of the 99 species identified as potential SCC are secure and their continued long-term persistence in the plan area are not at risk. As such, these species are no longer considered for further analysis as potential SCCs. Table 156 lists the species removed and the rationale for removing them. More detailed rationale for each species removed from SCC consideration is provided in Appendix G.

**Table 156. Potential species of conservation concern removed from further analysis, and rationale for removal**

| Common Name | Rationale for Removal from Potential SCC List |
|---|---|
| **Amphibians and Reptiles** | |
| Arizona toad | Well-distributed on Gila NF with locally abundant populations. No evidence of hybridization, and not impacted by Chytrid fungus in Gila region. Population is stable on Gila NF (Ryan et al., 2015). |
| **Birds** | |
| Abert's towhee | Transient on Gila NF (Shook et al. 2015). Population trend appears to be relatively stable to slightly increasing (Sauer et al. 2014). |
| American goldfinch | Transient on Gila NF with increasing population trend in New Mexico (Sauer et al. 2014). |
| American peregrine falcon | Relatively well-distributed across Gila NF in cliff habitat, particularly in wilderness areas. Protected habitat through inaccessibility, and trend is relatively stable to slightly increasing (Sauer 2014). |
| Bald eagle | Only nesting pair on Gila NF is tolerant of campgrounds where they build their nest. Typically occur on Gila NF during winter. Population increasing in Western United States (Sauer 2014). |
| Bank swallow | Transient on Gila NF (Zimmerman 1995). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Bell's vireo | Distributed through the lower Gila and lower San Francisco River drainages. Protections for other threatened and endangered species habitat also benefit this species and has alleviated some threats. Trend appears stable to slightly increasing in New Mexico (Sauer 2014) and showing a significant increase on the Gila NF (Shook et al. 2015). |
| Black swift | Transient on Gila NF. Lacking information to evaluate whether or not the species is at risk for persistence. |
| Blue-throated hummingbird | Distribution and abundance on Gila NF is not known. Population trends show relatively stable to increasing (NatureServe 2016). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Common blackhawk | Relatively well-distributed in lower elevations of major river systems on the Gila NF. Populations thought to be stable to increasing (NatureServe 2016, IUCN 2016). |
| Eastern bluebird | Rare winter residents on Gila NF (Zimmerman 1995). Lacking information to evaluate whether or not the species is at risk for persistence. |

| Common Name | Rationale for Removal from Potential SCC List |
|---|---|
| Elegant trogon | Vagrant on the Gila NF with only 2 historic sightings (Natural Heritage NM 2015). |
| Ferruginous hawk | Uncommon transient and winter resident on the Gila NF (Zimmerman 1995). |
| Harris's hawk | Vagrant on the Gila NF (NatureServe 2016). |
| Lincoln's sparrow | Uncommon winter residents and common transients through the Gila NF (Zimmerman 1995). |
| Marsh wren | Uncommon winter residents and common transients through the Gila NF (Zimmerman 1995). Populations stable to increasing in Southern Rockies/Colorado Plateau and Western United States (Sauer 2014). |
| Northern goshawk | Species is well-distributed across the Gila NF. Current management practices have alleviated threats from timber removal and are designed to help improve habitat. Trend is relatively stable to increasing (Sauer 2014). |
| Northern harrier | Uncommon winter residents and transients through the Gila NF (Zimmerman 1995). |
| Osprey | No osprey nests are known on Gila NF, and they are transients to Gila National Forest (Zimmerman, 1995). Population increasing in Western United States (Sauer 2014). |
| Ring-necked duck | Ring-necked ducks are uncommon summer residents but fairly common transients to Gila National Forest (Zimmerman, 1995). Populations increasing in Western United States (Sauer 2014). Game species (NMDGF 2016c). |
| Savannah sparrow | Uncommon winter residents and fairly common transients through Gila National Forest (Zimmerman, 1995). |
| Wilson's phalarope | Rare transients through the Gila NF (Zimmerman 1995). |
| Wilson's warbler | Common transients through the Gila NF (Zimmerman 1995). |
| **Fish** | |
| Desert sucker | Species is well distributed and still occurs in most streams it was present in historically in the Gila and San Francisco River drainages, even though their trend appears to be declining over the last 10 years (Paroz et al. 2006). Long-term decline of 10-30% regarded as relatively stable (NatureServe 2016). |
| Rio Grande cutthroat trout | Animas Creek no longer has any fish species as a result of the ash flows from the 2013 Silver Fire. Rio Grande cutthroat trout will be reintroduced into the creek in 2016 where they were believed to occur historically |
| Sonora sucker | Species is well distributed and still occurs in most streams it was present in historically in the Gila and San Francisco River drainages, even though their trend appears to be declining over the last 10 years (Paroz et al. 2006). Short term decline of <30% to relatively stable, and long-term decline of <30% to an increase of 25% (NatureServe 2016). |
| **Invertebrates** | |

| Common Name | Rationale for Removal from Potential SCC List |
|---|---|
| Arizona snaketail | Populations appear stable, species is reasonably widespread, and can be locally common (NatureServe 2016, IUCN 2016). |
| Cross snaggletooth | Little is known about distribution, abundance, and trend of this species (Metcalf and Smartt 1997). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Dashed ringtail | Not enough information known about species. Unknown life history or habitat needs. Population trend is stable (IUCN 2016). |
| Dry Creek woodlandsnail (*A.t. tetrodon*) | Little is known about distribution, abundance, and trend of this species (Metcalf and Smartt 1997). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Four-spotted skipperling skipper | Unknown habitat and life history needs. Lacking information to evaluate whether or not the species is at risk for persistence (Zimmerman 2001). |
| Mayfly | Unknown habitat and life history needs. Lacking information to evaluate whether or not the species is at risk for persistence (Bednarik and Edmonds 1980). |
| Notodontid moth | Unknown habitat and life history needs. Lacking information to evaluate whether or not the species is at risk for persistence (NatureServe 2016). |
| **Mammals** | |
| Arizona gray squirrel | Game species (NMDGF 2016c). |
| Bighorn sheep | Game species (NMDGF 2016c). |
| Hooded skunk | Unprotected furbearer (NMDGF 2016c). Relatively well-distributed in several ERUs on Gila NF, and thrives in areas of human disturbance (BISON-M 2016). Population trends show increase (IUCN 2016). |
| Spotted bat | Fairly well-distributed on the Gila NF (Natural Heritage NM 2015). This species occupies cliff and crevice habitat and is effectively protected from most threats. Trend appears to be relatively stable (NatureServe 2016) to stable (IUCN 2016). |
| White-nosed coati | Relatively well-distributed across the Gila NF (Natural Heritage NM 2015). Threats have been alleviated through protections implemented through the State of NM where they are classified as "a protected furbearer that cannot be taken" (NMDGF 2016c). Distribution has increased on the Gila NF since 1970. |
| **Plants** | |
| Gila thistle | It is not threatened by prevailing land uses within its range. It is known to increase with disturbance (NMRPTC 1999) and may be increasing after the fires that have burned within known occupied sites (Roth 2016). |

| Common Name | Rationale for Removal from Potential SCC List |
|---|---|
| Gooding's bladderpod | Occurs in several different ERUs, some of which have low to moderate departure. Prevailing land uses do not threaten the species within its range. It can occupy disturbed areas, such as highway rights-of-way. |
| Horned spurge | Little known about threats, trends, abundance, or habitat requirements for this species. It is well-distributed across the Gila NF and globally secure. Lacking information to evaluate whether or not the species is at risk for persistence. |
| Metcalf's groundsel | Fairly well-distributed and occurs within several different ERUs. There appear to be no significant land use threats to the species or its habitat, and it is quite common within its limited range (NMRPTC 1999). |
| Mogollon whitlowgrass (Draba) | Well-distributed across Gila NF, and the habitat this species occupies essentially removes most threats. Current land uses pose no threat to species and trend is unknown (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Mt. Graham beardtongue | Current land uses pose no threat to the species (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |
| New Mexican gumweed | Relatively well-distributed across Gila NF, can occur in many different ERUs, and trends are not known (SEINet 2016). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Nutrioso milkvetch | Most recent description of the species by Isely (1998) does not record the species in NM. Species is a narrow endemic to the Rio Nutrioso Drainage in AZ. Not palatable to livestock, but may be subject to weed eradication programs. No other threats known and trend is unknown. Lacking information to evaluate whether or not the species is at risk for persistence. |
| Silver mock orange | Little known about threats, trends, abundance, or habitat requirements for this species. It is fairly well-distributed across the Gila NF and globally secure. Lacking information to evaluate whether or not the species is at risk for persistence. |
| Threadleaf giant-hyssop | Relatively well-distributed, no threats noted, and no authors make note of rarity of species (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |
| Villous groundcover milkvetch | Fairly well-distributed, occurs within several ERUs, occurs in disturbed areas, no identified threats or trends (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |
| White Mountain groundsel | Well-distributed across Gila NF, occurs within several ERUs, some of which have low to moderate departure. Prevailing land uses do not threaten the species. It can occupy disturbed areas like road cuts (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |

| Common Name | Rationale for Removal from Potential SCC List |
|---|---|
| Winn Falls fleabane | Well-distributed across Gila NF, populations can be locally abundant, cliff habitat effectively removes threats to this species (NMRPTC 1999) and have not likely changed from reference conditions. Lacking information to evaluate whether or not the species is at risk for persistence. |
| Wright's catchfly (campion) | The species is tied to cliff/crevice habitat. These features offer considerable protection where current land uses pose no threat to the species (NMRPTC 1999). Lacking information to evaluate whether or not the species is at risk for persistence. |

There are 47 potential SCC with substantial concern about their capability to persist in the plan area over the long term. Gunnison's prairie dog remained on the potential SCC list as these species have concerns for persistence in the plan area; however, the concerns for persistence are due to actions or activities outside of agency control, authority, or capability (Sylvatic plague).

In summary, Table 157 lists the potential 47 SCC that are documented to occur on the Gila NF and that the best available scientific information indicates substantial concern about their capability to persist over the long term in the plan area.

**Table 157. Potential species of conservation concern for the Gila National Forest**

| Common Name | Scientific Name | NatureServe Ranking[48] |
|---|---|---|
| **Birds** | | |
| Gila woodpecker | *Melanerpes uropygialis* | G5/S2B,S2N |
| **Fish** | | |
| Rio Grande sucker | *Catostomus plebeius* | G3G4/S2 |
| **Invertebrates** | | |
| A Stonefly | *Capnia caryi* | G1/SNR |
| Bearded Mountainsnail | *Oreohelix barbata* | G1/S1 |
| Black Range Mountainsnail | *Oreohelix metcalfei acutidiscus* | G2/T1/SNR |
| Black Range Mountainsnail | *Oreohelix metcalei hermosensis* | G2/T1T2/SNR |
| Black Range Woodlandsnail | *Ashmunella cockerelli* | G1/T1/S1 |
| Cockerell Holispera Snail | *Holispera cockerelli* | G1/S1 |
| "Gila" Mayfly | *Lachlania dencyanna* | G1/SNR |
| Gila Springsnail | *Pyrgulopsis gilae* | G2/S2:Threatened |
| Iron Creek Woodlandsnail | *Ashmunella mendax* | G1/S1 |
| Marsh Slug Snail | *Deroceras heterura* | G1G2/SNR |

[48] NatureServe Ranking - Global (G), Taxonomic (T), State (S), Breeding (B), Non-breeding (N), Not Ranked (NR), or Uncertainty on ranking (?)

| Common Name | Scientific Name | NatureServe Ranking[48] |
|---|---|---|
| Mineral Creek Mountainsnail | *Oreohelix pilsbryi* | G1/S1:Threatened |
| Morgan Creek Mountainsnail | *Oreohelix swopei* | G1/S1 |
| New Mexico Hot Springsnail | *Pyrgulopsis thermalis* | G1/S1:Threatened |
| Nitrocris Fritillary Butterfly | *Speyeria nokomis nitocris* | G3/T3/SNR |
| No Common Name Snail | *Ashmunella cockerelli argenticola* | G1/T1/S1 |
| No Common Name Snail | *Ashmunella cockerelli perobtusa* | G1/T1/S1 |
| No Common Name Snail | *Ashmunella tetrodon animorum* | G3/T3/S3 |
| No Common Name Snail | *Ashmunella tetrodon inermis* | G3/T2/SNR |
| No Common Name Snail | *Ashmunella tetrodon mutator* | G3/T2/SNR |
| No Common Name Snail | *Oreohelix metcalfei radiata* | G2/T2/SNR |
| No Common Name (Black Range mountainsnail) | *Oreohelix metcalfei concentrica* | G2/SNR |
| Silver Creek Woodlandsnail | *Ashmunella binneyi* | G1/S1 |
| Sonoran Snaggletooth Snail | *Gastrocopta prototypus* | G1/SNR |
| Stonefly | *Taenionema jacobii* | G2/SNR |
| Tiger Moth | *Alexicles aspersa* | G1G2 |
| Whitewater Creek Woodlandsnail | *Ashmunella danielsi* | G1/S1 |
| **Mammals** | | |
| Arizona montane vole | *Microtus montanus arizonensis* | G5/T4/S1:Endangered |
| Gunnison's prairie dog | *Cynomys gunnisoni* | G5/S2 |
| **Plants** | | |
| Cliff Brittlebrush | *Apacheria chiricahuensis* | G2/S2 |
| Davidson's Cliff Carrot | *Pteryxia davidsonii* | G2/S2 |
| Gooding's Onion | *Allium gooddingii* | G4/S1 |
| Greene Milkweed | *Asclepias uncialis* ssp. *uncialis* | G3G4/T2T3/S2 |
| Heartleaf Groundsel | *Packera cardamine (=Senecio cardamine)* | G3/S3 |
| Hess's Fleabane | *Erigeron hessii* | G1/S1 |
| Metcalfe's Penstemon | *Penstemon metcalfei* | G1/S1 |
| Mimbres Figwort | *Scophularia macrantha* | G2/S2 |
| Mogollon Clover | *Trifolium neurophyllum* | G2/S2 |
| Mogollon Death Camas | *Zigadenus mogollonensis* | G3/S3 |

| Common Name | Scientific Name | NatureServe Ranking[48] |
|---|---|---|
| Mogollon Hawkweed | *Hieracium brevipilum (=H. fendleri var. mogollense)* | G4/T2?/S2? |
| New Mexico Groundsel | *Packera quaerens* | G2/S2 |
| Pinos Altos Flameflower | *Talinum humile* | G2/S2 |
| Porsild's Starwort | *Stellaria porsildii* | G1/S1 |
| Wooton's Hawthorne | *Crataegus wootoniana* | G2/S2 |
| Wright's Dogweed | *Adenophyllum wrightii var. wrightii* | G1?/S1 |
| Yellow Lady's-Slipper | *Cypripedium parviflorum* var. *pubescens* | G5/T5/S2? |

## Ecological Conditions

The next step associated the 47 remaining potential SCC (Table 157) and 14 federally listed species (Table 153) with ecological condition and key ecosystem characteristics described within ecological response units (ERUs) on the Gila NF. Vegetation is one of the primary factors that influences species diversity and abundance and is one of the more obvious habitat components influenced by management, land use, and natural disturbance. To make the species risk assessment relevant to other ecological risk assessments presented in this document, and because vegetation is such a significant habitat component for species, vegetation types and key ecosystem characteristics were categorized following ERUs, as applied in the Upland Vegetation and Riparian Chapters. These ERUs are a stratification of ecosystem settings that are each similar in indicator plant species, succession patterns, and disturbance regimes that, in concept and resolution, are most useful to management. In other words, ERUs are the range of plant associations (USDA FS 1997), along with structure and process characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006a).

A departed ERU may not contain the vegetation that would have existed under the natural range of variation (NRV) and historical disturbance regime. However, the assessment of vegetation characteristics within each ERU quantifies the current ecological conditions of each ERU. Species presence and absence on the Forest is, in many cases, directly tied to availability, current ecological condition, and key ecosystem characteristics of ERUs. Associating particular ERUs with specific species is critical for assessing future management needs. The description of current ecological condition for each ERU (see Upland Vegetation and Riparian Chapters) was used to discern the status of the ecological conditions on the Forest needed to recover federally listed species, conserve proposed and candidate species, and maintain viable populations of species of conservation concern.

Federally threatened, endangered, and proposed species, as well as potential SCC were associated with dominant ERU types in Table 158 below. These associations were informed by a number of different sources, including the Biota Information System of New Mexico (BISON-M 2016), the New Mexico Rare Plants Website (NMRPTC 1999), NatureServe Data Explorer (NatureServe 2015), and personal communications with ecologists, species experts, and agency biologists.

In many cases, species habitat needs were not represented solely by the overall ecological conditions of ERUs, but by more specific ecosystem characteristics required by the species (e.g., birds requiring snags or rocky outcrops for perching or nesting). In these cases, specific ecosystem characteristics were recorded

and assessed separately from the ERUs (Table 160). Overall, an effort was made to associate species with ERUs (based on current ecological conditions described therein) whenever possible, because later stages of forest plan revision will center on the management of ERUs. This relationship between species and ERUs is the premise of the coarse-filter approach discussed above and appropriate management of ERUs is expected to benefit at-risk and common species. The relationship between species and key ecosystem characteristics will help to identify fine-filter approaches necessary for preserving species diversity on the Gila NF.

**Table 158. Federally listed (*) and potential species of conservation concern currently known to occur in the plan area and associated ecological response unit types[49], riparian/aquatic habitats, and features[50].**

[1]=Unknown habitat or life history needs

| Common Name | SDG | MSG | CPGB | MMS | PJG | PJO | MPO | JUG | PPE | PPF | MCD | MCW | SFF | Riparian/ Aquatic | Feature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Amphibians and Reptiles** | | | | | | | | | | | | | | | |
| Chiricahua leopard frog* | | | | | | | | | | | | | | X | |
| Narrow-headed gartersnake* | | | | | | | | | | | | | | X | |
| Northern Mexican gartersnake* | | | | | | | | | | | | | | X | |
| Birds | | | | | | | | | | | | | | | |
| Gila woodpecker | | | | | | | | | | | | | | X | X |
| Mexican spotted owl* | | | | | | | | | | X | X | X | X | X | X |
| Southwestern willow flycatcher* | | | | | | | | | | | | | | X | |
| Western yellow-billed cuckoo* | | | | | | | | | | | | | | X | |
| **Fish** | | | | | | | | | | | | | | | |
| Chihuahua chub* | | | | | | | | | | | | | | X | |
| Gila chub* | | | | | | | | | | | | | | X | |
| Gila trout* | | | | | | | | | | | | | | X | |
| Headwater chub* | | | | | | | | | | | | | | X | |

[49] SDG=semi-desert grassland, MSG=montane sub-alpine grassland, CPGB=Colorado Plateau, Great Basin grassland, MMS=mountain mahogany mixed-shrubland, PJG= piñon-juniper grassland, PJO= piñon-juniper woodland, MPO=madrean pine-oak woodland, JUG=juniper grassland, PPE=ponderosa pine-evergreen oak woodland, PPF=ponderosa pine forest, MCD=mixed conifer frequent fire, MCW=mixed conifer with aspen, SFF=spruce-fir forest.

[50] Features include cliffs, talus slopes, rock scree, snags, leaf litter, and soils.

| Common Name | SDG | MSG | CPGB | MMS | PJG | PJO | MPO | JUG | PPE | PPF | MCD | MCW | SFF | Riparian/ Aquatic | Feature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Loach minnow* | | | | | | | | | | | | | | X | |
| Rio Grande sucker | | | | | | | | | | | | | | X | |
| Roundtail chub* | | | | | | | | | | | | | | X | |
| Spikedace* | | | | | | | | | | | | | | X | |
| Invertebrates | | | | | | | | | | | | | | | |
| A Stonefly (*C. caryi*)[1] | | | | | | | | | | | | | | X | |
| Bearded Mountainsnail | | | | | | | | | | | | | | X | X |
| Black Range Mountainsnail (*O.m. acutidiscus*) | | | | | | | | | | | | | | | X |
| Black Range Mountainsnail (*O.m. hermosensis*) | | | | | | | | | | | | | | | X |
| Black Range Woodlandsnail | | | | | | | | | | | | | | | X |
| Cockerell Holospira Snail | | | | | | | X | | | | | | | | X |
| "Gila" Mayfly (*L. dencyanna*)[1] | | | | | | | | | | | | | | X | |
| Gila Springsnail | | | | | | | | | | | | | | X | X |
| Iron Creek Woodlandsnail | | | | | | | | | X | X | X | X | | X | X |
| Marsh Slug Snail | | | | | | | | | | | | | | | X |
| Mineral Creek Mountainsnail | | | | | | | | | | | | | | | X |
| Morgan Creek Mountainsnail | | | | | | | | | | X | X | X | | | X |
| New Mexico Hot Springsnail | | | | | | | | | | | | | | X | X |
| Nitrocris Fritillary Butterfly | | | | | | | | | | | | | X | | |
| No Common Name (*A.c. argenticola*) | | | | | | | | | | | | | | | X |
| No Common Name (*A.c. pertubosa*) | | | | | | | | | | | | | | | X |
| No Common Name (*A.t. animorum*) | | | | | | | | | | | | | | | X |

| Common Name | SDG | MSG | CPGB | MMS | PJG | PJO | MPO | JUG | PPE | PPF | MCD | MCW | SFF | Riparian/ Aquatic | Feature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No Common Name (*A.t. inermis*) | | | | | | | | | | | | | | X | X |
| No Common Name (*A.t. mutator*) | | | | | | | | | | | | | | X | X |
| No Common Name (*O.m. radiata*) | | | | | | | | | | | | | | | X |
| No Common Name (*O.m. concentrica*) | | | | | | | | | | | | | | | X |
| Silver Creek Woodlandsnail | | | | | | | | | | | X | X | | | X |
| Sonoran Snaggletooth Snail | | | | | | | | | | | | | | X | |
| Stonefly (*T. jacobii*)[1] | | | | | | | | | | | | | | X | |
| Tiger Moth (*A. aspersa*)[1] | | | | | | | | | | | | | | | |
| Whitewater Creek Woodlandsnail | | | | | | | | | | | | | | | X |
| **Mammals** | | | | | | | | | | | | | | | |
| Arizona montane vole | | | | | | | | | | X | X | X | | X | |
| Gunnison's prairie dog | | X | X | | X | | | X | | | | | | | |
| Mexican gray wolf | | X | X | X | X | X | X | X | X | X | X | X | X | | |
| **Plants** | | | | | | | | | | | | | | | |
| Cliff brittlebrush | | | | | | | | | | | | | | | X |
| Davidson's cliff carrot | | | | | | | | | | | | | | | X |
| Gooding's onion | | | | | | | | | | | X | X | X | | |
| Greene's milkweed | | | X | | | | | X | | | | | | | X |
| Heartleaf groundsel | | | | | | | | | | | | X | X | | |
| Hess's fleabane | | | | | | | | | | | | | | | X |
| Metcalfe's penstemon | | | | | | | | | | | | | | | X |
| Mimbres figwort | | | | | | X | | | X | | | | | | X |

| Common Name | SDG | MSG | CPGB | MMS | PJG | PJO | MPO | JUG | PPE | PPF | MCD | MCW | SFF | Riparian/ Aquatic | Feature |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mogollon clover | | | | | | | | | | X | X | | | X | X |
| Mogollon death camas | | | | | | | | | | | | X | X | | |
| Mogollon hawkweed | | | | | | | | | | X | X | X | | | |
| New Mexico groundsel | | | | | | | | | | X | X | X | | X | X |
| Pinos Altos flame flower | | | | | | X | X | | X | | | | | | |
| Porsild's starwort | | | | | | | | | | X | X | X | | | |
| Wooton's hawthorn | | | | | | | | | | | | | | X | |
| Wright's dogweed | | | | | X | X | | | | | | | | | |
| Yellow lady's-slipper | | | | | | | | | | X | X | X | | | X |

## Grouping of Species

Species can be grouped a number of different ways that are useful for identifying broad threats to their continued existence on the Gila NF. For efficiency during the risk assessment portion of this evaluation, species were grouped according to their associated ERUs described above and presented in Table 158. This information is summarized by taxonomic group in Table 159. It is acknowledged that grouping species in this manner will not accurately capture all of their specific habitat needs, and so they have also been sorted by key ecosystem characteristics (Table 160).

**Table 159. Federally listed species and potential species of conservation concern summarized by taxonomic group and their associated ERUs, riparian/aquatic habitat, and features.**

| ERU | Amphibs | Birds | Fish | Inverts | Mammals | Plants | Reptiles | Total |
|---|---|---|---|---|---|---|---|---|
| **Semi-Desert Grassland (SDG)** | | | | | | | | |
| **Montane Subalpine Grassland (MSG)** | | | | | 2 | | | 2 |
| **Colorado Plateau-Great Basin Grassland (CPGB)** | | | | | 2 | 1 | | 3 |
| **Mountain Mahogany Mixed Shrubland (MMS)** | | | | | 1 | | | 1 |
| **Piñon-Juniper Grassland (PJG)** | | | | | 2 | 1 | | 3 |
| **Piñon-Juniper Woodland (PJO)** | | | | | 1 | 3 | | 4 |
| **Madrean Pine-Oak (MPO)** | | | | 1 | 1 | 1 | | 3 |
| **Juniper Grass (JUG)** | | | | | 2 | 1 | | 3 |
| **Ponderosa Pine-Evergreen Oak (PPE)** | | | | 1 | 1 | 2 | | 4 |

| ERU | Amphibs | Birds | Fish | Inverts | Mammals | Plants | Reptiles | Total |
|---|---|---|---|---|---|---|---|---|
| **Ponderosa Pine Forest (PPF)** | | 1 | | 2 | 2 | 5 | | 9 |
| **Mixed Conifer with Frequent Fire (MCD)** | | 1 | | 3 | 2 | 6 | | 12 |
| **Mixed Conifer with Aspen (MCW)** | | 1 | | 3 | 2 | 7 | | 13 |
| **Spruce-Fir Forest (SFF)** | | 1 | | 1 | 1 | 3 | | 7 |
| **Riparian/Aquatics** | 1 | 4 | 8 | 10 | 1 | 3 | 2 | 29 |
| **Features (cliffs,talus,rock,tree,soil)** | | 2 | | 20 | | 9 | | 31 |

**Table 160. Key ecosystem characteristics associated with federally listed species (*) and potential species of conservation concern known to currently occur in the plan area**

| Associated Key Ecosystem Characteristics | Associated Species |
|---|---|
| **Tree features (cavities, snags, leaves, bark, downed logs, leaf or forest litter)** | ▪ Mexican spotted owl*<br>▪ Gila woodpecker<br>▪ No Common Name (*A.c. argenticola*)<br>▪ Whitewater Creek Woodlandsnail<br>▪ Sonoran Snaggletooth Snail<br>▪ Bearded Mountainsnail |
| **Rock features (canyons, cliffs, crevices, outcrops)** | ▪ Mexican spotted owl*<br>▪ No Common Name (*A.c. argenticola*)<br>▪ Black Range Woodlandsnail<br>▪ No Common Name (*A.c. pertubosa*)<br>▪ Whitewater Creek Woodlandsnail<br>▪ No Common Name (*A.t. animorum*)<br>▪ Black Range Mountainsnail (*O.m. actutidiscus*)<br>▪ Black Range Mountainsnail (*O.m. hermosensis*)<br>▪ Mineral Creek Mountainsnail<br>▪ No Common Name (*O.m. concentrica*)<br>▪ No Common Name (*O.m. radiata*)<br>▪ Hess's fleabane<br>▪ Metcalfe's penstemon<br>▪ Porsild's starwort |
| **Riparian and aquatic features (riparian areas, springs, permanent water)** | ▪ Chiricahua leopard frog*<br>▪ Narrow-headed gartersnake*<br>▪ Northern Mexican gartersnake*<br>▪ Mexican spotted owl*<br>▪ Gila woodpecker<br>▪ Southwestern willow flycatcher*<br>▪ Western yellow-billed cuckoo*<br>▪ Chihuahua chub*<br>▪ Gila chub*<br>▪ Gila trout*<br>▪ Headwater chub*<br>▪ Loach minnow*<br>▪ Rio Grande sucker<br>▪ Roundtail chub*<br>▪ Spikedace*<br>▪ Bearded Mountainsnail<br>▪ Iron Creek Woodlandsnail<br>▪ Gila Springsnail<br>▪ A Stonefly (*C. caryi*)<br>▪ Stonefly (*T. jacobii*)<br>▪ "Gila" mayfly (*L. dencyanna*)<br>▪ New Mexico Hot Springsnail<br>▪ Sonoran Snaggletooth Snail<br>▪ Mogollon clover<br>▪ New Mexico groundsel<br>▪ Arizona montane vole |

| Associated Key Ecosystem Characteristics | Associated Species |
|---|---|
| **Meadows and small openings** | ▪ Greene Milkweed<br>▪ Yellow Lady's-Slipper<br>▪ New Mexico Groundsel<br>▪ Porsild's Starwort<br>▪ Mogollon Clover<br>▪ Nitrocris Fritillary Butterfly<br>▪ Gunnison's prairie dog<br>▪ Arizona montane vole |
| **Alpine and tundra** | ▪ Gooding's Onion<br>▪ Hess's Fleabane<br>▪ Heartleaf Groundsel<br>▪ New Mexico Groundsel<br>▪ Mogollon Death Camas<br>▪ Nitrocris Fritillary Butterfly |
| **Soil features (soil type, soil permeability, and soil condition)** | ▪ Black Range Woodlandsnail<br>▪ No Common Name (*A.c. pertubosa*)<br>▪ Whitewater Creek Woodlandsnail<br>▪ No Common Name (*A.t. animorum*)<br>▪ Black Range Mountainsnail<br>▪ No Common Name (*O.m. concentrica*)<br>▪ No Common Name (O.m. radiata)<br>▪ Greene Milkweed<br>▪ Yellow Lady's-Slipper<br>▪ Porsild's Starwort |

During the data-gathering and risk assessment portions of this assessment, species were also grouped by individual zones within the Gila NF (local scale) (Figure 4). This grouping is valuable in identifying where particular issues may need attention and drive Forest Plan components for some species. It is expected that this may also benefit other planning purposes; however, this scale is not as likely to drive ecological need for change (Ecological Integrity Chapter). Table 161 displays the at-risk species summarized by taxonomic group and associated local scale.

**Table 161. Federally listed, proposed, and potential species of conservation concern summarized by taxonomic group and associated local scale on the Gila National Forest**

| Local Scale | Amphibs | Birds | Fish | Inverts | Mammals | Plants | Reptiles | Total |
|---|---|---|---|---|---|---|---|---|
| **Apache (AP)** | 1 | 2 | 4 | 0 | 2 | 4 | 1 | 14 |
| **Black Range (BR)** | 1 | 1 | 3 | 15 | 1 | 5 | 0 | 26 |
| **Little Colorado – San Agustine Fringe (LCSAF)** | 1 | 1 | 5 | 1 | 2 | 3 | 1 | 14 |
| **Lower Gila River (LGR)** | 1 | 4 | 4 | 5 | 0 | 4 | 1 | 19 |
| **Mogollon Front (MF)** | 1 | 2 | 6 | 2 | 1 | 9 | 2 | 23 |
| **Upper Gila River (UGR)** | 1 | 2 | 6 | 8 | 1 | 10 | 1 | 29 |

# Federally Listed Species and Species of Conservation Concern Risk Justifications

All of the federally listed species and potential SCC can be affected by the management activities authorized under the current Gila NF plan. Risk was not assessed for ERUs or other habitat factors on non-Forest Service lands. Therefore, it is not possible to state with certainty the overall risk to the species at the context scale. However, for many of these species, habitat provided on the Forest represents the majority of habitat available. Changing land use patters, habitat degradation or loss, or simply the lack of suitable habitat off of the Forest, places a particular emphasis on the Gila NF to maintain these species.

## Federally Listed Species

There are 14 federally listed species within the plan area (USDI FWS 2016) (Table 162). Although federally listed species are not to be included as a species of conservation concern (separate list), making a determination on the presence or absence of a listed species in the plan area determines whether or not that species is to be considered in the planning phase.

**Table 162. Federally listed species relevant to the plan area.**

| Common Name | Scientific Name | Federal Status |
|---|---|---|
| **Amphibians and Reptiles** | | |
| Chiricahua leopard frog | *Lithobates chiricahuensis* | Threatened |
| Narrow-headed gartersnake | *Thamnophis rufipunctatus* | Threatened |
| Northern Mexican gartersnake | *Thamnophis eques megalops* | Threatened |
| **Birds** | | |
| Mexican spotted owl | *Strix occidentalis lucida* | Threatened |
| Southwestern willow flycatcher | *Empidonax traillii extimus* | Endangered |
| Western yellow-billed cuckoo | *Coccyzus americanus occidentalis* | Threatened |
| **Fishes** | | |
| Chihuahua chub | *Gila nigrescens* | Threatened |
| Gila chub | *Gila intermedia* | Endangered |
| Gila trout | *Oncorhynchus gilae* | Threatened |
| Headwater chub | *Gila nigra* | Proposed Threatened |
| Loach minnow | *Tiaroga cobitis* | Endangered |

| Common Name | Scientific Name | Federal Status |
|---|---|---|
| Roundtail chub | *Gila robusta* | Proposed Threatened |
| Spikedace | *Meda fulgida* | Endangered |
| **Mammals** | | |
| Mexican Gray wolf | *Canis lupus baileyi* | Experimental, Non-Essential population |

There are four federally endangered species occurring on the Gila NF, Southwestern willow flycatcher, Gila chub, Loach minnow, and Spikedace, seven federally threatened species, Chiricahua leopard frog, Mexican spotted owl, Yellow-billed cuckoo, Chihuahua chub, Gila trout, Narrow-headed gartersnake, and Northern Mexican gartersnake, two federally proposed species, Headwater chub and Roundtail chub, and one federally listed experimental, non-essential species, Mexican gray wolf. There are no candidate species currently present on the Gila NF.

Section 4 of the ESA requires the USFWS to identify and protect all lands, water, and air necessary to recover an endangered species; this is known as critical habitat. Critical habitat includes areas that have been determined to be needed for life processes for a species including space for individual and population growth and for normal behavior; cover or shelter; food, water, air, light, minerals, or other nutritional or physiological requirements; sites for breeding and rearing offspring; and habitats that are protected from disturbances or are representative of the historical geographical and ecological distributions of a species. The Southwestern willow flycatcher, Gila chub, Loach minnow, Spikedace, Chiricahua leopard frog, and Mexican spotted owl have designated critical habitat on the Gila NF, the Yellow-billed cuckoo, Narrow-headed gartersnake, and Northern Mexican gartersnake have proposed critical habitat on the Gila NF. No other federally listed species has designated or proposed critical habitat on the Gila NF.

Section 7 of the Endangered Species Act requires federal agencies to ensure actions they authorize, fund, or carry out are not likely to destroy or adversely modify designated critical habitat. Section 7 of the Act also requires that any federal agency that carries out, permits, licenses, funds, or otherwise authorizes activities that may affect a listed species must consult with the Fish and Wildlife Service to ensure that its actions are not likely to jeopardize the continued existence of any listed species.

### *Justification*

**Amphibians and Reptiles**

**Chiricahua leopard frog (*Lithobates chiricahuensis*)** is federally listed as threatened with approximately 2,488 acres of designated critical habitat on the Gila NF. In New Mexico and on the Gila National Forest, Chiricahua leopard frogs are thought to be most abundant in the Gila and San Francisco River drainages (Degenhardt et al. 1996), but they also occur in Beaver Creek (tributary to the East Fork Gila River), North Seco Creek, and in the Mimbres River drainage. Chiricahua leopard frogs prefer habitat with a variety of structure and cover, including emergent and submergent vegetation, overhanging banks and organic debris (Degenhardt et al. 1996). Although they can survive drought by burrowing in the mud, they require

a perennial source of running or standing water in the form of streams, springs, stock tanks, ponds, or lakes (USDI FWS 2007). Threats include disease particularly chytrid fungus, reduced water sources, habitat degradation through unmanaged grazing and recreation or other factors altering hydrologic function, and predation from non-native aquatic species (USDI FWS 2007).

**Narrow-headed gartersnake (*Thamnophis rufipunctatus*)** is federally listed as threatened with approximately 52,430 acres of proposed critical habitat on the Gila NF. The New Mexican distribution includes the Gila and San Francisco river drainages in Catron, Grant, and Hidalgo counties, at elevations of 1,125-2,100 meters (Degenhardt et al. 1996, NMDGF 1997 as cited in NatureServe 2016). This species is regarded as one of the most aquatic of all garter snakes (Conant 1963 as cited in NatureServe 2016). It often occurs along well-lit sections of rocky streams with abundant riparian vegetation. In New Mexico, fed exclusively on fishes (NMDGF 1985 as cited in NatureServe 2016). Threats include direct predation from non-native aquatic species, competition by non-native fish, and loss of riparian habitat through unmanaged grazing and recreation.

**Northern Mexican gartersnake (*Thamnophis eques megalops*)** is federally listed as threatened with approximately 8,717 acres of proposed critical habitat on the Gila NF. In New Mexico, this snake is known from the lower Gila River basin, along Duck and Mule creeks in Grant County and near Virden in Hidalgo County (Hubbard and Eley 1985 as cited in NatureServe 2016). It may now be eliminated from Duck Creek (NMDGF 1997 as cited in NatureServe 2016). A record from a single locality along Mule Creek is the only recent evidence of the presence of this species in New Mexico, but the current status of that population is unknown (Center for Biological Diversity 2003 as cited in NatureServe2016). This snake is strongly associated with permanent water with vegetation, including stock tanks, ponds, lakes, cienegas, cienega streams, and riparian woods (Degenhardt et al. 1996, Manjarrez 1998). The diet includes fishes, amphibians, earthworms, leeches, and various other small animals (NatureServe 2016). Threats include loss of streams, wetlands, and riparian zones through unmanaged grazing, water diversions, decline of native fish, and predation/competition from non-native aquatic species.

**Birds**

**Mexican spotted owl (*Strix occidentalis lucida*)** is federally listed as threatened with designated critical habitat on the Gila NF of which there is approximately 1,122,802 acres. The Mexican spotted owl (MSO) inhabits mixed coniferous and pine/oak forests, canyons, desert caves, cliff faces, and riparian areas throughout the Southwest. On the Gila National Forest mixed conifer and pine-oak habitat is considered either protected or recovery habitat in the recovery plan for this species. Protected habitat are Protected Activity Centers (PAC's), and unoccupied mixed conifer and pine-oak is considered recovery habitat (USDI FWS 2012). Many timber management activities negatively affected habitat before the MSO was listed as threatened in 1995. Timber harvest, prescribed burning, and other management activities are now designed following the 2012 Mexican Spotted Owl Recovery Plan along with consultation with the USFWS. These management activities can still have disturbance affects to the Mexican spotted owl and its habitat. Threats include habitat loss due to silvicultural treatments, uncharacteristic wildfire, and increased human activities in proximity to nest/roost territories.

**Southwestern willow flycatcher (*Empidonax traillii extimus*)** is federally listed as endangered with approximately 1,547 acres of designated critical habitat on the Gila NF. The species has been documented in the Gila and San Francisco River drainages. Habitat includes riparian and wetland thickets, generally of willow, tamarisk, or both, sometimes boxelder or Russian olive (USDI FWS 2013). On the Gila National Forest we have had two sites that have been consistently occupied for over 10 years along the Gila River. These two areas are in locations known as the Gila Bird Management Area (GBMA) and the Fort West

ditch site. In 2008 seven territories were found at the GBMA and four territories at the Forest West ditch site (Shook 2009). In 2007 a new breeding site was discovered on the Forest along the San Francisco River (Keller Canyon site). The Keller Canyon site, located on the reach between Deep Creek and Alma Highway 180, had three flycatcher territories in 2007, 2008, and 2009. Threats include loss of riparian habitat from floods, unmanaged grazing, uncharacteristic fire, nest parasitism, and unmanaged recreation.

**Yellow-billed cuckoo (*Coccyzus americanus occidentalis*)** is federally listed as threatened with approximately 1,680 acres of proposed critical habitat on the Gila NF. The western population of the yellow-billed cuckoo (*Coccyzus americanus occidentalis*), an insect-eating bird found in riparian woodland habitats, winters in South America and breeds in western North America (USDI FWS 2014). On the Gila NF it is found in the Gila and San Francisco River drainages. Threats include loss or degradation of riparian habitat, agriculture, water diversions, unmanaged grazing, uncharacteristic wildfire, and non-native plant invasion, particularly tamarisk (USDI FWS 2014).

**Fish**

**Chihuahua chub (*Gila nigrescens*)** is federally listed as threatened with no designated critical habitat on the Gila NF. Chihuahua chub is native to the Mimbres River drainage in New Mexico and the Guzmán and Laguna Bustillos basins in Chihuahua (Smith and Miller 1986). Specimens were first collected in the Mimbres River in 1851 (Baird and Girard 1854), but it was not again found in the Mimbres River drainage until 1975 when Rogers (1975) found a small, reproducing population in Moreno Spring. Chihuahua chub probably occupied all warmwater reaches in the Mimbres River drainage, but they now are found regularly only in Moreno Spring. They irregularly occur in about a 9.3 mile reach of the Mimbres River from the confluence of Allie Canyon downstream to the New Mexico Department of Game and Fish Mimbres Property south of Mimbres (Propst 1999). Ash-laden flows from wildfires have reduced Chihuahua chub abundance in the Mimbres River (Myers pers. comm. 2016). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, agricultural, water diversions, and competition/predation by non-native aquatic species.

**Gila chub (*Gila intermedia*)** is federally listed as endangered with approximately 764 acres of designated critical habitat on the Gila NF. Gila chub have been recorded in approximately 43 rivers, streams, and spring-fed tributaries throughout the Gila River basin in southwestern New Mexico, central and southeastern Arizona, and Northern Sonora, Mexico (Miller and Lowe 1967; Minckley 1973; Rinne 1976; DeMarais 1986; Bestgen and Propst 1989). Gila chub commonly inhabit pools in smaller streams, springs, and cienegas (a desert wetland), and can survive in small artificial impoundments, such as man-made ponds (Miller 1945; Minckley 1973; Rinne 1975). Gila chub are highly secretive, preferring quiet, deeper waters, especially pools, or remaining near cover including terrestrial vegetation, boulders, and fallen logs (Minckley 1973). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation by non-native fish species.

**Gila trout (*Oncorhynchus gilae*)** is federally listed as threatened with no designated critical habitat on the Gila NF. Historically, Gila trout was native to the Gila River drainage (including the San Francisco) in New Mexico and the Verde River drainage in Arizona (Miller 1950; 1972; Minckley 1973; Behnke 1992). Gila trout is found in moderate- to high-gradient perennial mountain streams above 1,660 m (5,400 ft) elevation. Streams typically flow through narrow, steep-sided canyons and valleys. Abundant invertebrate prey, cover, and water free from contaminants are also required. Cover typically consists of undercut banks, large woody debris, deep pools, exposed root masses of trees at waters edge, and overhanging vegetation (USDI FWS 2003). A great deal of time and effort has been invested in Gila trout restoration on

the Gila NF. Many streams have been cleaned out using piscicide, while others have been through ash flows from wildfire, and Gila trout have been repatriated into those streams. Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation/hybridization by non-native salmonid species.

**Headwater chub (*Gila nigra*)** is federally proposed for listing on the Gila NF. Headwater chub historically occur in a number of tributaries of the Verde River, most of the Tonto Creek drainage, much of the San Carlos River drainage, and parts of the upper Gila River in New Mexico (USDI FWS 2015b). It currently persists in all forks of the Gila River, but distribution and numbers have decreased. Habitats in the Gila River containing headwater chubs consist of tributary and mainstem habitats at elevations of 1,325 meters (m) (4,347 feet (ft)) to 2,000 m (6,562 ft) (Bestgen 1985; Bestgen and Propst 1989). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation by non-native aquatic species.

**Loach minnow (*Tiaroga cobitis*)** is federally listed as endangered with approximately 11,673 acres of designated critical habitat on the Gila NF. The loach minnow is endemic to the upper Gila River drainage of southwestern New Mexico, southeastern and east-central Arizona, and northeastern Sonora (Miller and Winn 1951; Koster 1957; Minckley 1973). The minnow was found throughout the San Francisco and Gila rivers in New Mexico, as well as lower elevation reaches of several tributaries (Koster 1957; Propst et al. 1988). Loach minnows are now restricted to the following areas: portions of the Gila River and its tributaries, the West, Middle, and East Fork Gila River (Grant, Catron, and Hidalgo counties, New Mexico); San Francisco and Tularosa rivers and their tributaries, Negrito and Whitewater creeks (Catron County, New Mexico); Blue River and its tributaries, Dry Blue, Campbell Blue, Pace, and Frieborn creeks (Greenlee County, Arizona, and Catron County, New Mexico) (NatureServe 2016). Loach minnows persist mainly in streams having relatively natural flow regimes and a predominance of native species (Propst and Bestgen 1991). Recurrent flooding is important in keeping substrate free of sediments and in helping this species maintain a competitive edge over invading non-native fishes (NatureServe 2015). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation by non-native fish species.

**Roundtail chub (*Gila robusta*)** is federally proposed for listing on the Gila NF. The species was historically considered common in deep pools and eddies of large streams throughout its range in the Upper and Lower Colorado River basins in Wyoming, Utah, Colorado, New Mexico and Arizona. Today the roundtail chub occupies about 52 percent of its historical range in the Lower Colorado River Basin and is limited to Arizona's Little Colorado, Bill Williams, Salt, San Carlos and Verde River drainages, Eagle and Aravaipa creeks, and New Mexico's upper Gila River (USDI FWS 2015b). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation by non-native aquatic species.

**Spikedace (*Meda fulgida*)** is federally listed as endangered with approximately 9,968 acres of designated critical habitat on the Gila NF. The spikedace is endemic to the Gila River drainage of southwestern New Mexico and southeastern and central Arizona, and perhaps northern-most Sonora (Koster 1957; Minckley 1973; Miller and Winn 1951). In New Mexico, spikedace was moderately common to abundant in the San Francisco River, the mainstem Gila River, and lower reaches of the three forks of the Gila River (Anderson 1978; Propst and Bestgen 1986). Spikedace have been extirpated from the San Francisco River (Anderson 1978; Propst and Bestgen 1986). The spikedace has a discontinuous distribution in the Gila River in New Mexico. It is irregularly collected in low numbers in the East Fork Gila River, regularly collected, but in declining numbers, in the West Fork Gila River, and may be extirpated from the Middle Fork Gila River

(Propst and Bestgen 1986; NMDGF unpublished data as cited by NatureServe 2016. The Cliff-Gila Valley as recently as the mid-1980s supported the largest New Mexico population of spikedace (Propst and Bestgen 1986), but its abundance there declined considerably in the late 1990s (NMDGF unpublished data as cited by NatureServe 2016). Threats include changes in flow regimes and stream characteristics from uncharacteristic fire in the uplands, unmanaged grazing, and competition/predation by non-native fish species.

**Mammals**

**Mexican gray wolf (*Canis lupus baileyi*)** is federally listed as an experimental, non-essential population on the Gila NF. Mexican gray wolves are the southernmost occurring (Nowak 1995 and 2003 as cited in Mexican Wolf Blue Range Adaptive Management Oversight Committee and Interagency Field Team 2005), rarest, and most genetically distinct gray wolf in North America (Garcia-Moreno et al. 1996). Historically the Mexican gray wolf primarily inhabited forested, mountainous terrain. The wolf does not require specific vegetation, however it reportedly most often occurred above 4,500 feet elevation in or near pine, oak, or piñon-juniper woodlands, interspersed with grassland. They occurred in the mountainous regions of the Southwest from throughout portions of southern Arizona, New Mexico, and Texas into central Mexico (NatureServe 2016). Mexican gray wolves were extirpated in the United States by aggressive predator control programs. Mexican gray wolves were reintroduced into the Blue Range Wolf Recovery Area within the Apache-Sitgreaves National Forests in Arizona in March 1998 (USFWS Mexican Wolf Recovery Program web-site https://www.fws.gov/southwest/es/mexicanwolf/BRWRP_home.cfm). In March 2000, Mexican gray wolves were translocated into the Gila Wilderness. At the end of April 2016, the wild Mexican wolf population consisted of 53 wolves with functional radio collars dispersed among 19 packs and two single wolves. The reintroduced wolves are classified as a “nonessential, experimental” population. Threats include in-breeding and human harassment.

## Species of Conservation Concern

Ninety-nine species met the initial criteria for being identified as a species of conservation concern on the Gila NF (Table 155), 52 of those species were removed from the list (Table 156; Appendix G) due to one of the following conditions: 1) the species was not known to occur on the Forest, or 2) the best available scientific information did not indicate substantial concern for the species to persist on the Forest. Forty-seven species were identified as potential species of conservation concern on the Gila NF (Table 163).

**Table 163. Potential Species of Conservation Concern (SCCs) relevant to the plan area.**

| Common Name | Scientific Name | NatureServe Rank |
|---|---|---|
| **Birds** | | |
| Gila Woodpecker | *Melanerpes uropygialis* | G5/S2B,S2N |
| **Fish** | | |
| Rio Grande sucker | *Catostomus plebeius* | G3G4/S2 |
| **Invertebrates** | | |
| "Gila" May Fly | *Lachlania dencyanna* | G1/SNR |
| A Stonefly | *Capnia caryi* | G1/SNR |
| Bearded Mountainsnail | *Oreohelix barbata* | G1/S1 |
| Black Range Mountainsnail | *Oreohelix metcalfei acutidiscus* | G2/T1/SNR |
| Black Range Mountainsnail | *Oreohelix metcalfei hermosensis* | G2/T1T2/SNR |
| Black Range Woodlandsnail | *Ashmunella cockerelli* | G1/T1/S1 |
| Cockerell Holospira Snail | *Holospira cockerelli* | G1/S1 |
| Gila Springsnail | *Pyrgulopsis gilae* | G2/S2 |
| Iron Creek Woodlandsnail | *Ashmunella mendax* | G1/S1 |
| Marsh Slug Snail | *Deroceras heterura* | G1G2/SNR |
| Mineral Creek Mountainsnail | *Oreohelix pilsbryi* | G1/S1 |
| Morgan Creek Mountainsnail | *Oreohelix swopei* | G1/S1 |
| New Mexico Hot Springsnail | *Pyrgulopsis thermalis* | G1/S1 |
| Nitrocris Fritillary Butterfly | *Speyeria nokomis nitocris* | G3/T3/SNR |
| No Common Name Snail | *Ashmunella cockerelli argenticola* | G1/T1/S1 |

| Common Name | Scientific Name | NatureServe Rank |
|---|---|---|
| No Common Name Snail | *Ashmunella cockerelli perobtusa* | G1/T1/S1 |
| No Common Name Snail | *Ashmunella tetrodon animorum* | G3/T3/S3 |
| No Common Name Snail | *Ashmunella tetrodon inermis* | G3/T2/SNR |
| No Common Name Snail | *Ashmunella tetrodon mutator* | G3/T2/SNR |
| No Common Name Snail | *Oreohelix metcalfei radiata* | G2/T2/SNR |
| No Common Name (Black Range mountainsnail) | *Oreohelix metcalfei concentrica* | G2/SNR |
| Silver Creek Woodlandsnail | *Ashmunella binneyi* | G1/S1 |
| Sonoran Snaggletooth Snail | *Gastrocopta prototypus* | G1/SNR |
| Stonefly | *Taenionema jacobii* | G2/SNR |
| Tiger Moth | *Alexicles aspersa* | G1G2/SNR |
| Whitewater Creek Woodlandsnail | *Ashmunella danielsi* | G1/S1 |
| **Plants** | | |
| Cliff Brittlebush | *Apacheria chiricahuensis* | G2/S2 |
| Davidson's Cliff Carrot | *Pteryxia davidsonii* | G2/S2 |
| Gooding's Onion | *Allium gooddingii* | G4/S1 |
| Greene Milkweed | *Asclepias uncialis* ssp. *uncialis* | G3G4/T2T3/S2 |
| Heartleaf Groundsel | *Packera cardamine (=Senecio cardamine)* | G3/S3 |
| Hess's Fleabane | *Erigeron hessii* | G1/S1 |
| Metcalfe's Penstemon | *Penstemon metcalfei* | G1/S1 |
| Mimbres Figwort | *Scrophularia macrantha* | G2/S2 |
| Mogollon Clover | *Trifolium neurophyllum* | G2/S2 |
| Mogollon Death Camas | *Zigadenus mogollonensis* | G3/S3 |
| Mogollon Hawkweed | *Hieracium brevipilum (=H. fendleri* var. *mogollense)* | G4/T2?/S2? |
| New Mexico Groundsel | *Packera quaerens* | G2/S2 |
| Pinos Altos Flame Flower | *Talinum humile* | G2/S2 |

| Common Name | Scientific Name | NatureServe Rank |
|---|---|---|
| Porsild's Starwort | *Stellaria porsildii* | G1/S2 |
| Wooton's Hawthorn | *Crataegus wootoniana* | G2/S2 |
| Wright's Dogweed | *Adenophyllum wrightii* var. *wrightii* | G1?/S1 |
| Yellow Lady's-Slipper | *Cypripedium parviflorum* var. *pubescens* | G5/T5/S2? |
| **Mammals** | | |
| Arizona Montane Vole | *Microtus montanus arizonensis* | G5/T4/S1 |
| Gunnison's Prairie Dog (prairie population) | *Cynomys gunnisoni* | G5/S2 |

## Species of Conservation Concern – Considered on Gila NF

Forty-seven species were identified as potential species of conservation concern on the Gila NF. The BASI indicates substantial concern about each species' capability to persist over the long term in the plan area. All species listed met one or more of the initial requirements for SCC. A number of sources, including professionals within Federal and State government were consulted to determine whether the species was at-risk on the Gila NF. For all potential SCCs, the ecological conditions for persistence were compared against the current and future trend of those conditions on the Forest as well as other key risk factors associated with those conditions. Concerns for persistence of the following species on the Gila NF are as follows:

### *Justifications*

**Birds**

**Gila Woodpecker (*Melanerpes uropygialis*)** occurs in low elevation, riparian woodlands. Found in the Burro Mountains along the Gila River near Patterson and Pancho Canyons. In New Mexico the species is confined to lower elevation woodlands, especially those dominated by mature cottonwoods and/or sycamores, along stream courses (Hubbard 1987 as cited in NatureServe 2016, NMDGF 1997 as cited in BISON-M 2016). These habitat types are characterized within the Cottonwood Group of ERUs as described in the Riparian Chapter and are distributed across all local units. These ERUs are moderately departed from reference conditions and approximately 66% of these ERUs contain ecological conditions necessary for persistence of the species. Riparian ERUs were not modelled using VDDT, but TEUI documentation suggests these ERUs have a stable trend. Diversions or other flood control practices can alter habitat through changes in the flood disturbance regimes and altered hydrographs necessary for establishment of certain riparian species. Competition with other cavity nesters (NatureServe 2016), particularly European starling, that compete aggressively for excavated cavities and may limit productivity (Kerpez and Smith 1990). The Gila woodpecker are only known from the Gila River Birding Area, and all Breeding Bird Survey regions, except one (Sierra Madre Occidental), show the population is declining (Sauer et al. 2014). Gila woodpecker appears to be at-risk on the Gila NF because the habitat it inhabits is uncommon, habitat is moderately departed from reference conditions, they only appear to inhabit a portion of the

available habitat on the Forest, and there is a high uncertainty of the species occurrence on the rest of the Forest.

**Fish**

**Rio Grande Sucker (*Catostomus plebeius*)** habitat includes rocky pools, runs, and riffles of small to medium rivers (Lee et al. 1980, Page and Burr 2011), usually over gravel and/or cobble, but also in backwaters and pools below riffles. This species is rarely found in waters with heavy silt and organic detritus (Sublette et al. 1990). Rio Grande sucker is found in the Mimbres, Gila, and San Francisco River drainages, as well as in Rio Grande drainages east of the Continental Divide on the Black Range. It should be noted that this fish is not native to the San Francisco River drainage and may have been introduced into the Gila River drainage, although it is uncertain (Sublette et al. 1990). A risk rating was developed for several different characteristics on the Forest and is detailed in the Water Chapter, including watershed condition, perennial streams, and streamflow. The two watersheds where Rio Grande sucker is present are both determined to be likely high risk for both perennial streams and streamflow, and potential high risk for watershed condition. Of the 10 sub-watersheds on the Gila NF that the Rio Grande sucker is known to be native and occurs or was historically present, they are only currently present in five. Four of those are moderately to highly departed in terms of fish assemblages, while one has low departure. Threats include habitat alteration from water management and flow modifications such as channelization, diversions, fire effects etc., as well as non-native predators and competitors. This is particularly evident in the Mimbres River drainage as there is a large amount of private lands that are allocated water for irrigation, and the 2013 Silver Fire burned in the uplands that may be affecting water flow, ash, etc. The amount of non-native competitors and predators is very high in the Mimbres River drainages that are likely contributing to population declines. Trend is stable in the Rio Grande and Mimbres River drainages (Sublette et al. 1990, NatureServe 2016, IUCN 2016). Overall short-term trend (<10 years) is relatively stable to decline of <30%, while long-term trend shows a decline of 10-50% (NatureServe 2016). This species should be considered at-risk on the Gila NF because of the small number of sub-watersheds in which it currently occurs, population declines, non-native species, and watershed conditions after recent wildfires that can affect perennial streams and streamflow.

**Invertebrates**

**"Gila" May Fly (*Lachlania dencyanna*)** was found in a high gradient, warm, medium river. It has only been found at junction of East Fork and mainstem Gila River clinging to woody debris. The area it was located was characterized as a warm, unshaded, turbid, and rapid stream. Specific threats are generally unknown, but likely anything that would affect other macroinvertebrates such as diversions or other de-watering of streams, reducing dissolved oxygen, pollution, or increased sediments could be considered threats. Distribution appears to be limited to the Gila River drainage in New Mexico and is the only endemic mayfly in New Mexico (McCafferty et al. 1997). Authors made no notes on abundance or trend, but felt that the Gila River drainage may be a refugium for this as well as other southwest species (McCafferty et al. 1997). This species should be considered at-risk on the Gila NF because of its restricted distribution, the proposed Gila River Diversion Project, large wildfires in the uplands, and it is identified as globally "critically imperiled" (G1) in NatureServe.

**A Stonefly (*Capnia caryi*)** was found in Iron Creek on the Gila NF in a clear, cool stream with scattered boulders and a mixture of cobble with gravels, and low (<3%) gradient. The species is only known from 2 tiny creeks; one in AZ (Mamie Creek at Escudilla Mtn.) and the other in NM (Upper Iron Creek, Catron Co). This species was only discovered in NM in February 1999 with another specimen found in March 2001 in AZ, and recently described as a new species by Bauman and Jacobi (2002). Specific threats are not known, but likely anything that may affect other macroinvertebrates such as diversions or de-watering of streams,

reducing dissolved oxygen, pollution, or increasing sediments could be considered threats. On the Gila NF it appears to be limited in its distribution to Upper Iron Creek, which is a small tributary of the Middle Fork Gila River. The authors only found and described <15 specimens, so it is likely not very abundant where it does occur. This species should be considered at-risk on the Gila NF because of its restricted distribution, large wildfires in the uplands, and it is identified as globally "critically imperiled" (G1) in NatureServe.

**Stonefly (*Taenionema jacobii*)** occurs in Gila River watershed where it was examined from larvae collected in Cherry Creek (Stewart 2009). The species has been found in the Gila River watershed into Arizona as well (NatureServe 2016). Specific threats are not known, but likely anything that may affect other macroinvertebrates such as diversions or de-watering of streams, reducing dissolved oxygen, pollution, or increasing sediments could be considered threats. In New Mexico, the species is known from <10 occurrences (NatureServe 2016), so it is likely not very abundant, and there is no trend data available for this species. This species should be considered at-risk on the Gila NF because of its restricted distribution, large wildfires in the uplands, and it is identified as globally "imperiled" (G2) in NatureServe.

**Silver Creek Woodlandsnail (*Ashmunella binneyi*)** occurs in the upper ends of Silver, Bull Top, and Spring Canyons in Black Range between 8,000-8,500 feet elevation. It has a limited distribution of approximately 2 miles north to south and occurs in ponderosa pine and Douglas-fir at the heads of these canyons. The Ponderosa Pine Forest (PPF) and Mixed Conifer with frequent fire (MCD) ERUs are highly departed across the Gila NF (Upland Vegetation Chapter), and often burn in a way that is not within its historic range of variability. The 2013 Silver Fire burned with high intensity through all the canyons in which this species was known. Little is known about habitat needs other than it occurs in rocks at the upper ends of the canyons mentioned above. The effects of fire to the species are not known, but they do occur within fire adapted ecosystems and likely evolved in the presence of fire. The high departure of these systems may not have exposed them historically to effects of higher severity fire. Threats may include uncharacteristic wildfire or any ground disturbing activities such as mining or road construction and/or maintenance; however, the terrain where this species occurs is very rugged and mostly inaccessible, so mining and road construction are not likely to occur. Metcalfe and Smartt (1997) only mention this species as being less abundant than *A. mendax* which has a broader distribution and is described as being "quite abundant". Trend appeared to be relatively stable prior to the fire as the species was found in the mid-1990s in the same areas it was originally described at the turn of the 20$^{th}$ century. This species should be considered at-risk on the Gila NF because of its restricted distribution, the 2013 Silver Fire burned all known locations of this species, and it is identified as globally and taxonomically "critically imperiled" (G1/T1) in NatureServe.

**No Common Name (*Ashmunella cockerelli argenticola*)** and **Morgan Creek Mountainsnail (*Oreohelix swopei*)** *A. c. argenticola* has been found in flourishing colonies along Forest Road 523 where it crosses Silver Creek Canyon and further north where it crosses Rustlers Canyon (a tributary or Silver Creek Canyon). It is found in the higher elevations where habitat is more mesic on rocks in deciduous leaf litter near creeks (Metcalf and Smartt 1997). *O. swopei* is found in canyons of northern Black Range, Turkey Run, head of Morgan Cr., Diamond Cr., and Black Canyon, both eastern and western slopes. These canyons are all mesic canyons with flowing water and riparian leaf litter amongst rock. Threats for both species include uncharacteristic wildfire, flooding, and any disturbances that may impact canyon bottoms and leaf litter covering rocks. The 2013 Silver Fire burned through all the canyons *A. c. argenticola* was known, as well as the uplands that feed Silver Creek and Rustlers Canyons. This will likely increase the intensity of water flow events throughout these canyons. Abundance for *A. c. argenticola* is described by Metcalfe and Smartt (1997) as being found in "flourishing colonies" in both Silver Creek and Rustlers

Canyons. *O. swopei* was described as "not abundant nor easy to find" by Metcalfe and Smartt (1997). Trend for these species appeared to be relatively stable prior to the fire as these species were found in the mid-1990s in the same areas they were originally described at the turn of the 20th century. These species should be considered at-risk on the Gila NF because of their restricted distribution, the 2013 Silver Fire burned all known locations of *A. c. argenticola*, and they are identified as globally "critically imperiled" (G1) in NatureServe.

**Black Range Woodlandsnail (*Ashmunella cockerelli cockerelli*), No Common Name (*Ashmunella cockerelli perobtusa*), Cockerell Holospira Snail (*Holospira cockerelli*), Black Range Mountainsnail (*Oreohelix metcalfei acutidiscus*), No Common Name (Black Range mountainsnail), (*Oreohelix metcalfei concentrica*), Black Range Mountainsnail (*Oreohelix metcalfei hermosensis*), No Common Name (*Oreohelix metcalfei radiata*),** and **Mineral Creek Mountainsnail (*Oreohelix pilsbryi*)** are all species that occur on the Black Range and whose habitat is described as talus of igneous rock, limestone talus or other calcareous rock, or limestone bedrock or outcrops. Also, all these species occur within the same range of woodland ERUs that are all moderately departed in the Black Range local area (Upland Vegetation Chapter). These ERUs tend to have longer fire return intervals than ponderosa pine or mixed conifer with frequent fire and tend to have fires burn that are of mixed-severity. The effects of fire to the species are not known, but they do occur within fire adapted ecosystems and likely evolved in the presence of fire. The 2013 Silver Fire burned through the known locations for all these species except *H. cockerelli, O. m. hermosensis*, and *O. pilsbryi*, although many of the areas within these woodlands burned with a low to mixed-severity. Additional threats may include any ground disturbing activities that would affect any of the rock formations mentioned above. The terrain where these species occur is very rugged and mostly inaccessible, so mining and road construction are not likely to occur. Distribution of these species is quite limited, often only known from one canyon, although some are described as being quite abundant where they do occur Trend for these species appeared to be relatively stable prior to the fire as they were found in the mid-1990s where they were originally described at the turn of the 20th century. These species should be considered at-risk on the Gila NF because of their restricted distribution, the 2013 Silver Fire burned all known locations of many of these species increasing the risk for severe flooding, and they are identified as globally or taxonomically "critically imperiled" (G1/T1) or globally or taxonomically "imperiled" (G2/T2) in NatureServe.

**Whitewater Creek Woodlandsnail (*Ashmunella danielsi*), No Common Name (*Ashmunella tetrodon inermis*), No Common Name (*Ashmunella tetrodon mutator*), No Common Name (*Ashmunella tetrodon animorum*), Sonoran Snaggletooth Snail (*Gastrocopta prototypus*),** and **Bearded Mountainsnail (*Oreohelix barbata*)** are all species that occur in canyon bottoms in riparian areas near creeks or springs in the Mogollon Mountains and the Black Range. Habitat for these species consists of igneous rock in talus on moist northern slopes, moss covered in places, and damp leaf litter in interstices, or deep canyons with riparian areas where deciduous trees produce an abundant leaf litter where snails occur under and around stones and logs. They occur from Dry Creek Canyon in the southwest Mogollon Mountains to Whitewater Creek Canyon and Willow Creek Canyon. *G. prototypus* is also found in the West Fork Gila River and fossils have been found in Trujillo Canyon in the Black Range and off Forest Service lands. Likely this species occurs in other ranges in Southwest New Mexico (Metcalf and Smartt 1997). *A. t. animorum* was only found at Holden Spring in the Black Range. All of the *A. tetrodon* subspecies need further study to determine if they are truly subspecies or all individual species (Metcalfe and Smartt 1997). The 2012 Whitewater Baldy and 2013 Silver Fires burned known locations or the uplands that drain into the creeks where these species occur on the Gila NF. This will likely increase the intensity of water flow events throughout these canyons and dry out the areas some species were found. Additional threats to these species may include flooding, or any other activities that could impact stream courses. No mention of

these species abundance is mentioned, but their distribution is limited to only a few known canyons. Trend for these species appeared to be relatively stable prior to the fires as they were found in the mid-1990s where they were originally described at the turn of the 20th century. These species should be considered at-risk on the Gila NF because of their restricted distribution, the 2012 Whitewater Baldy and 2013 Silver Fires burned known locations and much of the uplands of many of these species increasing the risk of severe flooding, and they are identified as globally or taxonomically "critically imperiled" (G1/T1) or globally or taxonomically "imperiled" (G2/T2) in NatureServe.

**Iron Creek Woodlandsnail (*Ashmunella mendax*)** occurs in wooded canyons at lower elevations but it is more widespread in wooded zones of higher elevations in the Black Range. It has been found from the town of Kingston on the east side of the Black Range crest, all the way to Gallinas Canyon on the west side of the crest. It is abundant where found and wide ranging in elevation from 5,500-9,000 feet (Metcalfe and Smartt 1997). It occurs from piñon-juniper woodlands all the way up to moist mixed conifer forests. Woodland, mixed conifer with frequent fire forest, and mixed conifer with aspen forest ERUs are moderately departed (Upland Vegetation Chapter) in the Black Range local area, but the ponderosa pine forest ERU is highly departed and likely to experience a higher fire severity than historically occurred. The upper elevations where this species occurs was burned in the 2013 Silver Fire. Effects from fire are unknown for this species, but the ponderosa pine forest ERU it occurs in likely experienced severe fire effects. Additional threats may include, increased effects due to flooding from the burned vegetation in the uplands, timber harvest, or other activities that would affect wooded canyons. Harvest activities are unlikely because of the steep, inaccessible terrain along the Black Range crest. Trend for this species appeared to be relatively stable prior to the fire as was found in the mid-1990s where it was originally described at the turn of the 20th century. This species should be considered at-risk on the Gila NF because of its restricted distribution, the 2013 Silver Fire burned approximately half of this species fairly restricted range, and it is identified as globally and taxonomically "critically imperiled" (G1/T1) in NatureServe.

**Marsh Slug Snail (*Deroceras heterura*)** is endemic to Willow Creek in the Mogollon Mtns. and from Sawyers Peak north to Morgan Creek (>20 miles as crow flies) Black Range, but appears to be widespread, and it occurs above 8,000 feet elevation. It occurs from ponderosa pine to moist mixed conifer forests (Metcalfe and Smartt 1997). Ponderosa pine forest ERU is highly departed on the Gila NF, while the mixed conifer with frequent fire and mixed conifer with aspen ERUs are moderately departed (Upland Vegetation Chapter). Much, if not all of the areas this species has been described as occupying has burned, either in the 2012 Whitewater-Baldy or 2013 Silver Fires. It appears this species requires more mesic habitats that may experience a drying trend because of the large fires. Additional threats may include timber harvest, road construction, or any other ground disturbing activities in these vegetation types. Much of the area this species occurs is wilderness area and/or very rugged terrain, thereby eliminating most threats to the species. No information was found about this species abundance or trend, and no efforts have been made to re-locate the species since originally being described by Pilsbry in the mid-1940s (Metcalfe and Smartt 1997). This species should be considered at-risk on the Gila NF because of its restricted distribution, the 2012 Whitewater Baldy and 2013 Silver Fire burned most, if not all, of this species fairly restricted range, it is identified as globally and taxonomically "critically imperiled" (G1/T1) in NatureServe, and there is a high uncertainty of the species occurrence on the rest of the Forest.

**Gila Springsnail (*Pyrgulopsis gilae*)** occurs in cool to warm springs in rhyolite fissures adjacent to the Gila River. The species is common within cool water springs within its range. There are 1,807 known seeps and springs on the plan area, with 51% of those occurring on Forest Service lands (Water Chapter). It is possible this species occurs in locations that are not on Forest Service lands that have had no survey. It is known from the East Fork, Middle Fork, and Mainstem Gila River, as well as tributaries forming the East

Fork (Beaver, Taylor, Whitetail, and Whitewater Creeks). Gila springsnail is relatively well distributed in the Gila River Drainage. USFWS determined listing of the species was not warranted after additional survey attempts yielded several additional locations of the species. Threats include habitat modification from water diversion, drying of springs/creeks, livestock trampling, and wetland habitat loss (NatureServe 2016, BISON-M 2016). The areas the Gila springsnail occupies already offer protections because other listed species occur in the same locations that also benefit this species. The short-term trend of this species is relatively stable (<10% change) (NatureServe 2016), and current management already offers some protections that would benefit this species. Long-term trend for this species is unknown (NatureServe 2016). This species should be considered at-risk on the Gila NF because it is identified as globally "imperiled" (G2) in NatureServe.

**New Mexico Hot Springsnail (*Pyrgulopsis thermalis*)** this species inhabits thermal waters (91-100 degrees F) issuing from multiple sources along a vertical cliff feature along the Gila River. Principal outflows are generally too hot for the snail, so they occur in cooler portions of the outflows. While seeps and springs have been mapped and assessed in the Water Chapter, it does not separate springs by warm or cold springs. Species occurs along a 3 mi stretch of the lower East Fork Gila River and another population 1.5 mi below the confluence of the East and West Forks Gila River (NatureServe 2016). Threats include habitat degradation from recreational bathing and water pollution/contaminants. The species only occurs within wilderness areas which may afford it some protections. It is only known from 2 sites and threats are potentially affecting both. One from recreational bathing and unauthorized digging/diverting water, and the other from water diversions on private land. The short-term trend is relatively stable (<10% change), while the long-term trend is unknown (NatureServe 2016). This species should be considered at-risk on the Gila NF because both known populations are potentially being impacted by human disturbance, and it is identified as globally "imperiled" (G1) in NatureServe.

**Nitrocris Fritillary Butterfly (*Speyeria nokomis nitocris*)** is limited to moist, montane meadows and occurs in alpine meadows on the Gila NF (Zimmerman 2001). The historic population known from the confluence of Little Creek and the Gila River was surveyed for and not found in 2000. Willow Creek campground is the only known extant population on the Gila NF, and it appears to hold fewer numbers than in years past (Zimmerman 2001). Threats may include Willow Creek campground development, collection, overgrazing, or any disturbance that reduces or eliminates *Viola nephrophylla* (Zimmerman 2001). Much of the spruce-fir forest ERU this butterfly occupies has been burned by wildfire in the last 5 years, is very departed, and it is modelled to worsen in the future. This ERU historically experienced high-severity, stand replacement fire; however, not likely at the scale it has seen in recent years (Upland Vegetation Chapter). This species should be considered at-risk on the Gila NF because there is only one extant site, numbers appear to be declining, and it is located in a high recreational use area.

**Tiger Moth (*Alexicles aspersa*)** - *Alexicles* is known from extreme NE Arizona and NW New Mexico. Details of its distribution in New Mexico is not recorded. Its life history and habitat requirements are not known. *Alexicles aspersa* was probably added to the NM list because of its limited distribution in New Mexico in habitats that are generally inaccessible because the lands are in Tribal Reservations (Metzler 2014). Two historical sightings are documented in southwestern New Mexico, one in Grant Co. and one in Sierra Co., but no specific locations were given (BugGuide 2016), so it is unknown if locations were on the Gila NF. This species life history and ecology are unknown, but it has been raised on dandelion and lettuce leaves in captivity (NatureServe 2016). Because nothing is known of *A. aspersa's* life history or habitat requirements, it is not possible to identify any specific threats (Metzler 2014). This species should be considered at-risk on the Gila NF because it is identified as globally "imperiled" (G2) in NatureServe.

**Plants**

**Wright's Dogweed (*Adenophyllum wrightii* var. *wrightii*)** occurs in piñon/juniper woodland, in sandy or silty soils in swales or drainages. The piñon-juniper woodland and piñon-juniper grassland ERUs have a low to moderate departure across the Gila NF (Upland Vegetation Chapter). On the Gila NF it is found from near the town of Fierro at the south end of the Forest, north and east to HWY 59, north of the town of Winston. Threats to this species are not well known, but may include unmanaged grazing and possibly spraying for unwanted weeds. In some areas of Mexico, it grows in abundance and it is treated as a weed (NMRPTC 1999). The species appears to be fairly well distributed on the Gila NF and it occurs within ERUs that have low to moderate departure. Populations in New Mexico were reported as "healthy and reproducing normally" (NMRPTC 1999). Range was expanded during the abnormally wet summer of 2006 when numerous populations of the plant were discovered. Additional surveys during wet summers may further extend this species range into other mountain ranges in New Mexico (NMRPTC 1999). The NMRPTC (1999) now considers this species common within its range in New Mexico. Because of the increase in the number of populations of this species, the trend is thought to be increasing. This species should be considered at-risk on the Gila NF because it is identified as globally "critically imperiled" (G1?) in NatureServe.

**Gooding's Onion (*Allium gooddingii*)** occurs in spruce-fir forest, mixed conifer with aspen from 6,500-9,400 ft. Mixed conifer with aspen and spruce-fir forest ERUs are moderately to highly departed on the Gila NF, and spruce-fir forest is modelled to get worse into the future (Upland Vegetation Chapter). This is likely because the majority of this ERU burned in the last 5 years with high severity. While the spruce-fir ERU historically burned on a 150-400 year cycle with mixed severity to stand replacement fire, the mean patch size of the disturbances was historically 200-1,000 acres (Upland Vegetation Chapter). A total of 28 out of 30 known occupied sites have been burned by wildfires since 2006, with 21 of them 30 burning during the Whitewater Baldy fire in 2012 (Roth 2016). Surveys post-fire found the species was present even in areas that burned with high severity. Surveys by Roth (2016) show that the plant is able to survive direct effects of fire, but likely will not persist in post-fire environment as evidenced by disappearance of a known population consisting of thousands of plants within the 2006 Bear Fire. This species is adapted to growing under the canopy of mixed conifer forests (Roth 2016), therefore it is likely that it persisted historically even though the ERUs it occurs in burn typically with severe conditions. The extent of fires that burned historically were not likely as broad as the most recent fires, which could impact persistence with fewer sites that are considered suitable. This species occurs from Freiborn Canyon, north of Eagle Peak in Long Canyon, south to Willow Creek Campground. Additional threats include impacts from flooding in the post-fire erosion events (Roth 2016), collection, grazing, logging, but it has been known to return following disturbance (NatureServe 2016). Results from Roth (2016) surveys show that abundance may have decreased, and the trend appears to be declining. This species should be considered at-risk on the Gila NF because approximately 93% of existing sites have burned within the last 10 years, ERUs this species occurs in are moderately and highly departed and not modelled to improve in the future, and both abundance and trend appear to be declining on the Gila NF.

**Cliff Brittlebush (*Apacheria chiricahuensis*)** occurs in areas containing bare rock/talus/scree/cliff, such as limestone or rhyolitic rock outcrops in Rocky Mountain montane conifer forests between 5,500-7,000 feet elevation (NMRPTC 1999). On the Gila NF it is found in Running Water Canyon, a tributary to Diamond Creek, in the Aldo Leopold Wilderness area. Mineral exploration and development are identified threats that could possibly impact some populations. However, on the Gila NF the cliff habitat in which the species occurs effectively removes threats to this species as it occurs in a wilderness area where mining is withdrawn. Although it has only been found in one canyon on the Gila NF, it is likely undersurveyed as the areas it inhabits are very inaccessible. The geologic formations necessary for the species are likely in low

departure from reference conditions. No information on abundance has been noted on the Gila NF specifically, but it is reported to be common and abundant in suitable habitat in the San Mateo and Animas Mountains (NMRPTC 1999) which the Gila NF falls right in between both. Trend is not described for the species either, but given the habitat in which it occurs, it is likely stable. This species should be considered at-risk on the Gila NF because it is only known from one canyon on the Gila NF, and it is identified as globally "imperiled" (G2) in NatureServe.

**Greene Milkweed (*Asclepias uncialis* ssp. *uncialis*)** occurs in grasslands, on sandy to rocky soils and within an elevational range of 5,000-7,000 ft. On the Gila NF it has only been found in one location approximately 1/4 mile from NM/AZ border (6 plants). The location where this population is mapped puts the species within the Colorado Plateau/Great Basin grassland ERU, but it may potentially occur within the juniper grassland ERU where they intergrade. The Colorado Plateau/Great Basin grassland ERU is highly departed, while the juniper grassland ERU is in low to moderate departure across the Gila NF, and they are not modelled to improve in the future (Upland Vegetation Chapter). Identified threats to the species include residential development (particularly in Arizona), agriculture, and livestock operations. The trend over the last 100 years is not well known, but it is likely declining (NatureServe 2016). This species should be considered at-risk on the Gila NF because it is only known from one population of 6 plants on the Gila NF, it occurs within an ERU that is highly departed and not modelled to improve into the future, and it is identified as taxonomically "imperiled" (T2) in NatureServe.

**Wooton's Hawthorn (*Crataegus wootoniana*)** occurs in riparian habitat in montane conifer forest at an elevational range of 6,500-8,000 ft. Riparian ERUs are in low to moderate departure on the Gila NF (Riparian Chapter). The species is distributed from the head of Little Creek off of the West Fork Gila River, south to Silver City. This species has been infrequently described on the Gila NF historically, with no documentation on abundance (NatureServe 2016). It is likely this species is not very abundant on the Gila NF because of this. Identified threats may include drought, climate change, timber harvest activities, possibly riparian disturbances, and wildfire effects. Because this species has been described infrequently with little work being done on it, little is known about the abundance and trend of the species. This species has not been specifically surveyed for, but it has been documented on the Forest and continuously documented in certain areas so the trend may be stable. This species should be considered at-risk on the Gila NF because it is identified as globally "imperiled" (G2) in NatureServe.

**Yellow Lady's-Slipper (*Cypripedium parviflorum* var. *pubescens*)** occurs in mesic meadows in ponderosa pine and mixed conifer forests, and wet areas along streams. Much of the ERUs (Ponderosa Pine Forest, Mixed Conifer with Frequent Fire, and Mixed Conifer with Aspen) this plant occurs in, including both known populations, have been burned in the last 5 years, and these ERUs are very departed and modelled to worsen in the future (Upland Vegetation Chapter). The species also appears to prefer growing in acidic soils. The species has only been documented at 2 sites on the Gila NF (Little Creek Box, and Little Turkey Creek) in 1978 and 1966, respectively, but no collections or surveyors named (Natural Heritage NM 2015). The Gila NF appears to be on the very periphery of the species range. Both known locations likely burned in the Dry Lakes Fire in 2003, and the Miller Fire in 2011, but the severity of the fires in the occupied sites is not known. No known attempts have been made to relocate the historic plant locations, so abundance and trend of the species on the Gila NF is not known. Identified threats include plant collection and habitat loss/degradation (NMRPTC 1999). There has been a range-wide decline of the species of 10-30% (NatureServe 2016). This species should be considered at-risk on the Gila NF because the ERUs in which it occurs are moderately to highly departed, the species is only known from two sites that are isolated from any other known plants, and the two known sites have both burned in wildfires.

**Hess's Fleabane (*Erigeron hessii*)** occurs in mixed conifer or sub-alpine forest at an elevational range of 9,500-10,200 feet. This species is a very narrow endemic with three sites documented near Whitewater Baldy. The species occurs exclusively and is dependent upon exposed rock or rocky outcrops (NMRPTC 1999). All three sites of this species occurred within the 2012 Whitewater-Baldy Fire perimeter, but it is not likely impacted or possibly even positively impacted by the fire. Also, it is experiencing few, if any, alterations to its habitat from direct impacts of the fire or post-fire impacts (Roth 2016). Exposed rock and cliff habitat where this species grows has not been altered and is likely in low departure from reference conditions. The fact that the species occurs in wilderness areas, offers protections from most threats to the species. One site had approximately 100 plants in full to late flowering stage on a rock outcrop during a 2013 survey of the known sites (Roth 2016). No surveys or studies have been conducted on this species, so trend is unknown but likely stable as they occur and persist in the known historic locations. This species is expected to persist into the future (Roth 2016). This species should be considered at-risk on the Gila NF because it is identified as globally "critically imperiled" (G1) in NatureServe.

**Mogollon Hawkweed (*Hieracium brevipilum* (=*H. fendleri* var. *mogollense*))** occurs in ponderosa pine to mixed conifer forests from 8,200-10,500 feet elevation (NMRPTC 1999). Much of the ERUs (Ponderosa Pine Forest, Mixed Conifer with Frequent Fire, and Mixed Conifer with Aspen) this plant occurs in are moderately to highly departed and modelled to worsen in the future (Upland Vegetation Chapter). This species is found from near Mogollon Baldy, north to Willow Creek. More work needed to determine effects from logging, as well as determining abundance and habitat requirements, but the species appears to respond positively to disturbance from fires. This species occurs within the 2012 Whitewater-Baldy Fire perimeter and it is not likely impacted or possibly even positively impacted by the fire, and it is experiencing few, if any, alterations to its habitat from direct impacts of the fire or post-fire impacts (Roth 2016). This species is known from wilderness areas that provide protections from most management activities. Surveys for this species were conducted after the 2012 Whitewater Baldy Fire and they were found to be highly localized, but abundant where they occurred, ranging from 50 to thousands of plants at each site (Roth 2016). Previously undocumented sites were also located during this survey, and it is felt that additional surveys in suitable habitat would likely document additional currently unknown populations. Since surveys by Roth (2016) located historic populations and identified new ones, the trend appears to be stable to slightly increasing. This species is expected to persist into the future (Roth 2016). This species should be considered at-risk on the Gila NF because it is identified as taxonomically "imperiled" (T2) in NatureServe.

**Heartleaf Groundsel (*Packera cardamine* (=*Senecio cardamine*))** occurs in mixed conifer wet and spruce-fir forest, typically above 8,000 feet elevation (Roth 2016). It is generally associated with Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), Mountain spray (*Holodiscus dumosus*), aspen (*Populous tremuloides*), alpine woodsorrel (*Oxalis alpina*), wild geranium (*Geranium* sp.), nodding ragwort (*Senecio bigelovii*), and Canadian violet (*Viola canadensis*) (Roth 2016). These ERUs are at moderate to high departure from reference conditions on the Gila NF and not modelled to improve over time (Upland Vegetation Chapter). Populations of this plant are distributed around Willow Mountain, just northwest of Whitewater-Baldy. Likely threats include drying out of sites because of timber harvest or forest fire. Many populations are on steep, inaccessible slopes (NMRPTC 1999, Roth 2016), but most populations likely burned in the 2012 Whitewater-Baldy Fire. While the spruce-fir ERU historically burned on a 150-400 year cycle with mixed severity to stand replacement fire, the mean patch size of the disturbances was historically 200-1,000 acres (Upland Vegetation Chapter). This species is adapted to growing under the canopy of mixed conifer forests (Roth 2016), therefore it is likely that it persisted historically even though the ERUs it occurs in burn typically with severe conditions. The extent of fires that burned historically were not likely as broad as the most recent fires, which could impact persistence with fewer sites that are

considered suitable. This species still occupied the general areas and habitat from where they were documented prior to the 2012 fire. Surveys conducted by Roth (2016) showed that plants were found in groupings of a few plants to thousands of plants, well past flowering stage. It can be assumed that these rare plants generally survive the direct impacts of fires, regardless of fire severity (Roth 2016). However, long term impacts of radical habitat alteration caused by severe fires may ultimately cause the decline or even disappearance of several species from their current occupied habitats (Roth 2016). This species should be considered at-risk on the Gila NF because all but one existing site has burned within the last 5 years, and ERUs this species occurs in are moderately and highly departed and not modelled to improve in the future.

**New Mexico Groundsel (*Packera quaerens*)** occurs in wet meadows and streambanks in upper montane coniferous forest (8,000-9,000 feet elevation). Its locations on the Gila NF have been mapped in the Arizona alder-willow, upper montane coniferous-willow, and ponderosa pine-willow ERUs, all of which are in low to moderate departure from reference conditions (Riparian Chapter). Several of the species in the *Packera hartiana* complex, which includes *P. quaerens*, are very difficult to differentiate, but *Packera quaerens* is treated as its own distinct species in the NRCS PLANTS database (NMRPTC 1999). Plants do not appear to recolonize eroded or disturbed areas (NatureServe 2016). The species is distributed across the Gila NF from the Burro Mountains, northeast to the town of Kingston on the eastern boundary of the Gila NF, north and west to the Arizona state line north of Alpine, Arizona. Identified threats include livestock grazing, recreation, logging, stream siltation, flooding, erosion, loss of habitat due to reservoir construction, and collecting (NatureServe 2016). Loss of habitat due to large wildfire and climate change may also be a factor, as 12 of the 17 known collection sites for this species were likely burned in the 2012 Whitewater-Baldy Fire. Severity of the fire at the sites is not known, and surveys have not been conducted to document abundance or trend for the species on the Gila NF. Overall trend for the species appears to be declining in New Mexico, but the rate of decline is unknown (NatureServe 2016). This species should be considered at-risk on the Gila NF because it is identified as globally “imperiled” (G2) in NatureServe.

**Metcalfe's Penstemon (*Penstemon metcalfei*)** occurs in cliffs and steep north slopes of montane conifer forest from 6,600-9,500 feet elevation. This species occurs within the ponderosa pine and mixed conifer with frequent fire ERUs, which are moderately to highly departed from reference conditions (Upland Vegetation Chapter). Associated species include Douglas fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), Gambel oak (*Quercus gambelii*), orange gooseberry (*Ribes pinetorum*), alpine woodsorrel (*Oxalis alpina*), scarlet penstemon (*Penstemon barbatus*), New Mexico locust (*Robinia neomexicana*), red elderberry (*Sambuccus racemosa*), chokecherry (*Prunus virginiana*), canyon maple (*Acer grandidentatum*), and aspen (*Populus tremuloides*) (Roth 2016). It is presently known from a small region of the Black Range in Trujillo and Percha canyons. The majority of the occupied habitat and all 5 knowns sites of Metcalfe’s penstemon burned moderately to severely in the 2013 Silver Fire (Roth 2016). In addition to fire severity impacts and canopy removal, much of the stream bank habitat of Metcalfe’s penstemon was significantly impacted by post-fire erosion, including stream bank scouring and incision, debris flows and large volumes of debris deposition (Roth 2016). Because very few plants were documented in 2014 and Metcalfe’s penstemon appears to have a preference for growing in cool, shady areas, underneath the canopy of mixed conifer forests and along stream banks, the species may not persist over time in the majority of documented sites on the Gila National Forest, due to radical habitat alterations caused by the Silver Fire (Roth 2016). A total of 138 plants were found during the post-fire surveys conducted by Roth (2016), and no plants were found at the type locality where there were once “thousands” documented. Trend for this species appears to be declining on the Gila NF. This species should be considered at-risk on the Gila NF because the majority of its habitat and all known locations

have burned in the last 5 years, the ERUs it occurs within are moderately to highly departed from reference conditions, and it is identified as globally "critically imperiled" (G1) in NatureServe.

**Davidson's Cliff Carrot (*Pteryxia davidsonii*)** occurs on moist, rocky places on sheer north facing cliffs in woodland ERUs between 6,500-8,000 feet elevation (NMRPTC 1999). The woodland ERUs are in low to moderate departure from reference conditions across the Gila NF (Upland Vegetation Chapter). The species is found in the Burro Mountains, near Silver City, and near the town of Mogollon. Threats are not well known but may include mining or mineral exploration. This plant inhabits cliff faces that are very inaccessible, and which effectively removes most threats to this species. Geologic features that comprise cliff habitat likely are in low departure from reference conditions. Another threat to the species may include uncharacteristic wildfire. The 2012 Whitewater-Baldy fire may have burned one of the known sites, but no surveys have been conducted to evaluate effects. There is no documentation on abundance or trend for this species on the Gila NF, but it may be more abundant than we think because it inhabits rugged, inaccessible habitat that is difficult to survey. Also, trend for the species on the Gila NF may be stable based on that same inaccessibility. Range-wide, short-term trend is relatively stable <10% change, while the long-term trend is estimated to be stable with no evidence to the contrary (decline of <30% to increase of 25%) (NatureServe 2016). This species should be considered at-risk on the Gila NF because it is identified as globally "imperiled" (G2) in NatureServe.

**Mimbres Figwort (*Scrophularia macrantha*)** occurs on north facing slopes in piñon-juniper woodlands to dry mixed conifer between 6,500-8,200 feet elevation (NMRPTC 1999). Woodland ERUs are in low to moderate departure from reference conditions, but ponderosa pine and mixed conifer forest with frequent fire are moderately to highly departed from reference conditions (Upland Vegetation Chapter). Fire may have impacted frequent fire ERUs (ponderosa pine and mixed conifer with frequent fire forests) more severely than the woodland ERUs. This species is located along the HWY 152 corridor in Gallinas, Railroad, and Bear Canyons on the east side of the Black Range crest. Many of these populations may have been misidentified as the similar looking mountain figwort (*Scrophularia montana*), which occurred within the habitat of Mimbres figwort (Roth 2016). This may explain why several of the historic populations may not have been found, particularly the locations outside the 2013 Silver Fire boundary. Mimbres figwort may be far more rare than previously thought (Roth 2016). Currently, 15 of 16 existing sites occur within the 2013 Silver Fire boundary. Most of these previously documented sites did not burn, but may have experienced some post-fire flooding and associated scouring of the stream banks. Nonetheless, plants should still be expected along the slopes adjacent to the stream banks, from where they were previously reported. Because Mimbres figwort appears to have a preference for growing in cool, shady areas, underneath the canopy of mixed conifer forests and along stream banks, the species may not persist over time in the majority of documented sites on the Gila National Forest due to radical habitat alterations caused by the Silver Fire (Roth 2016). Additional threats may include mining or mineral exploration, road construction or maintenance, and collection, particularly adjacent to campgrounds where this plant was historically found. No documentation on abundance was available before the fire on the Gila NF, but post-fire surveys conducted by Roth (2016) documented fewer than 400 individuals within the fire perimeter and only 10 outside. They were located in groups of 25 individuals or less. Trend has not been documented for this species on the Gila NF, but the plant was not found at historic sites, most of which were outside the fire boundary. The trend may therefore be declining, but it may be due to factors other than the fire effects. Also, misidentification of the plant within several of the historic sites may explain why the plant was absent from some of the sites and the trend may be more stable. This species should be considered at-risk on the Gila because its trend may be declining, all but one known site was burned in the 2013 Silver Fire, and it is identified as globally "imperiled" (G2) in NatureServe.

**Porsild's Starwort (*Stellaria porsildii*)** occurs in shade and partially open understory of mixed conifer with aspen between 7,900-8,200 feet elevation (NMRPTC 1999). Mapped locations on the Gila NF show that this plant may occur within ponderosa pine, mixed conifer with frequent fire, and mixed conifer with aspen ERUs on the Gila NF. The Ponderosa pine forest ERU is highly departed from reference conditions, while the mixed conifer with frequent fire and mixed conifer with aspen ERUs are moderately departed from reference conditions (Upland Vegetation Chapter). These ERUs are not modelled to improve in the future. This species is occasionally found scattered on roadsides with steep, loamy and rocky embankments. It has been found along roadsides on the road to Signal Peak in the Pinos Altos Range and in the immediate vicinity of Signal Peak on the Gila NF. Road maintenance activities may impact populations that occur along roadsides or road cuts. Drought is reported as a threat as plants may not emerge during dry periods. Additionally, forest fire, grazing, and recreational impacts may be threats but have not been studied (NatureServe 2016). All known populations on the Gila NF have been burned in the 2014 Signal Fire. There is no documentation for abundance on the Gila NF, but this species has only been found in two disjunct populations (one in AZ and one in NM) and are known to occupy only a small area in each. This species is not likely very abundant. Trend has also not been documented for this species as it has not been studied, but may be declining since this is a shade-loving species and much of the forest overstory where this plant occurred was removed by the 2014 Signal Fire. This species should be considered at-risk on the Gila because its trend may be declining, all known sites were burned in the 2014 Signal Fire, and it is identified as globally “critically imperiled” (G1) in NatureServe.

**Pinos Altos Flame Flower (*Talinum humile*)** occurs in pine/oak woodland on rocky, south facing slopes, usually on shallow, gravelly, usually clayey soils overlaying rhyolite (NMRPTC 1999). Mapped locations on the Gila NF place this species in piñon-juniper woodland, Madrean pine-oak woodland, and ponderosa pine-evergreen oak forest ERUs. The woodland ERUs are currently in low to moderate departure from reference conditions, while the ponderosa pine-evergreen oak ERU is moderately departed (Upland Vegetation Chapter). Modelling suggests these ERUs will remain in the same conditions or get worse in the future. This species is distributed in the Pinos Altos Range and around the Mimbres Valley. It is located along HWY 15 in the Pinos Altos Range north of Silver City, east to Noonday and Gallinas Canyons, and in Rabb Park. Threats include grazing and, to a lesser extent, housing developments. Threats from grazing in at least two sites in New Mexico have been alleviated causing those populations to "explode" until other vegetation became competitive. This plant seems to grow in inaccessible areas where grazing is the only threat (NMRPTC 1999). Abundance is not well known on the Gila NF, but it is likely not very abundant as range-wide numbers are a little more than 2,000 individuals. Trend is not well documented on the Gila NF, but the locations where the numbers “exploded” are at sites immediately adjacent to the Forest boundary. Grazing occurs on Forest Service lands, so trend may be stable to declining. Overall trend for the species range-wide shows a short-term trend of a 30-70% decline (NatureServe 2016). This species should be considered at-risk on the Gila because its trend may be declining, and it is identified as globally “imperiled” (G2) in NatureServe.

**Mogollon Clover (*Trifolium neurophyllum*)** occurs in wet meadows, springs, and along riparian corridors in montane coniferous forest from 6,500-9,000 feet elevation (NMRPTC 1999). It can occur within ponderosa pine forest, mixed conifer with frequent fire forest, upper montane coniferous-willow, ponderosa pine-willow, Arizona alder-willow, and herbaceous wetland ERUs on the Gila NF (Upland Vegetation Chapter). The two forested ERUs are moderately to highly departed from reference conditions, while the riparian ERUs are in low to moderate departure across the Gila NF. There is no departure data for herbaceous wetlands, so the departure of that ERU is not known. The forested ERUs have been modelled and show no improvement into the future, but the riparian ERUs have not been modelled because there was insufficient data for model runs (Riparian Chapter). In AZ the plant has been found in

drier areas (ponderosa pine forest, mixed conifer with frequent fire ERUs), but not in NM. The species has a fairly broad distribution on the Gila NF and is found from just east of the town of Mogollon, north and east to the Tularosa Mountains, north to the Mangas Mountains, and west to the Arizona state line. Threats include drought and impacts to riparian habitat due to grazing, both native and domestic, or drying of streams or wet meadows through water developments (NatureServe 2016, NMRPTC 1999). Abundance is not well documented on the Gila NF, but estimates of known sites show there are approximately between 10,000-16,000 individuals distributed across the Gila NF with several populations containing several thousand individuals. Trend has not been documented on the Gila NF, but it may be decreasing due to continued habitat disturbance from grazing pressures and continued drought conditions (NatureServe 2016). This species should be considered at-risk on the Gila because its trend may be declining, and it is identified as globally "imperiled" (G2) in NatureServe.

**Mogollon Death Camas (*Zigadenus mogollonensis*)** occurs in wet mixed conifer, sub-alpine fir >8,700 ft (NMRPTC 1999). The mixed conifer with aspen and spruce-fir forest ERUs are moderately to highly departed from reference conditions on the Gila NF, and the spruce-fir ERU is modelled to worsen into the future (Upland Vegetation Chapter). While the spruce-fir ERU historically burned on a 150-400 year cycle with mixed severity to stand replacement fire, the mean patch size of the disturbances was historically 200-1,000 acres (Upland Vegetation Chapter). This species is adapted to growing under the canopy of mixed conifer forests (Roth 2016), therefore it is likely that it persisted historically even though the ERUs it occurs in burn typically with severe conditions. The extent of fires that burned historically were not likely as broad as the most recent fires, which could impact persistence with fewer sites that are considered suitable. All known populations burned during the Whitewater-Baldy Fire in 2012. Thirty-four sites where this plant occurred within the 2012 Whitewater-Baldy fire perimeter were documented, and only 6 of the sites had not burned. In 28 of the sites, fire burned severely and up to several thousand plants were found at these sites. In the 6 unburned sites there were 71 plants found. The species was found to be growing post-fire in numerous locations, but because Mogollon death camas has never been observed to grow naturally in open areas, the species may not persist over time in the majority of documented sites on the Gila National Forest due to radical habitat alterations caused by the Whitewater-Baldy Fire (Roth 2016).The species is distributed in the Mogollon Mountains, centered around Willow Mountain, in an area of approximately 5 miles x 6.5 miles (Roth 2016). This plant is not threatened by current forest uses, and livestock will not intentionally eat them as they are thought to be poisonous (NMRPTC 1999). Trend has not been documented on the Gila NF, but may decline due to alterations to its habitat after the 2012 Whitewater-Baldy fire. This species should be considered at-risk on the Gila because its trend may be declining, and the ERUs in which the species occurs are moderately to highly departed and modelled to get worse in the future.

**Gunnison's Prairie Dog (prairie population) (*Cynomys gunnisoni*)** occurs in grasslands/shrublands 6,000-12,000 ft. The species is relatively well distributed in the north half of the Gila NF as it is found from Kemp Mesa, near Beaverhead, north and west to the northern boundary of the Gila NF. Information is lacking on population size or trends, but it is thought some of the populations on the Gila NF are declining (Jerry Monzingo pers. comm.). Habitat restoration work currently being conducted in areas that are occupied may benefit the species by moving grasslands more toward reference conditions. Short-term trend appears to be relatively stable to <30%, but the long-term trend shows a 70-90% decline (NatureServe 2016). This species should be considered at-risk on the Gila NF because the ERUs they inhabit are moderately to highly departed and not modelled to improve in the future, numbers on the Gila NF may be declining, and high susceptibility to Sylvatic plague.

**Arizona Montane Vole (*Microtus montanus arizonensis*)** occurs in mesic meadows in ponderosa pine and mixed conifer. The ponderosa pine forest, mixed conifer with frequent fire, and mixed conifer with aspen ERUs are highly, moderately to highly, and moderately departed, respectively (Upland Vegetation Chapter). The species is found in two disjunct and isolated locations on the Gila NF. One location is in the northwest part of the Forest in Centerfire Bog, while the other is located to the west near the Arizona state line in Jenkins Creek (Frey et al. 1995). These two locations are separated by approximately 8 miles. Threats include habitat alteration through over-grazing or other activities that dry out mesic meadows (BISON-M 2016). Abundance of the species may be quite low as trap attempts yielded only one vole, even though 40 Sherman traps were set and there was an abundant number of vole runways with fresh feces and grass clippings (Frey et al. 1995). In New Mexico, the trend is unknown as the previously mentioned sites are the only locations the vole has been found. However, in Arizona surveys have found that it is much more abundant than once thought (BISON-M 2016). This species should be considered at-risk on the Gila NF because the ERUs they inhabit are moderately to highly departed and not modelled to improve in the future, only two isolated populations have been found on the Gila NF, and numbers at both sites appear to be very low.

## Stakeholder Input

Over the past year, the Gila NF has initiated the first phase of Forest Plan Revision and began working on an Assessment of the Gila NF resources. Throughout that time period there have been community meetings, symposiums, and presentations given on the various aspects of the assessment where the public and other stakeholders have been encouraged to provide any input, comments, or additional information sources to aid in the development of the assessment. The comments have been compiled by resource area and evaluated to help create the most comprehensive assessment from which to base the revised forest plan.

There were many comments regarding at-risk species and species of conservation concern (SCC) ranging from a few words to several pages. Several of the comments were quite polarized in the message including comments on grazing (too much, too little), threatened and endangered species (too many, too few), predators (too many wolves and coyotes, need more apex predators), and human influence to the ecological landscapes (reduce human influence, actively manage Forest). Some comments brought up things that the Forest Service has no control over (i.e. species listings, hunting regulations) which highlights that there may be misconceptions about what the Forest Service does and the responsibilities the agency has. There were also several suggestions on where to find relevant information to incorporate into the assessment.

Even with these polarized comments, there were some common themes that most people felt the Gila NF needs to capture and take forward into the plan revision phase. The use of sound science in developing management practices for all issues from grazing to fire use to fisheries management. This appeared to be the single most commonality amongst commenters providing input. Another important item was the need for not just monitoring, but focused and meaningful monitoring. It is felt that better information to inform managers will aid in providing adaptive management for a resilient landscape. There was also a feeling that the agency needs to manage the Forest more holistically to get away from single species management and manage in a way that benefits multiple species and resources.

Fortunately the 2012 Planning Rule Directives attempt to address the very comments the Gila NF received during public input. They direct the Gila NF to use Best Available Scientific Information as well as guiding the Forest to manage landscapes using the Ecological Response Unit and SCC concepts. The general premise of these concepts is to manage the Forest in a way that restores or maintains ecological integrity which in many cases will move the Forest closer to reference conditions. This ecological integrity should

provide conditions favorable to species that occur and evolved in those systems, thus managing in a holistic manner.

## Summary

The Gila NF is home to hundreds of animal and plant species, some of which are found only on the Gila NF, and others for which changing land-use patterns in the broader landscape have increased their reliance on Gila NF managed lands. These species provide many ecosystem services, including: (1) supporting services, such as nutrient cycling, soil formation and manipulation, primary production, and seed dispersal; (2) regulating services, including carbon sequestration, pollination, and erosion control; (3) provisioning services, such as food, fiber, medicine, and forest products; and (4) cultural services, including recreation, opportunities for scientific discovery and education, and cultural, intellectual, or spiritual inspiration. The most important drivers of change in ecosystem services are habitat change, climate change, invasive species, overexploitation, and pollution. This chapter focuses on at-risk species that occur on the Gila NF, which indicate the ecosystem services provided by these species are decreasing and at risk.

At-risk species decisions are based on best available scientific information. Unfortunately many species lack specific information on current population status, distribution, or abundance making it difficult to determine risk. Another confounding issue is scale. Although some species information indicate increase or a decline on a large geographic scale (i.e. nationwide or statewide), forest-wide expertise may not suggest a similar determination. Should any new information become available the plan can be amended to accommodate the new information.

There are 61 at-risk species on the Gila NF, 14 are federally listed threatened or endangered and 47 are identified as species of conservation concern. A total of 14 federally recognized species (five endangered, seven threatened, two proposed threatened) were determined to be relevant to the plan area. Of the 14, seven are fish, three birds, two reptiles, one mammal, and one amphibian.

Potential SCC were determined following guidance in the proposed directives issued for the 2012 Planning Rule. Wildlife and plant species identified as at-risk by a number of different entities were considered. The species that were ultimately considered to be at-risk met the following criteria: (1) met the initial requirements; (2) had been documented on the Gila NF; and (3) had the potential to be both positively and negatively affected by Forest Service management activities. An overall risk assessment for each species was calculated from data identifying the status of historic, current, and future population trends and associated ERUs and data identifying threats to the species or to key ecosystem characteristics. A total of 47 potential SCC were determined to have substantial concern over species' capability to persist over the long term in the plan area, including: 26 invertebrates, 17 plants, two mammals, one fish, and one bird.

If management activities focus on ecosystem integrity and diversity goals by including disturbance-absorbing connected habitats, then ecological conditions could be effectively restored and maintained. These improved ecological conditions would maintain the diversity of plant and animal communities and support the abundance, distribution, and long-term persistence of common and secure, imperiled, or vulnerable native species. Species-specific plan components within each ERU will be developed for those species with additional or key ecosystem characteristics or where ecological conditions are not otherwise met.

# Chapter 9. System Drivers and Stressors

## Introduction

System drivers are factors or processes that determine what is ecologically possible on the landscape and the natural range of variability in conditions. Stressors are natural or human caused alterations in system drivers that may directly or indirectly threaten resource sustainability. It is the combination of and interactions between system drivers and stressors that have resulted in current conditions discussed throughout the ecological volume of the assessment. This chapter identifies and evaluates the reference and current status of system drivers and stressors common to water resources and terrestrial, riparian and aquatic ecosystems. Drivers and stressors that apply to individual resources or characteristics are described in those respective chapters.

## Predominant Climatic Regime

Climate, or the average weather, is the primary system driver. It largely determines the timing, quantity, duration and distribution of available water, and influences all ecological processes and ecosystem characteristics including but not limited to: the potential natural vegetation community, natural rates of soil formation and loss, fire regimes and patterns of insects and disease.

For the most part, climate across the plan and context areas is characterized as semiarid and warm, with low annual precipitation and a high number of sunny days. Past precipitation and temperature of the region has varied sharply at time scales ranging from annual to multi-decadal. Climate also varies by elevation, topography and aspect. North facing slopes tend to be cooler and wetter than south facing slopes due to differences in solar radiation. Topographic features such as mountain ranges, influence wind patterns that carry air masses with different temperatures and moisture content. Mountain ranges can force approaching air masses to move upward quickly, resulting in cooling and precipitation. Annual precipitation data for the context area is displayed in Figure 169. The area in gray is the Gila NF. No equivalent data is available for the portion of the context area in Mexico.

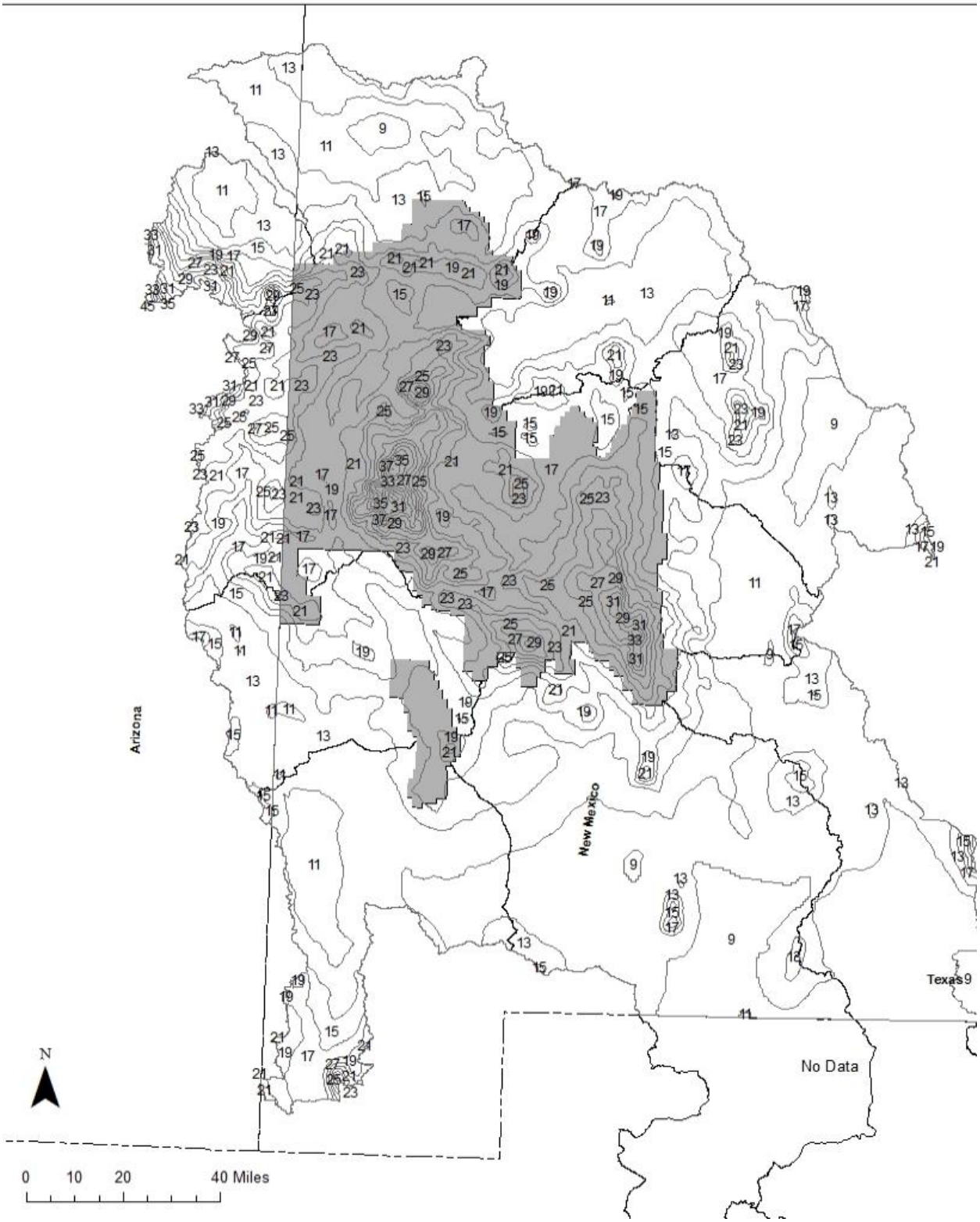



**Figure 169. Average annual precipitation in inches, 30 year normals, time period 1981-2000.**
Note: From Parameter-Elevation Regressions on Independent Slopes Model (PRISM)

Areas of higher precipitation are found at higher elevations in the Mogollon and Black Range Mountains on the Gila NF and along the Mogollon Rim in Arizona. Areas of lower precipitation occur throughout the lower elevations of the context area, but become more common toward the south and west. Average annual precipitation by subbasin and watershed, and the percent falling on the Gila NF are included in Appendix D.

Across the context area, there are generally two principal periods of precipitation. The summer monsoon season typically occurs July through August. Rainfall during this time period is characterized by convective, high intensity, short duration storms. These are usually small storms, averaging an estimated five square miles. Late in the monsoon season and continuing into October, the area can experience high intensity, longer duration storms of cyclonic origin associated with hurricanes in the Gulf of Mexico and Pacific Ocean. These do not occur with the same regularity of the monsoon rains.

The second principal period of precipitation typically occurs from December through February when easterly storm tracks originating from the Pacific Ocean cross over the Forest allowing for widespread precipitation. This precipitation usually falls as snow in the higher elevations. The snow pack at these higher elevations generally develops continuously over this period but melts over a much shorter time span. In years where there is an El Niño event, winter precipitation tends to be higher than normal. In La Niña years, drier than normal conditions exist from late summer and into the winter.

There is limited snow pack data for the context and plan area. The available data comes from the Natural Resources Conservation Service and National Water and Climate Center's Snow Telemetry (SNOTEL) and Snow Course datasets. Periods of record are highly variable between stations and the characteristics measured (e.g. snow depth or snow water equivalent). Prior to 2004, many stations were not consistently recording data for the same months every year. Table 164 summarizes what snow pack information exists by subbasin (4$^{th}$ level watershed) and watershed (5$^{th}$ level watershed).

**Table 164. Snow pack characteristics by subbasin and watershed[1]**

| Watershed Name | Station Name | Elevation (ft) | On Gila NF (yes/no) | Average Monthly Snow Depth (in) | | | | | | Average Snow Water Equivalent (in) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Jan | Feb | Mar | Apr | May | June | Jan | Feb | Mar | Apr | May | June |
| *Mimbres Subbasin* | | | | | | | | | | | | | | | |
| Gallinas Canyon-Mimbres River | McKnight Cabin Snotel | 9,240 | Yes | 9.6 | 12.5 | 16.1 | 2.6 | 0.3 | 0.1 | 2.2 | 3.4 | 3.6 | 0.9 | <0.1 | <0.1 |
| | Emory Pass | 7,800 | Yes | 4.3 | 4.6 | 2.7 | 0.6 | 0 | No data | 0.9 | 1.3 | 0.9 | 0.1 | 0 | No data |
| *Little Colorado Headwaters* | | | | | | | | | | | | | | | |
| | Baldy | 9,125 | No | 12.6 | 20.4 | 21.6 | 7.2 | 0.2 | 0 | 3.4 | 5.8 | 7.3 | 4.6 | 0.3 | 0 |
| | Cheese Spring | 8,700 | No | 11.3 | 17.8 | 21.0 | 12 | 0 | No data | 2.4 | 4.0 | 5.5 | 3.6 | 0 | No data |
| | Fort Apache | | No | 15.6 | 24.7 | 28.0 | 20.8 | No data | No data | 3.6 | 6.0 | 7.7 | 6.7 | No data | No data |
| *Upper Gila Subbasin* | | | | | | | | | | | | | | | |
| Sapillo Creek | Signal Peak | 8,360 | Yes | 8.8 | 11.0 | 8.5 | 1.2 | 0 | 0 | 2.3 | 4.0 | 4.35 | 0.7 | 0 | 0 |
| Middle Fork Gila River | Whitewater | 10,070 | Yes | 41.4 | 54.4 | 67.0 | 65.3 | No data | No data | 9.5 | 14.8 | 19.6 | 22.5 | No data | No data |
| Headwaters East Fork Gila River | Lookout Mountain | 8,500 | Yes | 4.9 | 4.2 | 1.6 | 0.2 | 0.2 | 0 | 1.5 | 2.2 | 1.5 | <0.1 | <0.1 | 0 |
| Outlet East Fork Gila River | McKnight Cabin Aerial Marker | 9,300 | Yes | 8.1 | 14.3 | 16.0 | 6.1 | No data | No data | 1.8 | 3.6 | 4.7 | 2.2 | No data | No data |
| *San Francisco Subbasin* | | | | | | | | | | | | | | | |
| Centerfire Creek-San Francisco River | Frisco Divide | 8,000 | Yes | 6.8 | 7.4 | 2.9 | 0.1 | 2.9 | 0 | 1.4 | 2.5 | 2.4 | <0.1 | 0 | 0 |
| Pueblo Creek-San Francisco River | Silver Creek Divide | 9,000 | Yes | 21.9 | 16.8 | 20.7 | 12.6 | 1.6 | 0.1 | 3.8 | 6.1 | 8.5 | 8.3 | 1.8 | 0 |
| | Stateline | 8,000 | No | 5.5 | 10.3 | 8.7 | 2.0 | 0 | No data | 1.2 | 2.5 | 2.3 | 0.7 | 0 | No data |
| | Coronado Trail | 8,425 | No | 6.4 | 10.8 | 9.1 | 2.6 | 0.1 | 0 | 1.5 | 2.8 | 2.8 | 0.8 | <0.1 | 0 |
| | Nutrioso | 8,500 | No | 4.8 | 7.5 | 9.4 | 2.0 | 0 | 0 | 1.1 | 1.9 | 1.8 | 0.6 | 0 | 0 |
| **Gila NF Average** | | | | **14.0** | **21.0** | **24.1** | **19.7** | **1.1** | **<0.1** | **2.9** | **5.3** | **6.4** | **5.5** | **0.4** | **<0.1** |
| **Total Average** | | | | **11.6** | **15.5** | **16.7** | **9.7** | **0.5** | **<0.1** | **2.6** | **4.4** | **5.2** | **4.3** | **0.5** | **0** |

[1] Watersheds are not listed for those stations outside the plan area. The data for the Coronado Trail Snow Course and Snotel were averaged because they are in the same watershed with a 50 foot elevation difference. The data for the Nutrioso Snow Course and Snotel were averaged because they are in the same watershed at the same elevation.

The United States is divided into climate divisions. Each division represents an area with relatively similar climate conditions. The Forest's distribution across these climate divisions is displayed in Figure 170.

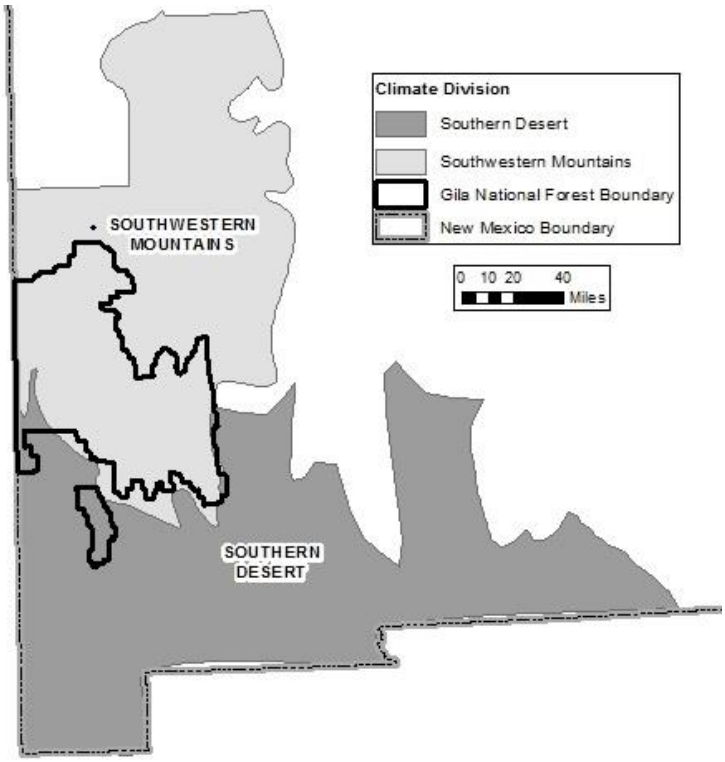



**Figure 170. Climate Divisions of the Gila NF**

The plan area falls primarily in the Southwest Mountains, but portions also fall within the New Mexico Southern Desert. Figure 171 displays temperature data for these climate divisions from 1895-2014.

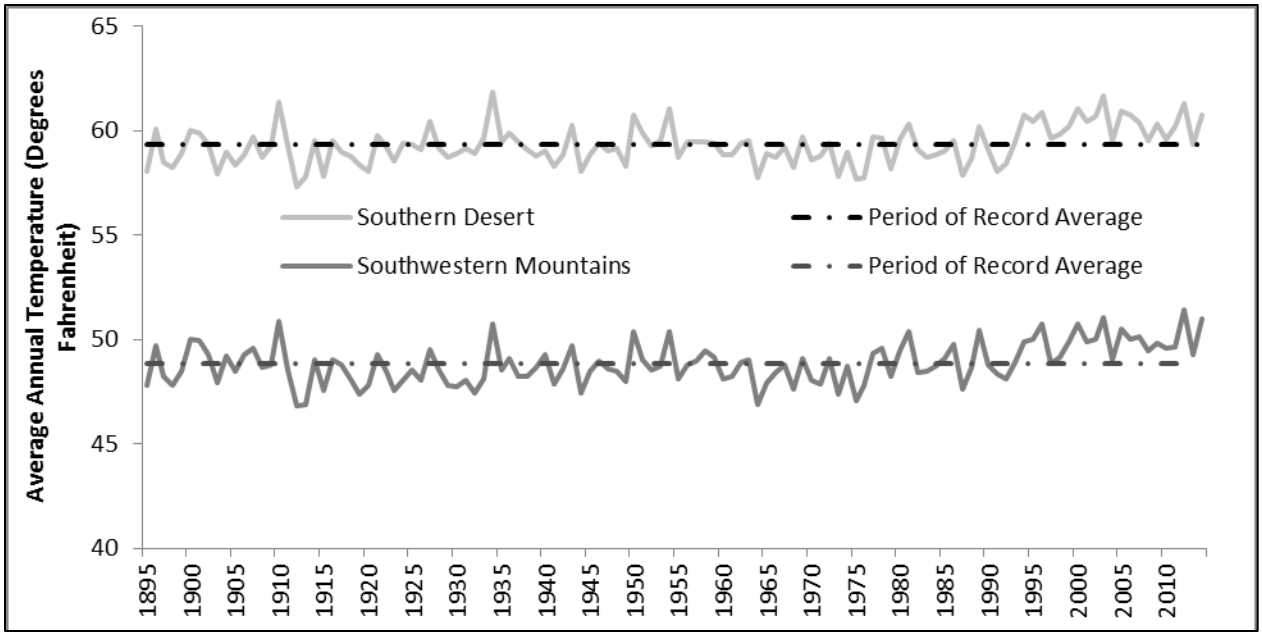



**Figure 171. Average annual temperature for the New Mexico Southwestern Mountains and Southern Desert climate divisions, 1895-2014 time periods**

In the Southwestern Mountains, the average annual temperature across all years is 48.9 degrees Fahrenheit. The highest annual average temperature was 50.9 degrees Fahrenheit in 1910. The lowest annual average temperature (46.8 degrees Fahrenheit) occurred in 1912. In the Southern Desert, the average annual temperature across all years is 59.1 degrees Fahrenheit with the hottest year being 1934 (61.9 degrees Fahrenheit) and the coolest year also being 1912 (57.3 degrees Fahrenheit). Although higher temperatures have always occurred in the Southern Desert, the pattern of annual and decadal variability is similar for both divisions.

Temperature exerts a significant influence on precipitation patterns, from the El Niño-La Niña cycles which are largely driven by temperatures in the Pacific Ocean, to the more regional and local convective heating that contributes to the summer monsoons. Figure 172 displays the average annual precipitation for the climate divisions.

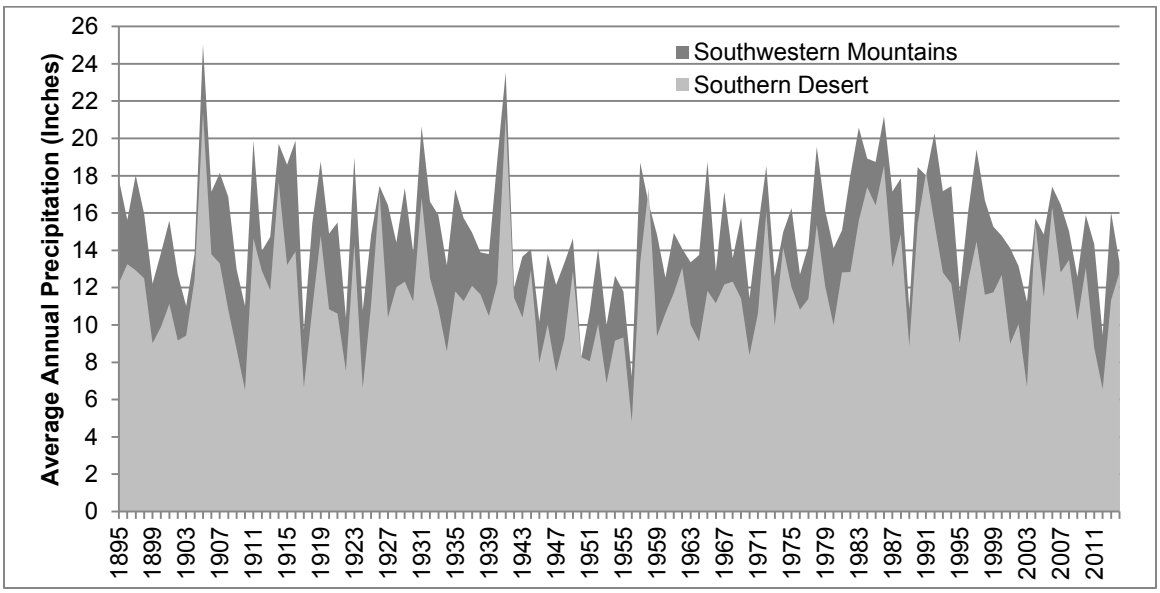



**Figure 172. Average annual precipitation for the New Mexico Southwestern Mountains and Southern Desert climate divisions, 1895-2014 time periods**

In the Southwestern Mountains, the average annual precipitation across all years is 15.3 inches. The highest annual average precipitation was just over 20 inches and occurred in 1905. The lowest annual average precipitation (7.2 inches) occurred in 1956. In the Southern Desert, the average annual precipitation across all years is 11.9 inches with the driest year also being 1956 (4.8 inches) and the wettest year 1905 (21.4 inches). Although higher precipitation has always occurred in the Southwestern Mountains, the pattern of annual and decadal variability is similar for both divisions.

The instrumental record does not extend to the time prior to European settlement. The Climate Assessment for the Southwest (CLIMAS) at the University of Arizona has developed a Paleoclimate Tool which provides a reconstruction of cool season precipitation for each climate division in Arizona and New Mexico back to the year 1000. This tool is based on data collected from tree ring studies across the southwest and is available at http://www.climas.arizona.edu/paleoclimate-tool. Cool season precipitation can be correlated to annual tree-ring widths with more certainty than warm season precipitation. Efforts by the North American Monsoon Project may prove the reconstruction of the warm season precipitation to be possible in the future. Figure 173 and Figure 174 display the reconstructions for the Forest's two climate divisions. This work was completed in 2006 and has not been updated to include subsequent years.

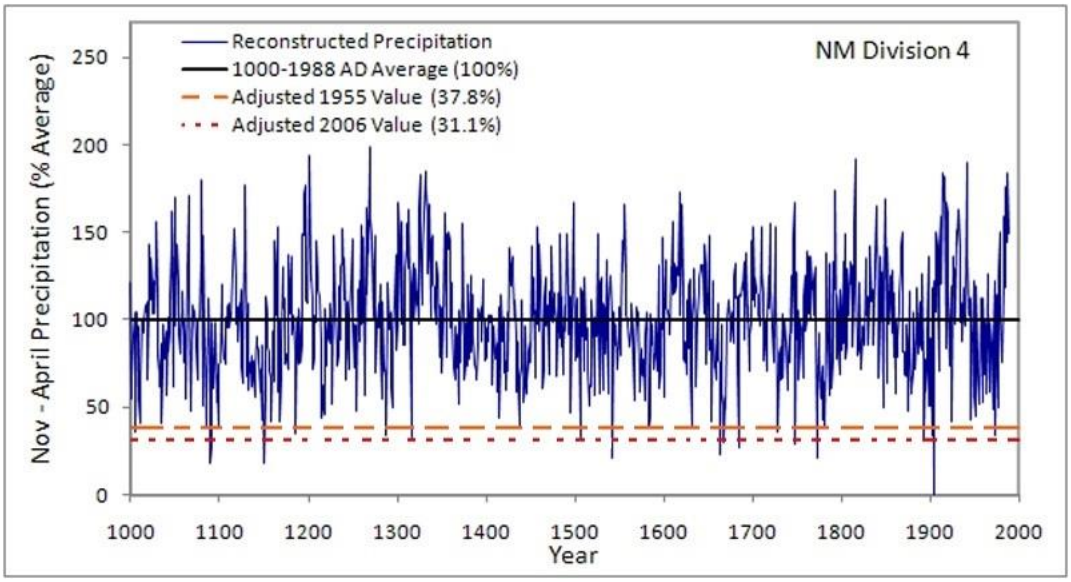



**Figure 173. Reconstructed cool season precipitation for the Southwestern Mountains climate division**

Note: The adjusted 1955 and 2006 value lines were altered from the original CLIMAS graph to improve readability in black and white.

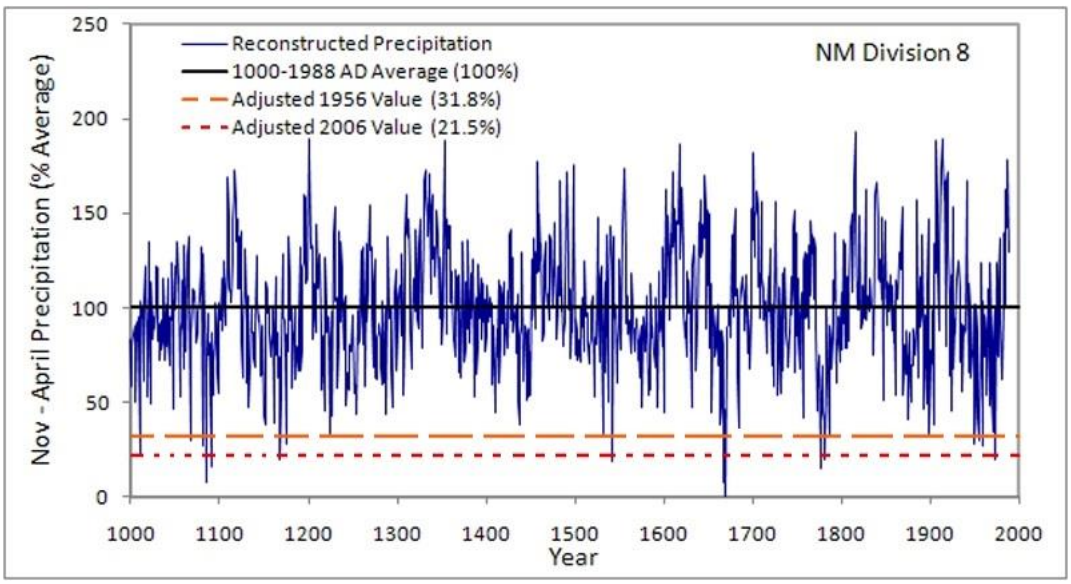



**Figure 174. Reconstructed cool season precipitation for the Southern Desert climate division**

Note: The adjusted 1955 and 2006 value lines were altered from the original CLIMAS graph to improve readability in black and white.

The reconstructions show not many years in the last 1000 years were drier than 1956 and even fewer drier than 2006. Table 165 and Table 166 compare the driest and wettest five year period using the reconstructed time period (1000-1894) and the instrumental record (1895-2006).

**Table 165. Comparison of reference and current precipitation for the New Mexico Southwestern Mountains climate division**

| | Reference Time Period (1000-1894) | | | | | Instrumental Record (1895-2006) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Driest Five-Year Period* | | | | | | | | | | |
| | 1666-1670 | 1090-1094 | 1778-1782 | 1147-1151 | 1214-1218 | 1902-1906 | 1955-1959 | 1900-1904 | 1972-1976 | 1901-1905 |
| **Precipitation (in)** | 9.0 | 9.7 | 10.0 | 10.1 | 10.6 | 11.3 | 12.6 | 12.7 | 12.7 | 13.3 |
| **Percent of Average (1000-2006)** | 49 | 53 | 55 | 55 | 58 | 63 | 65 | 66 | 66 | 68 |
| *Wettest Five-Year Period* | | | | | | | | | | |
| | 1330-1334 | 1267-1271 | 1197-1201 | 1325-1329 | 1309-1313 | 1993-1997 | 1985-1989 | 1986-1990 | 2003-2007 | 1940-1944 |
| **Precipitation (in)** | 30.8 | 29.2 | 28.1 | 26.8 | 26.3 | 28.8 | 27.6 | 26.9 | 26.5 | 26.4 |
| **Percent of Average (1000-2006)** | 159 | 156 | 156 | 155 | 154 | 186 | 163 | 162 | 157 | 157 |

The higher percent of average values suggest that in the Southwestern Mountains, cool season precipitation has generally been greater during the last 111 years than in the reference time period.

**Table 166. Comparison of reference and current precipitation for the New Mexico Southern Desert climate division**

| | Reference Time Period (1000-1894) | | | | | Instrumental Record (1895-2006) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Driest Five-Year Period* | | | | | | | | | | |
| | 1777-1781 | 1667-1671 | 1782-1786 | 1090-1094 | 1166-1170 | 1955-1959 | 1902-1906 | 1911-1915 | 1954-1958 | 1910-1914 |
| **Precipitation (in)** | 7.4 | 7.6 | 9.8 | 10.1 | 10.2 | 10.1 | 10.5 | 10.6 | 10.7 | 11.0 |
| **Percent of Average (1000-2006)** | 43 | 43 | 56 | 58 | 58 | 63 | 65 | 66 | 66 | 68 |
| *Wettest Five-Year Period* | | | | | | | | | | |
| | 1330-1334 | 1617-1621 | 1812-1816 | 1837-1841 | 1116-1120 | 1993-1997 | 1994-1998 | 1985-1989 | 1992-1996 | 1991-1995 |
| **Precipitation (in)** | 27.8 | 27.3 | 27.2 | 27.1 | 27.0 | 30.1 | 26.4 | 26.2 | 25.4 | 25.4 |
| **Percent of Average (1000-2006)** | 159 | 156 | 156 | 155 | 154 | 186 | 163 | 162 | 157 | 157 |

In the Southern Desert, the reconstructions also suggest that cool season precipitation has generally been higher than it was during the reference time period.

## Drought

A drought is a prolonged period of time of below average precipitation. Droughts are normal and recurrent climatic features that have occurred both before and after European settlement on time scales ranging from single growing seasons to multiple years, even decades (Sheppard et al. 2002). Drought impacts can include, but are not limited to: reduced streamflow; reduced water quantity and reliability of upland water sources; reduced vigor, growth and regeneration of riparian species and a reduction in the ability of re-sprouting species to do so after fire; reduced canopy cover, vigor, growth and seed production in grasses; reduced vegetative groundcover and decreased fuel moisture. Drought also has cascading effects associated with increased risk of erosion, sedimentation and wildfire, as well as downward trends in rangeland condition.

The Palmer Drought Severity Index (PDSI) is considered the most appropriate drought index for unirrigated land. It uses precipitation and temperature data, incorporates soil moisture and calculates water supply and demand (Climate Prediction Center Internet Team 2005). Figure 175 illustrates the patterns of drought that have occurred over the instrumental record for both climate divisions. Drought years are indicated by negative values.

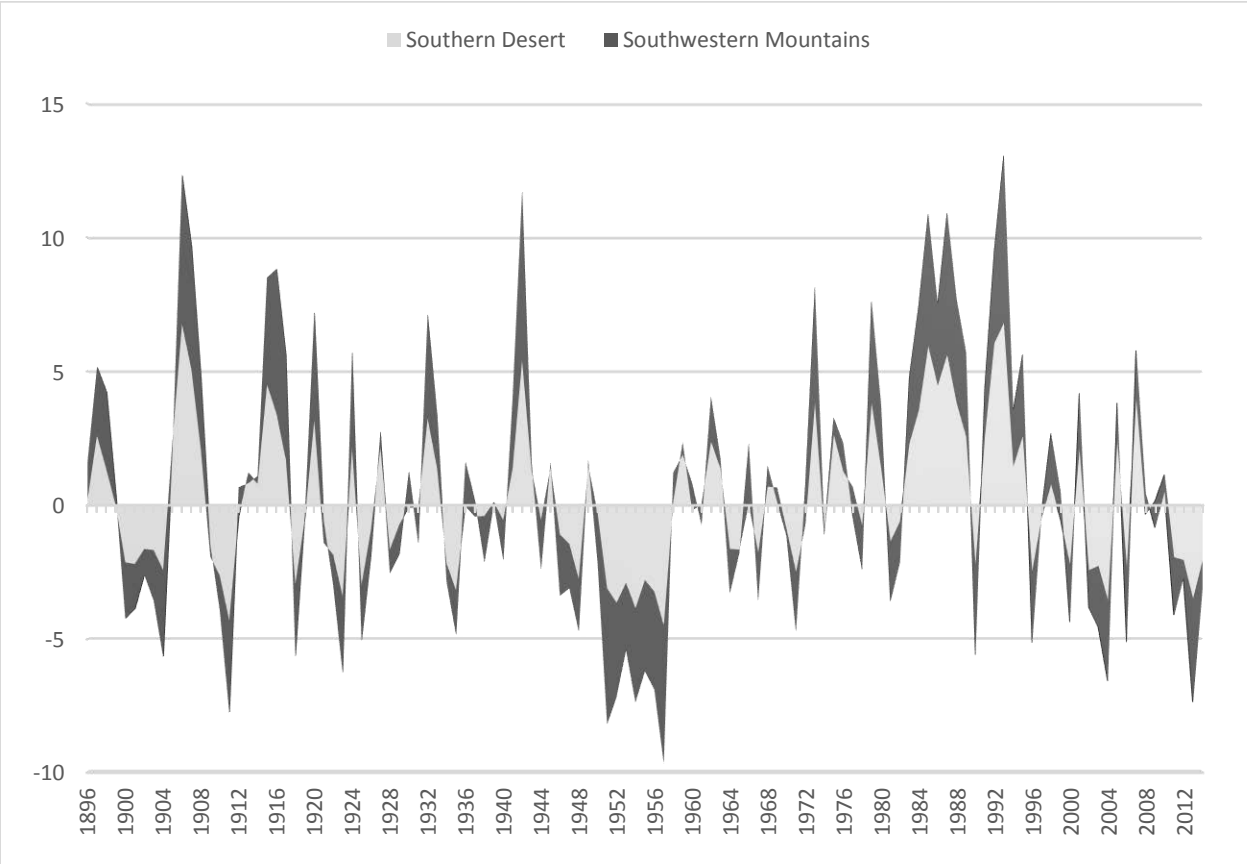



**Figure 175. Drought cycles as depicted by the climate division PDSI values, period of record 1896-2014**

The droughts of the last 110 years pale in comparison to some of the decades-long "megadroughts" that the region has experienced over the last 2000 years (Seager et al. 2008). The most severe drought in the period of record occurred in the 1950s and was more severe in the Southwestern Mountains than in the Southern Desert. The most recent drought began in the late-1990s and has been made worse by record increases in temperature. Although average to above average precipitation in 2015 relieved some of the short-term drought conditions, multiple years of average to above average precipitation are needed for long-term relief (University of Arizona CLIMAS 2015). Climate change is projected to increase the frequency, severity and duration of droughts (IPCC 2007; Seager et al. 2007).

## Climate Change

Climate change is a stressor. In the Southwest, climate modelers agree there is a drying trend that will continue well into the latter part of 21st century (IPCC 2007; Seager et al. 2007). While some models have predicted an increase in precipitation (Seager et al. 2007), associated temperature increases are expected to increase evaporation such that an overall decrease in available moisture remains likely. Regional

warming and drying trends have occurred twice in the 20th century during the 1930s Dust Bowl and the 1950s Southwest Drought.

Climate change is projected to increase the frequency, severity and duration of droughts (IPCC 2007; Seager et al. 2007). Models predict the slight warming trend observed in Southwest over last 100 years may continue into the next century, with temperature rising approximately five to eight degrees Fahrenheit by the end of the century. The greatest warming is expected to occur during winter (IPCC 2007). While the region is expected to get drier, it is likely to see larger, more destructive flooding events. Average air temperatures are rising. It is likely that continued warming will accentuate the temperature difference between the Southwest and the tropical Pacific Ocean, enhancing the strength of the westerly winds that carry moist air from the Pacific Ocean into the Southwest during the monsoon. This scenario may increase the monsoon's intensity, or its duration, or both, in which case floods will occur with greater frequency (Guido 2008). Along with storms in general, hurricanes and other tropical cyclones are projected to become more intense overall. New Mexico and Arizona typically receive 10 percent or more of their annual precipitation from storms that begin as tropical cyclones in the Pacific Ocean. In fact some of the largest floods in the Southwest have occurred when a remnant tropical storm hit a frontal storm from the north or northwest (Guido 2008).

Climate change is likely to modify ecological conditions, processes and ecosystem services across the context and plan areas, by altering precipitation patterns, and the timing, quantity, duration and distribution of available water. The effects of climate change could be particularly profound for native fishes and aquatic ecosystems of the Rocky Mountains and Arizona-New Mexico Mountains because those systems often lack resilience and are strongly dependent on temperature and stream flow regimes that are already documented to be changing (Rieman and Isaak 2010). In addition, plants in the arid Southwest already live near their physiological limits for water and temperature stress (Archer and Predick 2008). Therefore, even slight changes in temperature and moisture or a change in the scale and frequency of extreme climatic events could significantly alter the composition, abundance and distribution of species. Vegetative communities are expected to shift upward in elevation and contract in elevation range. Compositional changes in vegetative communities are also predicted, as individual species respond differently to changes in climate. In fact, changes such as these have already been documented in the montane grassland and mixed conifer vegetation types of the Southwest (Brusca et al. 2013).

Eighty percent of the habitats in the Southwest have warmed over the last 55 years; some have warmed twice as fast as others (Karl et al. 2009, Robles and Enquist 2010, Beschta et al. 2012). The climate data presented in the previous discussion on the predominant climate illustrates that average annual temperatures within the Forest's two climate divisions have not dropped below the period of record average since the mid-1990s

In 2015, the Forest Service Southwestern Region prepared the Climate Change Vulnerability Assessment (CCVA) for the Gila NF (Triepke 2015). This is an ecosystem-based vulnerability assessment for all major upland ecosystems in Arizona and New Mexico based on the anticipated effects of climate change. Four vulnerability categories are reported: low, moderate, high and very high. Vulnerability categories are accompanied by uncertainty categories to account for difference in climate model predictions. These uncertainty categories are low, moderate and high. Vulnerability and uncertainty results are summarized at the ERU, Forest and local unit scales. Vulnerability is also summarized by subwatershed, but these ratings are not accompanied by uncertainty ratings. Although riparian systems were not specifically analyzed, some inferences can be made related to their vulnerability based on the subwatershed summary.

Essentially, the CCVA describes the relative susceptibility of an ecological type conversion (Triepke 2015). The conversion of a mixed conifer-frequent fire type to a Gambel oak shrubland type, or a ponderosa pine-willow type to a ponderosa pine type would be an examples of ecological type conversions.

The CCVA provides a means to account for climate change predictions and modify projected future trends, and risk. While climate change is a stressor outside the control of Gila NF management key climate change factors may be addressed by:

- Enhancing adaptation by anticipating and planning for disturbances from intense storms
- Reduce vulnerability by maintaining and restoring resilient native ecosystems
- Increase water conservation and plan for reductions in upland water supplies
- Anticipate increased demand for forest resources
- Monitoring climate change influences

Table 167 summarizes the CCVA results for the Forest's upland ERUs, followed by Figure 176 providing the watershed vulnerability ratings and Table 168 summarizing the watershed ratings on an area weighted basis for the Forest's riparian ERUs.

**Table 167. Ecological Response Units of the Gila NF and the summarized Climate Change Vulnerability Assessment vulnerability and uncertainty ratings**

| ERU Name | ERU Acres on the Gila NF | ERU Percent of Gila NF | CCVA Vulnerability Rating | CCVA Uncertainty Rating |
|---|---|---|---|---|
| Colorado Plateau Great Basin Grassland | 89,033 | 3 | Moderate | Moderate |
| Juniper Grass | 114,396 | 3 | Moderate to High | Moderate |
| Mixed Conifer-Frequent Fire | 367,209 | 11 | Moderate to High | Moderate |
| Mixed Conifer with Aspen | 51,908 | 2 | Moderate to Very High | Low to Moderate |
| Mountain Mahogany Mixed Shrubland | 166,488 | 5 | Low to Moderate | Moderate |
| Madrean Piñon-Oak Woodland | 17,361 | 1 | Low to Moderate | Moderate |
| Montane Subalpine Grassland | 113,806 | 3 | Moderate | Moderate to High |
| PJ Evergreen Shrub | 10,679 | <1 | Not Assessed | Not Assessed |
| PJ Grass | 291,647 | 9 | Moderate | Moderate |
| PJ Woodland | 848,447 | 26 | Low to Moderate | Moderate |
| Ponderosa Pine Evergreen Oak | 378,157 | 12 | Moderate | Moderate |
| Ponderosa Pine Forest | 630,294 | 19 | Moderate to High | Moderate |
| Semidesert Grassland | 55,993 | 2 | Low to Moderate | Moderate |
| Spruce-Fir Forest | 23,779 | 1 | Very High | Low |
| Gila NF Uplands Total | 3,159,197 | 97 | Moderate | Moderate |

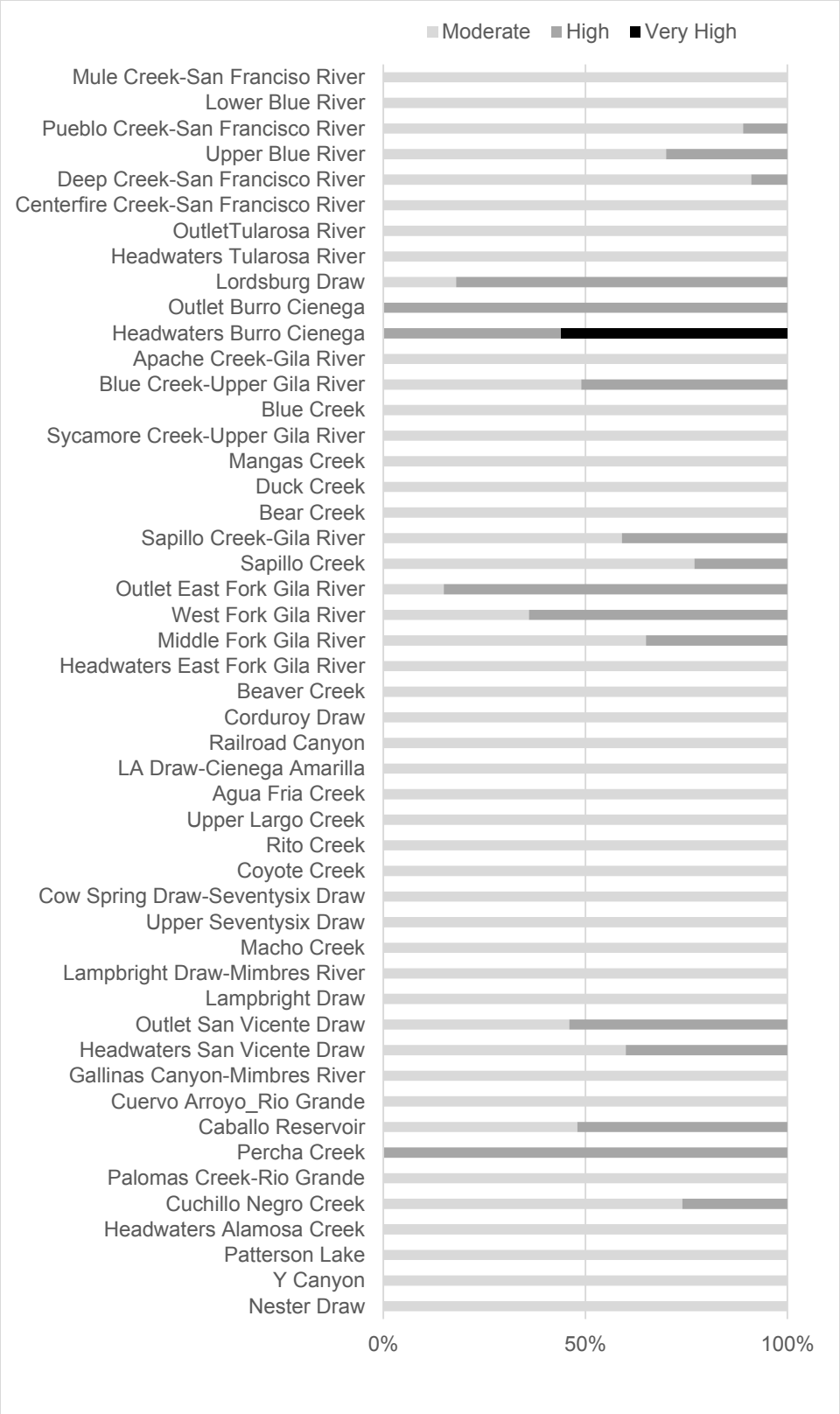



**Figure 176. Climate change vulnerability categories by watershed**

**Table 168. Climate change vulnerability ratings for Gila NF riparian ERUs**

| | Percent of ERU by Subwatershed Vulnerability Rating | | |
|---|---|---|---|
| **Ecological Response Unit** | **Moderate** | **High** | **Very High** |
| Arizona Alder-Willow | 48 | 52 | 0 |
| Arizona Walnut | 89 | 11 | 0 |
| Desert Willow | 68 | 32 | 0 |
| Fremont Cottonwood-Shrub | 94 | 6 | 0 |
| Herbaceous Wetland | 93 | 7 | 0 |
| Walnut-Ponderosa Pine | 100 | 0 | 0 |
| Narrowleaf Cottonwood-Shrub | 77 | 23 | 0 |
| Ponderosa Pine-Willow | 100 | 0 | 0 |
| Sycamore-Fremont Cottonwood | 75 | 25 | 0 |
| Upper Montane Conifer-Willow | 74 | 26 | 0 |
| Willow-Thinleaf Alder | 56 | 44 | 0 |

Overall, most of the Forest's uplands fall into the moderate vulnerability and uncertainty categories. Vulnerability tends to increase with elevation. The highest vulnerability with the lowest uncertainty occurs at the highest elevations in the Spruce-Fir Forest ERU. The same general pattern is observed with regard to riparian ERUs and vulnerability.

## Water Supply and Demand

Water directly or indirectly influences all resources. The quantity, distribution, timing and duration of water supplies are both characteristics for analysis (see Water Chapter) and a system driver. In the arid and semi-arid Southwest, the relationship between water supply and demand is a system stressor. The right to use water, and the allocation of that right are administered by the State. Water use is outside of the Gila NF's authority and ability to control.

Prior to European settlement, Native Americans used surface water for domestic and irrigation purposes. Extensive water controls in the form of irrigation diversions and canal systems across New Mexico have been associated with this time period (Harris 1984). It is assumed that water demand did not exceed supply except in times of severe drought.

The arrival of the Spanish brought with it an increased demand for water and a European system governing the use of water. This system involved the formation of acequias, or community ditches. Under that system, the ditch master granted the right to use water and delegated maintenance duties (Harris 1984).

Beginning in the last half of the 19$^{th}$ century as populations increased and technology developed, irrigation projects became increasingly large in size and scope, upland water sources were created to improve livestock management, and groundwater began to supplement surface water supplies. Other industries such as mining also increased the human demand for water.

There are currently 30 acequias or community ditches that depend on water that flows from the Forest. According to the watershed condition classification water quantity indicator, the cumulative effects of these relatively small irrigation diversions alter natural streamflow patterns, reduce streamflow, and contribute to aquatic habitat fragmentation in roughly 12 percent of all subwatersheds. An estimated 49 percent of springs occurring on the Gila NF have been developed for livestock waters.

In addition to water contained in naturally occurring features such as streams, springs, seeps and wetlands, water is provided by the Forest through constructed features, such as waterbodies and wells. Waterbodies

on the Gila NF are nearly all constructed features, although a few natural depressions that may hold water seasonally do occur. Most waterbodies are earthen tanks built to provide livestock water (stock tanks), with a secondary benefit of providing water to wildlife. Not all stock tanks hold water year round, some are poorly located or designed, and many are in need of maintenance. The most reliable livestock tanks are associated with areas of groundwater discharge. A few have been stocked with non-native fish for recreational purposes by the New Mexico Department of Game and Fish (NMDGF). NMDGF also constructed, and has the management responsibility for dams that create the three lakes or reservoirs located, entirely or in part, on the Forest for recreational fisheries purposes. These lakes are Quemado Lake, Snow Lake and Lake Roberts. Similarly, wells constructed on the Gila NF are mostly to provide livestock water, with the exception of 15 drinking water systems associated with recreation and administrative sites (see Infrastructure Chapter).

The Forest does not have an inventory of storage capacity and condition related to all stock tanks located within its boundaries, but is currently conducting an inventory in the Gila-San Francisco River basin (3rd level), which includes the Upper Gila, Upper Gila-Mangas and San Francisco subbasins (4th level). The Forest is also lacking a complete water rights inventory. In general, there are relatively few wells located within the Gila NF. Similarly, there are relatively few stock tanks located on Forest in most plan area watersheds with the exception of those watersheds that are located primarily on Forest, or have few naturally occurring surface water resources. Appendix D contains a table based on information from the NHD and New Mexico, Arizona, and Texas Offices of the State Engineers about the number of waterbodies and wells within the context and plan areas, both on and off-Forest.

Although local populations in southwestern New Mexico are projected to remain stable over the next several decades (UNM-BBER 2014), the supply of and demand for surface water is regional in nature. Climate change, coupled with one of the fastest growing regional populations in the nation, may present major management challenges in the Southwest.

Work by Christensen and Lettenmaier (2006) predicts precipitation across the context area is to drop by 5-10 percent by 2100. Such a decrease in precipitation could have a more serious impact than the numbers suggest. The decrease of water draining from the landscape into rivers and reservoirs typically can be double or triple the proportional reductions in rainfall amounts, especially when combined with higher temperatures, which leads to increased evaporation (Christensen and Lettenmaier 2006). It has been estimated that just over four percent of New Mexico's precipitation is delivered to streams, and then 30 percent of that four percent is transpired by streamside vegetation (McLean 1981).

Recent warming in some areas of Southwest is occurring at a rate that is among the most rapid in the nation (Seager et al. 2007), and significantly higher than the global average in some areas. Overall water quantity on the Gila and San Francisco rivers has been predicted to decrease between six and 11 percent between 2040 and 2070 (Gori et al. 2014).

In a drought of the magnitude of the worst one-year drought on record, water demand may exceed supply by 68 percent. In the five-year scenario modeled after the worst drought in the historical record, water demand in Arizona could exceed supply by 67 percent, and in the ten-year scenario, demand may exceed supply by 59 percent (Lenart 2007). In the Southwest, intense debate will likely continue over water allocation. As supplies become increasingly scarce, trade-offs among competing uses could potentially lead to conflict.

Indeed, this is happening as illustrated by the Arizona Water Settlements Act (AWSA) which approves the consumptive use of an additional 14,000 acre-feet of water from the Gila and/or San Francisco rivers, their tributaries, and groundwater sources in New Mexico. The AWSA has polarized communities over proposals

for a diversion project on the Gila River and potentially placed ecological flow needs and human demands into direct conflict (Gori et al. 2014).

Even without considering climate change or ecological flow needs, more water has been committed to users in the Southwest than is available (Phillips et al. 2011; Unruh and Liverman 2013). The increased severity and duration of drought predicted as a result of climate change could very well lead to decreased water availability in streams, springs, lakes and earthen tanks on the Forest. This would likely alter patterns of use by livestock and wildlife and reduce carrying capacity.

A smaller supply of surface water will inevitably lead to an increased demand for groundwater, which is not widely developed on the Forest. Although the Office of the State Engineer has recently required meters be installed as existing wells are deepened or new wells are drilled, there is not enough data over a sufficient period of time to understand groundwater supply and demand in the planning area. However, the New Mexico Water Resources Research Institute at New Mexico State University has estimated that 73 percent of the groundwater withdrawals made state-wide constitute depletion (Unruh and Liverman 2013). According to a 1997 USGS investigation, 76 percent of groundwater withdrawals constituted depletion in Catron County (Basabilvazo 1997). Depletion means water is being withdrawn faster than the rate of recharge. Groundwater withdrawals can impact streamflow. Groundwater recharge and discharge are assessed as a key characteristic in the Water Chapter.

There has been, and remains considerable interest in the potential of forest thinning to increase water yield across the scientific community, within land management agencies and with Gila NF stakeholders. Results of watershed experiments conducted in the Southwest indicate that mechanical restoration of piñon-juniper woodlands or mechanical conversion of these woodlands to herbaceous covers have little effect on water yields (Ffolliott and Gottfried 2012). This holds true for all ecological types receiving less than 18 inches of precipitation per year or where the total annual precipitation is less than potential evapotranspiration (Ffolliott and Gottfried 2012; Gottfried et al. 2008).

Potential evapotranspiration (PE) is a measure of the ability of the atmosphere to remove water from the surface through evaporation and transpiration, assuming unlimited water supply. It changes hourly, daily, monthly and annually. PE increases with exposure to solar radiation and wind, higher temperatures and lower humidity. All of these things can result from decreases in vegetative cover. The predicted and observed increases in temperatures across the planning area, discussed in the previous sections on climate and climate change, will also result in higher PE.

Where total annual precipitation is greater than PE, relatively small and short-lived increases in water yield may occur until re-growth (Ffolliott and Gottfried 2012; Gottfried et al. 2008). However, those increases may be economically significant in arid regions (Simonit et al. 2015). Recent work conducted on the Mogollon Rim in Arizona by Moreno et al. (2016) suggests that increased water yield may be more a function of soil compaction rather than reductions in evapotranspiration. This study also concluded that in the Southwestern climate, increases in streamflow as a result of mechanical thinning are likely to be realized during the winter months, but during summer months may lead to drier conditions. Additionally, increases in water yield are likely offset by decreases in storage. This may increase ecosystem vulnerability to the hydrologic conditions and extremes expected with climate change (Moreno et al. 2016).

## Natural Vegetation Succession

Natural succession is a system driver with respect to vegetation. It is the progressive change in species composition and structure over time. Early successional stages, or seral states, are often dominated by small, short-lived, poorly competitive, non-woody species such as annual forbs and grasses. These species take advantage of available space, nutrients and sunlight in the absence of more competitive, perennial

species after disturbance. As succession proceeds, soil nutrients are converted into plant biomass and the dominant species shift toward larger, longer-lived species that are better competitors for space, nutrients and sunlight. For example, in forested systems this progression might include a shift to shrubs, then to shade-intolerant tree species, and eventually shade-tolerant tree species. Disturbances like wildfire, drought and grazing can interrupt or reverse succession.

The shade tolerance and competitive ability of the species that define the latest seral (climax) state tend to decrease along an elevational climatic gradient. For example, the latest-successional plant communities on the highest elevation sites have the highest precipitation and lowest temperatures and tend to be dominated by Engelmann spruce and corkbark fir, both good competitors for limited soil nutrients.

Descending in elevation to progressively warmer, drier sites, the highest seral species found are mixed-conifer followed by ponderosa pine, then piñon-juniper woodland, then shrublands, and finally, desert scrub or grasslands at the lowest elevations. A relatively high seral species on one site is likely to be present as a relatively mid-seral species on a site that is higher in elevation. For example, Douglas fir may be a climax species in a mixed-conifer forest, but may be present as a mid-seral species in a spruce-fir forest 1,000 feet higher in elevation.

## Reference and Current Disturbance Regimes

### Fire

Fire is an integral part of many ecosystems across the western United States and on the Gila NF. Wildfire frequency and effects vary from short return intervals and low severity to long return intervals and high severity. In fuel types where fires historically burned frequently, like ponderosa pine, the interaction between pattern and process was integral in maintain characteristic species composition, structure and spatial pattern. That is, frequent fires removed surface fuels, but maintained forest structure that encouraged continued low-severity fires (Reynolds et al. 2013). In other systems, like spruce-fir forest or piñon-juniper woodlands, fire was less frequent and had less influence on stand structure, but may have significantly influenced landscape scale patterns.

Native Americans both managed fire as a tool and suppressed it during the reference time period (Liebmann et al. 2016; Williams 2000). However, the extent and frequency of fire use and fire suppression patterns on the Forest prior to the arrival of Europeans remain largely unknown. However there is some evidence to suggest it was not extensive in upland systems (Abolt 1997). In some riparian areas, such as the Mimbres River valley, Native Americans used fire to clear riparian zones for agricultural purposes (Williams 2000; Schollmeyer 2005) to the extent that some riparian tree species may have gone locally extinct (Schollmeyer 2005).

The arrival of Europeans and the decline in Native American populations introduced changes in land management that began to alter fire regimes in complex ways. This included an increase in woody vegetation (Liebmann et al. 2016). At the turn of the 19$^{th}$ century, the policy of fire suppression contributed to an increase in woody vegetation and fuel loading. Livestock grazing practices reduced herbaceous vegetation (fine fuels) and contributed to an increase in woody vegetation as a result of reduced competition for water and nutrients (Boucher and Moody 1998; Dahms and Geils 1997; Rummel 1951; Madany and West 1983; Savage and Swetnam 1990; Smith 2006b, among others). These changes in vegetative cover altered fuel types and distributions.

Each ERU has evolved under a specific fire regime to adapt to the frequency and severity of fire characteristic in that ERU, such that ecological integrity is maintained over time. Fire may either restart the successional process by establishing an earlier seral state as in infrequent fire systems (e.g. spruce-fir),

or maintain a given seral state, as occurs in frequent fire systems (e.g. ponderosa pine). Multiple interacting influences may alter an ERU's fire regime; some are legacies of past human impacts, while others are still evolving. A history of fire suppression and unmanaged grazing, leading to a lack of fine fuels to carry fire, has resulted in fewer fires since the late-1800s. The subsequent accumulation of live and dead fuels in some ERUs has created the potential for larger and more severe fires. Tree mortality from drought or insect and disease outbreaks contributes to fuel accumulation. Into the future, according to Westerling et al. (2006), changing climate is expected to continue to lengthen the fire season and favor larger, more frequent fires. Thus, fire may be either a driver or a stressor, depending on whether its effects are characteristic of the system or not. Prescribed fire acts as a driver. Large extents of high and moderate burn severity are in many cases stressors, because their effect can degrade the integrity of the system, and may convert the system to a condition that may never recover (Savage and Mast 2005; Roccaforte et al. 2012). Fire regime (frequency and severity) is an upland vegetation characteristic analyzed at the ERU scale in the Upland Vegetation Chapter of the assessment. Altered fire regimes can contribute to climate-changing greenhouse gases, provide a pathway for establishment and/or spread of invasive plant species, alter watershed conditions and present a direct risk to biodiversity and human habitation (Shlisky et al 2007).

Since the Gila NF become one of the first national forests to begin using fire as a tool in the mid to late 1970s (Boucher and Moody 1998), approximately 875 prescribed burns are documented in the Forest's Fire History database, totaling 408,886 acres. Between 1996 and 2014, the Forest averaged 11,326 acres of prescribed burning per year (see timber section of Multiple Uses Chapter). Over 1,400 wildfires have been allowed to burn an additional 564,891 acres, putting fire on the equivalent of 30 percent of the Forest. The actual acres of prescribed and wildfire use fires are greater than this amount, but prior to 1984, most of the records remain as hardcopy and have not been entered into the Fire History database. Also, some of these acres included in the database may have burned more than once. The Gila NF does not prescribe burning of riparian areas.

Fire severity, pattern and extent determine post-fire soil and watershed effects. In general, prescribed fire has minor and relatively short-term negative effects on watershed condition as severities are typically lower than those associated with wildfires. Over the long term, prescribed fire can have positive effects as it reduces the risk of larger, more severe wildfires. High burn severities result in removal of vegetative canopy and ground cover, soil organic carbon and nutrient loss, and alteration of soil properties and function (Busse et al. 2014). These things can occur at moderate severity as well, depending on the degree, depth and length of time at which soil heating occurs. High burn severities are typically associated with relatively long return interval, stand replacing wildfires.

Following moderate to high severity fire, watershed responses include: accelerated erosion and sediment delivery to stream channels; increased peak flow and stream power; changes in stream channel geometry, gradient and elevation; removal of riparian vegetation; long and short-term impacts to the quantity and distribution of LWD in stream systems; and water quality impacts. There is also an increased risk of invasive and/or noxious weed populations becoming established and/or expanding. The amount of time it takes for watersheds to stabilize depends burn severity, topography, geology, soils, vegetative species present pre-fire, post-fire treatments and precipitation patterns. In some areas, livestock management practices and/or concentrated use of burned areas by elk can also affect the rate of watershed recovery.

According to the Gila NF's Fire History and the Monitoring Trends in Burn Severity (MTBS) dataset, there have been a total of 2,502 wildfires where suppression was the management strategy. These wildfires have burned over a million acres. About 884 of these fires and half of these acres burned between 2011 and 2013. Large fires in this time frame include the 2011 Miller and Wallow, 2012 Whitewater Baldy Complex, and 2013 Silver Fires. The Wallow Fire burned primarily on the neighboring Apache-Sitgreaves NFs, but

burned almost 16,400 acres on the Gila NF with 12 percent at high or moderate severity. The Miller Fire burned 84,817 acres in 10 fifth-code watersheds with 25 percent at high or moderate severity. The Whitewater Baldy Fire, the largest fire in New Mexico history, burned 307,052 acres in 26 watersheds, again with 25 percent at high or moderate severity. The Silver Fire burned 140,839 acres in 23 watersheds with 48 percent at high or moderate severity. Overall, high and moderate burn severities have increased over the last several years, accounting for 29 percent of all burned acres in the 2010-2014 time period, as opposed to the 19 percent in the 1984-1999 time period and 16 percent in the 2000-2009 time period. Since 2000, 83 percent of the Spruce-Fir Forest, 60 percent of the Mixed Conifer with Aspen and 25 percent of the Mixed Conifer-Frequent Fire have burned at high or moderate severity with the vast majority of these acres burning in the Whitewater Baldy Complex and Silver Fires. Prior to these fires, the historical size of high severity fire in the upper elevation mixed conifer and spruce-fir forests in the wilderness could be estimated based on the extent of the quaking aspen stands. Aspen stands within the Whitewater Baldy Complex Fire perimeter ranged in size from between 14 and 254 acres, and in age from between 59 and 264 years old (Abolt 1997).

The increase in the number and size of fires are consistent with climate change predictions. In general, these trends are expected to continue across the Southwest. However, due to recent wildfire activity, the probability of the Gila NF to experience large, high severity fires in the near future has been reduced (Parks et al. 2014 and 2015a), but not eliminated. Recent studies including those in the Gila and Aldo Leopold Wildernesses concluded that the ability of burn scars to limit the occurrence of fire on the Forest may last approximately nine years (Parks et al. 2015b), the size of fires by two to six years depending on weather conditions (Parks et al. 2015a).

Most wildfires on the Forest have been started by lightning with notable exceptions being the 1998 Leggett, 2000 Saliz, 2006 Bear, and 2014 Signal fires. Although the area's population is expected to remain static over the next decade or more (UNM-BBER 2014), predicted increases in recreational use (Chapter 12. Recreation) could lead to an increase in human started fires. Lightning strikes are predicted to increase with climate change (Reeve and Toumi 1999).

Burned Area Emergency Response (BAER) teams have conducted 19 post-fire assessments on the Gila NF since 1995. Between 1995 and 2000, four of these assessments resulted in recommendations for seeding treatments. Approximately 1,300 acres were seeded with certified weed-free seed mix comprised of native and non-native annual and perennial species. The weed-free certification means that no species designated as noxious are present. After 2000, treatment recommendations included seeding on seven fires, and seeding and mulching on two: the 2012 Whitewater Baldy Complex Fire and 2013 Silver Fire. Seed mixes remained certified weed-free and included annual cereal grains, but no longer included non-native perennials. Only native perennial grass species such as Junegrass, muttongrass, blue grama, sideoats grama, mountain brome, western wheatgrass, slender wheatgrass, Arizona fescue, squirreltail and little bluestem have been applied since that time. Seed was applied to approximately 59,000 acres. Seed and straw mulch, also certified weed-free, was applied to approximately 18,800 acres.

Treatment effectiveness monitoring of seeding, and seeding and mulching has varied in its rigor and duration. Monitoring methods have included viability testing of the native seed bank, visual inspection, repeat photography, quantitative canopy, groundcover and species data collection, and/or measurement of soil loss rates using sediment traps or erosion bridges. The most rigorous monitoring efforts include the 1998 BS, 2013 Silver and 2014 Signal Fire treatments. The Plant Materials Center in Los Lunas, New Mexico tested the viability of the native seed bank on the 1998 BS Fire. This testing demonstrated very low to no viability (USDA FS Gila NF 1999). Although it is not possible to completely eliminate accelerated post-fire erosion, monitoring has documented treatment effectiveness in keeping more soil in place after high severity fire (USDA FS Gila NF 1999, 2013b and 2014a).

Fire characteristics and impacts in riparian areas are different than those in adjacent upland ecosystems, however there are also similarities. Effects depend on the relationships between fire frequency, severity and timing, climate conditions, vegetation community and landscape characteristics, as well as position within the watershed. With few exceptions, the current scientific understanding is that natural fire frequency and severity in riparian areas are less than surrounding uplands. Fires occur less often and at lower severity largely because of higher fuel moisture, soil moisture and relative humidity. Riparian areas are more susceptible to fire related impacts because of their high edge to area ratio (Pettit and Naiman 2007; Dwire and Kauffman 2003).

Landscape features such as topography, watershed position and aspect are also important factors. Steeper toe slopes leading into the valley floor tend to restrict the movement of fire into and through the riparian zone, contributing to longer fire return intervals, whereas shallower valleys tend to have return intervals closer to those of the adjacent upland ecosystems (Pettit and Naiman 2007). Fire frequency also tends to increase with decreasing valley width, making the period between fire shorter in headwater streams in the higher elevations of the watershed, and longer at middle and lower watershed elevations. Aspect influences burn patterns associated with fires entering riparian zones from the uplands, as cooler and wetter north slopes do not typically burn as often as south facing slopes. In some areas riparian community structure exerts a stronger influence over fire return intervals than landscape features. This includes where trees have been harvested from riparian areas. Where canopy gaps are created, fuels dry out quicker and may decrease the fire return interval and increase severity (Pettit and Naiman 2007; Dwire and Kauffman 2003).

Timing, as it relates to pre- and post-fire climate conditions, is an important determiner of ecological effects. Fires that occur early in annual dry periods tend to be lower in terms of severity and negative impacts as fuel and soil moisture remain relatively high. Fires that occur late in annual dry periods tend to occur at higher severity and ecological impact, as fuel and soil moistures are at their lowest. Periods of drought magnify both fire risk and severity when it does occur. It can also reduce the ability of species to recover from fire disturbance (Pettit and Naiman 2007; Dwire and Kauffman 2003).

Most riparian species are disturbance adapted. The ability to re-sprout following disturbance is an important characteristic following fire. Re-sprouting allows for rapid regeneration of the riparian community as this mode of reproduction is not dependent on the timing of seed dispersal and flooding. Seed longevity is typically short for these species, with germination and seedling establishment dependent on the timing between seed dispersal and the floods that prepare the seedbed and maintain adequate soil moisture (Gori et al. 2014). These events do not occur with any annual regularity. Shifts toward earlier and shorter snowmelt runoff periods, discussed in the Water Chapter, have enormous implications for riparian reproduction by seed.

While cottonwoods, willows, alders, sycamore may re-sprout after fire (and flood) in some regions and circumstances, willows are the only species that have been observed to re-sprout after fire with any reliability on the Gila NF. Although this has not been documented quantitatively, it has been widely observed that Fremont and narrowleaf cottonwood, sycamore and alder do not typically re-sprout after fire. This is of particular concern in alder communities as their thin bark makes them highly susceptible to mortality, even at low severity, and are largely single age-class communities. On the other hand, saltcedar is fire adapted, re-sprouts readily and can therefore displace native riparian vegetation more efficiently in the post-fire environment.

Prescribed fire and wildfire use are projected to increase with the continued emphasis on the restoration of fire to fire-adapted ecosystems. However, forest management and the public should not expect to completely restore the historic fire regime given altered fuel characteristics, climate change and operational, budget, policy and political constraints. There is some evidence suggesting that the higher

temperatures predicted to occur with climate change may lead to increasing trends in fire related tree mortality, independent of fire intensity (van Mantgem et al. 2012). This might mean that fire intensities that did not result in tree mortality in the past, could be expected to result in tree mortality in the future. Furthermore, research suggests that historic return intervals under a changing climate, without thinning, could result in a decline in some forest types, while longer than historic intervals (e.g. 20 years instead of 5 years in the ponderosa pine) could provide for the long term maintenance of restoration treatments (Diggins et al. 2010).

While the best available science utilized in this assessment is based multiple corroborating lines of evidence, a need for a wider spectrum of reference condition datasets across environmental gradients has been identified in General Technical Reference (GTR)-310 (Reynolds et al. 2013). Return intervals are described by vegetation type and only indirectly account for soil, slope, elevation, aspect, topography and local climate variability within those vegetation types. All of these things have been directly or indirectly identified as important variables in pre-settlement fire regimes and in some cases, more important than vegetation type (Abolt 1997; Baisan and Swetnam 1990; Parks et al. 2015; Rollins et al. 2000). While such information would generate too fine-scale a portrait for use in forest plan revision, where these local data are available they can be used to guide project-level planning in the future.

There has been some relevant data collected on the Gila NF, only in the Gila and Aldo Leopold wildernesses for the Ponderosa Pine, Mixed Conifer-Frequent Fire, and Mixed Conifer with Aspen ERUs, and to a very limited extent, the Spruce-Fir Forest (Abolt 1997; Baisan and Swetnam 1990; Rollins et al. 2000). These data are embedded in the fire regime reference conditions for those ERUs, but the estimates also include data from other locations across the Southwest. Recent work by Korb et al. (2013) suggests a need for caution when using fire return interval and forest structure information from specific localities and applying it elsewhere, particularly in warm/dry mixed conifer forests. While such information might generate too fine-scale a portrait for use in forest plan revision, where these local data are available they can be used to guide project-level planning in the future.

Fire has and will remain the most important management tool in supporting sustainable, fire-adapted ecosystems in the face of climate change (Fulé 2008; Tarancón et al. 2014). Accounting for site specific variability in reference forest structure and fire frequency may become increasingly important given climate change projections of larger and more frequent wildfires (Korb et al. 2013). Future forest management could be faced with finding a balance between actions or inactions to resist climate change impacts to protect highly valued resources, those that create resilience or those that facilitate the vegetation type conversions expected to accompany climate change (Millar et al. 2007).

### Non-Fire Vegetation Management Activities

Non-fire vegetation management activities, either mechanical, manual or chemical, are a system stressor. Chemical vegetation management activities are discussed in the pesticide use section of this chapter. Manual activities include harvesting of trees for fuelwood, construction or hazardous fuel reduction purposes using hand-held equipment like axes or chainsaws. Mechanical activities include but are not limited to: timber harvest, non-commercial thinning and pushing, chaining or mastication[51] of woody vegetation using heavy equipment such as backhoes, skidders, bulldozers etc. Mechanical activities alter the structure and composition of vegetative communities on a larger scale than is possible with manual activities. At this larger scale, these activities may be used to move vegetative communities toward or away from reference condition; however, they do not replicate the ecological functions associated with the reference fire regime. They have the potential to disrupt soil hydrologic function, stability and nutrient

[51] Pushing refers to uprooting individual trees with heavy machinery. Chaining refers to uprooting multiple trees with a chain secured between two pieces of equipment. Mastication refers to grinding, shredding or chopping of individual trees without uprooting.

cycling as heavy equipment causes surface or subsurface soil compaction or other detrimental changes in soil structure, disturbs the vegetative groundcover important for soil stability or in the case of mastication, can produce thick layers wood mulch that may delay the establishment of herbaceous species. Any of these practices prepare a seedbed that may favor woody species (Severson 1986) and some can also result in displacement, redistribution and/or mixing of the topsoil with less productive subsurface soils.

Compaction is generally the greater concern, where these activities take place on level ground. Compaction results in a change in soil structure and reduction of pore space and rooting depth. This alters the patterns of air and water exchange between the soil and atmosphere, reducing infiltration, soil moisture holding capacity, rooting depth, soil microbial activity and nutrient cycling. Soils with higher clay content are more susceptible to compaction, as are those that are wet at the time the activity occurs. The pounds of equipment per square inch of soil and operator skill are additional factors contributing to the degree of soil disturbance. Freeze-thaw action is a natural process that can break up compaction.

Non-fire vegetation manipulation prior to European settlement was limited to small-scale manual activities with non-motorized equipment. Similar to the previous discussion regarding Native American use of fire on the Gila NF, impacts were likely greatest in riparian areas as there is evidence that Native Americans harvested some riparian species for construction purposes to the extent that some may have gone locally extinct (Schollmeyer 2005). Despite the ecological values and ecosystem services provided by riparian vegetation, there was a time after European settlement when it was widely viewed as undesirable and even hazardous. Riparian species were targeted for removal, although how much of this was accomplished through fire versus non-fire treatments is not well known or described in the literature.

In the present time, the viewpoint that riparian vegetation is undesirable, is still held by some members of the public, as expressed during the assessment. This viewpoint originated owing to the fact that riparian vegetation slows water and spreads it out across a wider area which influences where flooding impacts occur. Human infrastructure and other values that occur upstream have a higher flood hazard, while those values downstream have a lower hazard. Riparian vegetation also uses relatively high volumes of water and occupies land often suitable for farming (Webb et al. 2007).

There is also a long history of mechanical vegetation treatments in the upland systems of the Gila NF. After the establishment of the Gila River Forest Reserve in 1899, the USGS sent Theodore Rixon to complete an inventory and examination of resources and conditions. Rixon described logging operations as having endangered the remaining stands by increasing the losing them to fire and/or exposure to wind and drought (1905). Since that time, lumber production continued to increase, but logging practices presumably improved. After 1952, New Mexico lumber production declined dramatically and further declined after 1996 due to forest plan amendments that incorporated guidance for northern goshawk habitat and Mexican spotted owl recovery (USDA FS 1996; see timber section of the Multiple Uses Chapter).

Since 1996, thinning of upland vegetation on the Forest has been limited to relatively small timber sales, and post, pole and fuelwood harvest with total treatments averaging just under 18,000 acres per year (see timber section of the Multiple Uses Chapter). In the last few years, pushing of piñon-juniper has regained favor. Mastication is a method that has not yet been used on the Gila NF, but may be in the future. Because of the small number of acres treated annually, this disturbance regime is not currently a major stressor. However, in the future it may increase in significance as the emphasis on restoration continues.

Intended outcomes of treatments are related to reductions in fuels and wildfire risk, wildlife habitat restoration, forest health restoration, watershed protection, and increased grass production.

The Forest has not conducted quantitative, short or long-term treatment effectiveness or soil disturbance monitoring associated with non-fire vegetation manipulation. However, qualitative observations made across the Forest suggests variability in outcomes. Pre-treatment vegetative community composition and structure, soils, and site specific climatic conditions contribute to this variability. Decreases in canopy cover as a result of treatment has often produced increases in canopy cover and/or stems per acre of shade intolerant, re-sprouting species such as evergreen oak and alligator juniper[52]. While there is research demonstrating that thinning treatments followed by prescribed fire are more likely to be effective in long-term restoration and ecosystem resilience than thinning alone (Covington et al. 2007; Tarancón et al. 2014), the previous observations have been made where thinning treatments were followed by prescribed fire and where they were not.

Graminoid responses are variable due to differences in the production potential of particular soils. A robust response by perennial grass species does not typically occur on shallow soils of many rhyolites and conglomerates, and on all shallow rhyolitic ash tuff. On soils with higher production potentials, increases in herbaceous cover do occur. Graminoid responses are also affected by the amount and timing of precipitation.

Scientific information about the effectiveness of mechanical control of alligator juniper is limited as most of the research on piñon-juniper control is related to species that do not re-sprout. A study conducted on the Gila NF near Fort Bayard, NM included both one-seed and alligator juniper. One-seed juniper, and other shaggy bark junipers found on the Forest do not re-sprout. The Fort Bayard study concluded that there was no difference in tree density between top thinning and areas that were not treated within 13 to 18 years. Treatments that involved uprooting and pushing trees over with a bulldozer had a slower rate of reestablishment of those tree species. The study demonstrated that no method of treatment produced a grass response, but did produce woody regeneration even though the area was not grazed during the 13 year study period (Severson 1986). Herbicides may represent a cost effective means of controlling re-sprouting and regeneration of woody species after these treatments, and limit soil disturbance. Recent work supported by New Mexico State Forestry indicates herbicide application significantly reduces re-sprouting and regeneration of woody species after treatments (Boykin pers. comm. 2016), lengthening the time between initial treatment and any maintenance that might be needed. Therefore, herbicides represent a potential means to reduce soil disturbance.

Vegetation treatments within riparian zones are limited to the restoration of the native riparian species. Activities include the removal of upland species where they are not part of the potential natural community, and planting of willow and cottonwood poles. Neither of these activities are being done at a large scale. Vegetation treatments in the upland portions of contributing watersheds also have the potential to impact riparian areas by altering the delivery of water, sediment and nutrients.

### Herbivory

Herbivory has been a disturbance regime in all ecological types both before and after the arrival of Europeans. In the reference time period, this disturbance regime was a system driver. In the current time period it is both a system driver and stressor.

In pre-European times, native ungulate species such as deer, elk, pronghorn antelope and bighorn sheep grazed across the Gila NF, with populations being kept in check by predators, weather patterns and natural cycles of disease. Grazing and browsing by native species during the reference period differed in degree, location, pattern, diet, slope preference, time spent in a single area and ground disturbance. After the arrival of Europeans, native ungulate populations declined, and in the case of elk, were completely

[52] *Juniperus deppeana*

eliminated from the Forest. The introduction of domestic livestock grazing in the late 1800s is one of the events that marks the end of the reference period (Smith 2006b).

Historically New Mexico rangelands were overstocked, primarily with cattle and sheep. Combined with cyclical drought, this resulted in deteriorated rangeland conditions. Evidence of these degraded conditions remain to this day. Examples include woody species encroachment and expansion, and gully erosion.

Permitted and authorized use have fluctuated in recent years. This is due in large part to the preference of the grazing permittee as an adaptive management response to drought conditions. Historic and current rangeland and grazing management is discussed in more detail in the range section of the Multiple Uses Chapter. As of 2001, an estimated 9,779 acres of riparian were excluded from livestock grazing, including roughly 210 acres of springs and wetland areas. 641 acres of riparian pastures had been created to better control livestock use and 1,445 acres of riparian were not grazed because the allotment was vacant. Permits were not expected to be reissued at that time. Since 2001, an estimated 860 additional riparian acres were excluded and 184 acres of riparian pastures were created. Concerning the riparian acres not grazed because the allotment was vacant and the permit was not expected to be reissued, grazing is now permitted on two of those allotments and portions of another, while ten additional allotments are now currently vacant, bringing the total riparian acres not grazed to 1,102.

Herbivory has the potential to impact the composition, structure and function of upland and riparian vegetative communities, and soil hydrologic function, stability and nutrient cycling. Reductions in vegetative canopy cover can reduce the above and below ground vigor of the plant, and reduce the amount of material available to create litter. These reductions can lead to decreased water infiltration, increased runoff and accelerated erosion (Belsky and Blumenthal 1997; Holechek et al. 2010).

Where decreases in herbaceous biomass occur, the ability of frequent fire ecosystems to carry low intensity fire can be reduced (Belsky and Blumenthal 1997; Holechek et al. 2010). It also reduces the risk of moderate and high intensity fire. Additionally, decreases in the herbaceous component reduces competition by grasses with woody species, allowing those woody species to expand or encroach into grasslands and woodland and forest openings. Sustained grazing over time can reduce species diversity as some plants are more palatable than others to specific ungulates (Fleischner et al. 1994).

Hoof action can break up vegetative groundcover and compact soil. In extreme cases, compaction results in a change in soil structure and reduction of pore space. This alters the patterns of air and water exchange between the soil and atmosphere, reducing infiltration, soil moisture holding capacity, rooting depth, soil microbial activity and nutrient cycling.

While there is evidence that heavy grazing can degrade arid rangelands (Fleischner 1994; Todd and Hoffman 1999; among others), some native plants are adapted to ungulate grazing (Pieper 1994; Holecheck et al. 2010) and grazing animals may play a role in nutrient cycling (Pieper 1994). Properly managed grazing, with respect to utilization levels, season of use, and type of animal may minimize impacts to ecosystem function and can be sustainable over the long term (Pieper 1994; Holecheck et al. 2006; Davies et al. 2011). Rest from grazing has been shown to reduce ecosystem degradation, especially in riparian areas (Schulz and Leininger 1990; Dalldorf et al. 2013), but alone, even total cessation of all grazing may not return grass systems to a historic reference state (Pieper, 1994). The amount and timing of precipitation also plays a large role in determining rangeland vegetation conditions. Through adaptive management of the timing, intensity and duration of grazing, effects to vegetation productivity and species composition can be managed (Holechek et al. 2010).

Livestock grazing management has led to the development of upland water sources, which has the secondary benefit of providing water for wildlife. In some cases, these waters have also been used in wildfire suppression activities.

Based on the rangeland vegetation condition indicator score from the watershed condition classification, 23 percent of the Forest is considered Functioning Properly, 70 percent Functioning at Risk and six percent Impaired Function. The watershed condition classification, and the rangeland vegetation indicator are described in the data section of the water resource chapter. District range specialists referenced the data collected at permanent range monitoring sites and used the national ruleset provided in the technical guide and professional judgement to rate this indicator. According to the Multiple Uses Chapter, range conditions are stable, or are trending upward across the majority of the Forest.

Repeat measurements at permanent range monitoring sites (clusters) have been collected using the Parker 3-step method. The strength of this dataset lies in its relatively long period of record. Weaknesses of this methodology include the fact that range condition ratings do not consider site potential, only the conditions that are suitable to support livestock. This means that there can be areas rated in fair (Functioning at Risk) or poor (Impaired Function) that are actually at their ecological potential. Many of these areas are located on steep, rocky slopes with shallow soils. Also, because of the way it differentiates between rock and bare soil, bare soil may be overestimated and rock underestimated.

In general, rangeland conditions on the Forest have improved substantially over the last several decades due to adaptive management responses to changing conditions. As previously mentioned, these adaptive responses are frequently implemented at the request of the permittee. These responses include reductions in actual use during times of drought and subsequent restocking to permitted numbers once conditions have improved. However, legacy issues remain and future trends in rangeland condition will increasingly depend on the ability of monitoring and adaptive management to respond effectively to climate change.

Elk were officially reintroduced to the Forest in the 1950s, although some migration from earlier reintroduction efforts on adjacent lands likely occurred. These populations have steadily increased, particularly on the Quemado and Reserve Ranger Districts, and have caused negative ecological impacts in some areas. Ecological impacts are typically highest in wet meadows, riparian areas and aspen stands.

### Invasive and Noxious Species

Invasive species are defined by Executive Order 13112 (1999) as those species that are non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Not all non-native species are invasive. Some invasive plant species are so harmful they have been given regulatory designation of “noxious” by the Federal or State Departments of Agriculture. The presence of these species constitutes a system stressor. Potential harmful effects include but are not limited to decreased soil stability, interrupted upland and riparian forest succession, changes in wildfire frequency and intensity (Levine et al. 2003; Brooks et al. 2004; Brooks 2008; and Invasive Species Advisory Committee 2006), and reduced water quality.

Prior to European settlement, invasive and noxious species were not known to occur. European settlement introduced many non-native plants which are now permanent components of the systems they inhabit. Since that time, plants, and other organisms have continued to enter systems they did not originate in. The threat these species do or do not pose depends on the degree of ecological and economic harm they cause.

Noxious plant species are not generally well established on the Gila NF as compared to other western forests as reflected in the terrestrial invasive species indicator rating. However, there have been few

noxious weed surveys on the Forest. Known populations of species designated as Class A[53] noxious weeds by the State of New Mexico include less than five acres of camelthorn (*Alhagi maurorum* Medik)and less than 10 acres of yellow starthistle (*Centaurea solstitialis* L.). Occurrences of spotted knapweed (*Centaurea stoebe* L. ssp. *micranthos* (Gugler) Hayek) and Canada thistle (*Centaurea arvensis* L.) are known, but acres affected are not. One small infestation of purple loosestrife (*Lythrum salicaria* L.) was treated repeatedly between 2006 and 2010 and has not been documented since. The Gila NF has a concern about the Class A listed yellow toadflax (*Linaria vulgaris* Mill.) and hoary cress (*Cardaria draba* (L.) Desv.) as they have been documented in close proximity to the Forest boundary.

Known populations of species designated as Class B[54] noxious weeds by the State of New Mexico are limited to tree of heaven (*Ailanthus altissima* (Mill.) Swingle which is estimated to affect more than 500 acres. These populations occur mainly in riparian areas, but have been documented in upland ecosystems as well. African rue (*Peganum harmala* L.), also a Class B listed species is a concern as it has been documented in close proximity to the Forest boundary.

Known populations of species designated as Class C[55] noxious weeds include more than 80 estimated acres of bull thistle (*Cirsium vulgare* (Savi) Ten.), 600 acres of cheatgrass(*Bromus tectorum* L.), unknown acreage of Russian olive (*Elaeagnus angustifolia* L.), 300-1000 acres of saltcedar (*Tamarix* L.) and more than 100 acres of Siberian elm (*Ulmus pumila* L.). General observations by Forest staff not associated with a formal noxious weed species inventory indicate Siberian elm is far more widespread than saltcedar. Saltcedar is of particular concern to riparian and aquatic resources as it creates salty conditions that favor itself, potentially excluding native riparian species if flood flows are insufficient to remove accumulating salts. Spiny cocklebur(*Xanthium spinosum* L.), a species on the noxious weed Watch List[56], has been documented adjacent to the Forest in Arizona as recently as 1978 and was documented a single time in 1951 on the San Francisco River near Glenwood (SEINet 2016).

All of populations described here were known as of 1997 (USDA FS Gila NF 1997). An additional non-native plant survey of the Aldo Leopold Wilderness area conducted between 2011 and 2014 by the Upper Gila Watershed Alliance, in support of the Gila NF's Wilderness Stewardship Challenge. This survey focused on approximately 66 miles of trails and streams, 18 off-trail miles, seven corrals, six stock tanks and numerous springs. While many non-native species were observed, a single Siberian elm was the only noxious species found (Keith 2014).

Noxious weed species are highly competitive, disturbance adapted, prolific reproducers and are readily disseminated by wind, water, animals and humans. They often have the advantage over native species because they have been introduced unaccompanied by their natural predators or diseases that would normally keep them in check. Burned areas are at higher risk of invasion by noxious weeds due to lack of competition for sunlight, water and nutrients. With the wildfires that have occurred and the proximity of the burned areas to known invasive plant populations, the Forest has an elevated concern for the spread of invasive species and the establishment of invasive species that have not been documented.

[53] "Class A noxious weed species are those not currently present in New Mexico, or having limited distribution. Preventing new infestation of these species and eradicating existing infestations is the highest priority" (NM Department of Agriculture 2009).
[54] "Class B noxious weed species are those limited to portions of the state. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread" (NM Department of Agriculture 2009).
[55] "Class C noxious weed species are those that are wide-spread in the state. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation" (NM Department of Agriculture 2009).
[56] "Watch List species are of concern in the state. These species have the potential to become problematic. More data is needed to determine if these species should be listed. When these species are encountered, their location should be documented and the appropriate authorities contacted" (NM Department of Agriculture 2009).

The application of certified weed-free seed, as discussed in the prescribed fire and wildfire section of this chapter provides a secondary benefit to soil and watershed stabilization by providing for more immediate competition. The certification process includes genetic laboratory testing of random samples to ensure no species designated as noxious are present. The certification process for straw mulch is not as rigorous as it only involves a walk-through field inspection. While the Silver Fire BAER monitoring included a noxious weed survey, more noxious weed inventory and monitoring is needed.

At the subwatershed level, the watershed condition classification indicator documents one percent of subwatersheds as having established populations of invasive species with the rate of expansion or potential impact on watershed resources considered moderate. All other subwatersheds have few or no invasive species that would affect soil and water resources and necessitate treatment for that purpose.

In addition to the successful treatment of the small population of purple loosestrife, the Forest has had successes treating yellow starthistle and spotted knapweed. Bull thistle treatment and monitoring is ongoing. Both hand-pulling and herbicide treatments are treatment tools.

Cut-stump herbicide application to saltcedar has been successful in some areas, but much more inventory and treatment is needed. As a Class C noxious weed species, saltcedar is wide-spread in the state, but populations on the Gila NF are relatively small and discontinuous. This is due to several factors. The existing native riparian community structure and condition, and the free-flowing, perennial nature of the Forest streams on which most populations are found being chief among those factors. Because saltcedar is shade-intolerant, the multi-storied and/or dense canopy cover provided by native riparian communities prevent saltcedar populations from expanding in size and number.

Where saltcedar is found on intermittent streams, or where streamflow is regulated by dams, saltcedar has the advantage over native species. Depth to groundwater is typically lower along intermittent streams. Native species, cottonwoods and willows in particular, tolerate a smaller range of depth to groundwater that saltcedar does. Large and/or sudden fluctuations in the water table depth are common along streams where flows are regulated by dams other control structures. Saltcedar remains subdominant to native species on free-flowing streams where the natural flood frequency, timing and duration favors natives. Drying trends, changes in flood frequency and reductions in native canopy cover increase the risk associated with saltcedar infestations on the Gila NF.

Vegetation changes associated with climate change are expected to be species specific, making it difficult to determine what future threats might be posed by invasive and noxious plant species. More research is needed to predict trends with any confidence, however it is likely that shifts in vegetation community composition will provide new opportunities for invasion (Middleton 2006).

Aquatic invasive species also exist on the Gila NF, are a continuing challenge and a threat to native fish. Crayfish (*Cambaridae*) can be found within reservoirs, streams, irrigation canals, or silt-covered/rocky or gravel substrates, particularly in lentic, or still, very slow moving, water. Bullfrogs (*Lithobates catesbiana* Shaw) have invaded habitats for native aquatic species, and may be common in any permanent water bodies within lower elevations of the Gila NF, particularly in lentic waters (Hayes, NMDGF 2015 pers. comm.). A couple of invasive aquatic plants have been found on the Gila NF, Eurasian watermilfoil (*Myriophyllum spicatum* Kom.) which has been found in SA tank #1, and watercress (*Nasturtium officinale*) which has been found in the Gila River (Hayes NMDGF 2015 pers. comm.) and other streams across the Forest.

## Insects and Disease

Insects and diseases are important components of forest and woodland ecosystems, greatly influencing structure and species composition over time. They can be both a system driver and stressor. Forested

systems have developed under locally specific pathogen levels that were sustainable historically and may help maintain ecosystem function. An outbreak may have uncharacteristic effects to which the system may or may not be resilient to, either because the outbreak is more severe, or because of factors that amplify damaging effects.

Insects and disease have been disturbance mechanisms throughout time, and have many positive impacts. In cases of severe infection levels or periodic outbreaks of insects, the effects are more obvious and can be negative (Ryerson 2015), including increased fuel loading and an elevated risk of wildfire. Conditions such as these were readily observed prior to the 2013 Silver Fire in the southern portions of the Black Range along NM Highway 152. With the exception of white pine blister rust, which is established on the Gila NF, the primary forest insects and diseases are native with outbreaks tied primarily to drought or disturbance (Ryerson 2015).

The period of record documenting insect and disease patterns on the Gila NF is relatively short, and less detailed than other forests in the Southwestern Region prior to the beginning of aerial detection surveys in the 1950s owing to the remoteness and accessibility of the terrain. Since aerial detection surveys began, relatively little activity has been documented compared to other forests. This may be partly due to the Gila NF's proactive fire management. Regardless, the record demonstrates no clear changes in native insect and disease outbreaks (Ryerson 2015).

On a watershed scale, the forest health indicator from the Gila NF's watershed condition classification classifies 99 percent of the Forest as Functioning Properly, with less than 20 percent of any subwatershed anticipated or experiencing tree mortality as a result of insects, disease or air pollution. In the future, the non-native white pine blister rust is expected to expand in terms of occurrence and severity. Climate change is anticipated to substantially change insect and disease dynamics, likely leading to increased tree mortality (Ryerson 2015).

Diseases affecting aquatic species also pose a threat. *Batrachochytrium dendrobatidis* fungus, also known as Chytrid, has been documented in amphibians in multiple locations of the Gila NF including the Upper Gila/San Francisco, Lower Gila, and Mimbres River/Black Range areas (Hayes, NMDGF 2015 pers. comm.). Chytrid fungus infects amphibian species with the chytridiomycosis disease, which is linked to devastating population declines or species extinctions (Kilpatrick et al. 2009). Another bacterial disease has been detected on the Gila NF is *Renibacterium salmoninarum*, also known as bacterial kidney disease (BKD). *Renibacterium salmoninarum* is an obligate pathogen of salmonid fishes. To date, the bacterium has not been found to infect other species of fish or other animals. It can be transmitted from fish to fish (Mitchum and Sherman 1981), or from adults to their progeny via eggs (Bullock 1980; Bullock et al. 1978).

### Pesticide Use

Pesticides, including herbicides, insecticides and piscicides (pesticides that target fish) have been used to a limited extent on the Forest. As these types of chemicals did not exist in the reference period, in a strict sense their use is considered a system stressor. However, non-native and/or noxious species are also system stressors. These species are typically the target of current pesticide use on the Forest. The use of chemicals as a management tool raises concerns about water quality, aquatic species and human health for some members of the public, as was expressed during the assessment.

According to a Southwest Regional pesticide-use report from 1987, 835 acres were treated with Picloram and 150 acres with Hexazinone for range vegetation improvement. 250 additional acres were treated the Hexazinone for noxious weeds and 80 acres for thinning (USDA FS 1987). The location of these applications are not included in the documentation and no monitoring documentation has been located. In more recent years, only species designated as noxious by the State of New Mexico have been treated with herbicides. The Forest has had some successes where cut-stump applications of Garlon 3A has been

applied to saltcedar, but ongoing inventory and monitoring demonstrate that the saltcedar infestation is not yet resolved.

Insecticides are only known to have been used in a single instance. This occurred in the Catwalk area of Whitewater Canyon on the Glenwood Ranger District in 1966, prior to the National Environmental Policy Act (NEPA) and Clean Water Act. Carbaryl was used to control a heavy infestation of an unidentified tussock moth causing 'light" damage to boxelder seedlings (USDA FS Gila NF 1965). Piscicide has been an important tool in the Gila trout (*Oncorhynchus gilae*) recovery program, beginning with a 1961 application of Antimycin A in Iron Creek. Since that time, both Rotenone and Antimycin A have been used in various streams identified as important to Gila trout recovery. .

Piscicide will continue to be utilized where determined to be the appropriate method to manage and control nonnative fishes. Piscicide use and trends in the future will likely depend on the New Mexico Department of Game and Fish, US Fish and Wildlife Service, and native fish management needs. Herbicide use and trends will likely be tied to invasive and noxious weed management. Although, it may be considered as tool to remove alligator juniper and other re-sprouting species as restoration of grassland and woodland vegetation communities continues.

## Roads and Trails

The presence of roads and trails represents a system stressor. Roads directly affect natural sediment and hydrologic regimes by altering stream flow, sediment loading, sediment transport and deposition, channel morphology, channel stability, substrate composition, stream temperatures, water quality, and riparian conditions in a watershed (USDA FS 2000). They also provide a vector for the spread of invasive and noxious species and contribute to habitat fragmentation.

Roads have three primary effects on hydrologic processes. They intercept rainfall directly on the road surface and road cut and fill slopes, and intercept subsurface water moving down the hillslope; they concentrate flow either on the surface or in an adjacent ditch or channel; and they divert or reroute water from natural flow paths (USDA FS 2000).

Roads contribute more sediment to streams than any other land management activity (USDA FS 2000). Large increases in the amount of sediment delivered to the stream channel can greatly impair or even eliminate fish and aquatic invertebrate habitat and alter the structure and width of stream banks and adjacent riparian zone. The amount of sediment can affect channel shape, sinuosity, and relative balance between pools and riffles. Indirect effects of increased sediment loads may include increased stream temperatures and decreased inter-gravel dissolved oxygen (USDA FS 2000).

Prior to European settlement, Native Americans created trails as they followed game, seeds, nuts and fruits of native plants; conducted commerce and warfare; and visited places of religious significance. While these trails existed on the Gila NF, because of the relatively low density and small footprint of these trails, modes of travel and frequency of use, it is assumed that they did not have significant impacts.

After the arrival of Europeans, many of these trails were used by an increasing number of people and new trails and wagon roads were created, many of which followed streams. Upland wagon roads that became too rutted and eroded to use were abandoned and new roads created. Evidence of some of these roads persists on the landscape today. As travel became more commonly motorized, the impacts on soil and other watershed resources increased.

The roads and trails indicator from the watershed condition classification describes the likelihood of altered hydrologic and sediment regimes in terms of road density, maintenance and proximity to water attributes. Ratings of Functioning Properly indicate the hydrologic and sediment regimes are largely intact.

Functioning at Risk and Impaired Function ratings indicate moderate and higher likelihoods of alteration of hydrologic and sediment regimes. Between 64 and 67 percent of subwatersheds are Functioning Properly with respect to road density and proximity to water while only approximately 12 percent are considered Functioning Properly with respect to maintenance. Roads in close proximity to water not only have some of the highest maintenance requirements, but also have the most immediate effects on riparian vegetation, channel shape and function, and sediment and hydrologic regimes.

For this assessment, road density was calculated specific to each ERU and is displayed in the following two tables.

**Table 169. Road density in the upland ERUs of the Gila NF.**

| Roads and Trails | Forests | | | | | Woodlands | | | | | Shrubland/Grasslands | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ponderosa Pine Forest | Mixed Conifer Frequent Fire | Ponderosa Pine-Evergreen Oak | Mixed Conifer with Aspen | Spruce Fir Forest | PJ Woodland | PJ-Grass | Juniper Grass | Madrean Piñon-Oak | PJ-Evergreen Shrub | Mountain Mahogany Mixed Shrubland | Montane Subalpine Grassland | Colorado Plateau-Great Basin Grassland | Semidesert Grassland |
| Open | 1.1 | 0.3 | 0.9 | 0.4 | 0.3 | 0.5 | 0.5 | 0.9 | 0.1 | 1.2 | 0.1 | 1.9 | 2.4 | 2.0 |
| Closed | 0.6 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.2 | 0.3 | 0.1 | 0.05 | 0.1 | 0.3 | 0.3 | 0.4 |
| All Roads | 1.7 | 0.5 | 1.2 | 0.6 | 0.4 | 0.7 | 0.7 | 1.2 | 0.2 | 1.3 | 0.2 | 2.2 | 2.8 | 2.4 |
| Motorized Trails | 0.02 | | 0.04 | 0.01 | | 0.05 | 0.01 | 0.1 | | | 0.04 | | 0.01 | 0.02 |
| Non-motorized Trails | 0.2 | 0.8 | 0.4 | 0.4 | 0.9 | 0.1 | 0.3 | 0.1 | 0.1 | 0.03 | 0.2 | 0.1 | 0.1 | 0.1 |
| Total Roads and Trails | 2.0 | 1.3 | 1.6 | 1.0 | 1.3 | 0.9 | 1.0 | 1.4 | 0.3 | 1.3 | 0.5 | 2.3 | 2.9 | 2.5 |

**Table 170. Road density in the riparian ERUs of the Gila NF.**

| Roads and Trails | Cottonwood Group | | | | Montane Conifer-Willow Group | | | | Walnut-Evergreen Oak Group | Desert Willow Group | Wetland-Ciénega Group |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fremont Cottonwood-Oak | Fremont Cottonwood-Shrub | Narrowleaf Cottonwood-Shrub | Sycamore-Fremont Cottonwood | Upper Montane Conifer-Willow | Willow-Thinleaf Alder | Arizona Alder-Willow | Ponderosa Pine-Willow | Arizona Walnut | Desert Willow | Herbaceous-Wetland Riparian |
| Open | | 8.4 | 3.5 | 2.6 | 0.8 | 1.2 | 1.5 | 5.9 | 5.7 | 5.6 | 3.5 |
| Closed | | 0.2 | 0.8 | 0.9 | 0.1 | 1.0 | 0.2 | 1.2 | 1.5 | 1.5 | 1.1 |
| All Roads | | 8.6 | 4.3 | 3.5 | 0.9 | 2.2 | 1.6 | 7.0 | 7.3 | 7.1 | 4.6 |
| Motorized Trails | | | 0.5 | | | | 0.02 | | 0.5 | 0.7 | |
| Non-motorized Trails | | 1.0 | 3.9 | 1.4 | 13.3 | 7.5 | 7.7 | 0.9 | 1.5 | 0.2 | 0.9 |
| Total Roads and Trails | | 9.6 | 8.7 | 4.9 | 14.2 | 9.7 | 9.3 | 7.9 | 9.5 | 8.1 | 5.5 |

After implementation of the Travel Management decision resulting in motorized travel being restricted to a designated transportation system, impacts to riparian ecosystems and watershed condition are expected to decline (USDA FS Gila NF 2013a). As future projects include decommissioning of unneeded system roads and unauthorized roads, impacts will be further reduced. On the other hand, as described in the Infrastructure Chapter, the Forest's ability to conduct sufficient road maintenance is limited by budgets. Road maintenance on the Gila NF is of larger concern than road density. If the budget trends continue downward, so will soil conditions associated with the road and motorized trail system on the Forest.

### Recreation

Any natural resource impacts caused by unmanaged, illegal, or inappropriate recreation use on Forest lands may be a stressor. This may include illegal and/or inappropriate recreation use incompatible with particularly sensitive areas (such as OHV use in riparian areas), littering, numbers of visitors exceeding the designed capacity of a developed site, excessive use of an area for dispersed recreation activity, and excessive numbers of, or unsuitably located, user developed campsites within General Forest Areas.

Based on National Visitor Use Monitoring (NVUM) survey results, total recreation visitation to the Gila National Forest increased by 69%, or from 305,000 to 514,000 visitors, between 2006 and 2011. The same survey results also showed that certain recreation site types demonstrated longer duration stays per visit, including General Forest Areas (increased by 19.3 hours per visit), Overnight Use Developed Sites (increased by 17 hours per visit), and Designated Wilderness (increased by 1.8 hours per visit). This recent trend of longer duration per visit may indicate that a significant number of visitors are now staying for three-day visits, as compared to two-day visits. Day Use Developed Sites were the only site type that demonstrated a shorter visitor stay duration, reduced by 1.4 hours. The overall duration of a National Forest visit between these surveys has increased by 2.4 hours per visit.

General Forest Areas (GFAs) are National Forest lands that are considered undeveloped, with the exception of system roads and trails. These areas are typically associated with dispersed recreation. Examples of uses on General Forest Areas are dispersed camping, OHV riding, hunting, backpacking, and horseback riding. Most recreation special uses requiring the issuance of a special use permit also involve some type of dispersed recreation activity.

There are many user-developed dispersed campsites distributed throughout the Gila National Forest. Most user-developed campsites are in good physical condition, and many Forest visitors use existing, hardened user-developed campsites and are observed to maintain a clean camp and minimize resource impacts. However, common resource impacts associated with dispersed camping include litter, wheel ruts from driving during wet conditions, and human-caused wildfire caused by unattended campfires.

Developed recreation sites are those designated areas where the agency provides constructed facilities and improvements for both visitor convenience and resource protection. These sites are designed for concentrated use of an area by a set maximum number of visitors, reducing the likelihood of human-caused resource impacts when used as intended. The Gila National Forest currently has 33 developed campgrounds (including 2 group sites), 6 picnic sites (including 3 group sites), 98 developed trailheads, 3 public target shooting ranges on the Glenwood, Silver City, and Reserve Ranger Districts, an observation site, and an Interpretive Site Visitor Center near the Gila Cliff Dwellings National Monument. Developed sites and areas experience greater use during the summer through fall seasons and on holidays, although some remain open and in use year-round.

The current trend for some developed recreation facilities is of declining conditions due to a backlog of deferred maintenance, age of infrastructure, budget limitations, and vandalism (e.g., graffiti, litter, physical damage to facilities, etc.). This trend may also contribute to increased resource damage due to improperly functioning facility improvements, or by concentrations of larger numbers and more frequent visitation

exceeding design capacity at some sites. For more information on dispersed and developed recreation trends and threats, see the Recreation Chapter.

Designated Wilderness includes areas designated under laws passed in Congress for preservation and protection in their natural condition, but may also contain ecological, geological, or other feature(s) of scientific, educational, scenic, or historical value. The Gila NF currently has three designated wilderness areas – Gila Wilderness, Aldo Leopold Wilderness, and Blue Range Wilderness. The Wilderness Act requires management of human-caused impacts and protection of wilderness character to insure that they are "unimpaired for the future use and enjoyment as wilderness." Wilderness character as defined under the Wilderness Act consists of five qualities: untrammeled (free from control or manipulation), natural, undeveloped, outstanding opportunities for solitude or primitive unconfined recreation, and other features of value.

Acceptable recreation uses in wilderness, as mandated by law, policy and regulation, only allow non-mechanized travel and non-motorized uses, which have a lower potential to cause significant resource damage. The Gila's wilderness areas are considered "destination attractions" for visitors seeking a wilderness experience. Increased visitation may create stressors to wilderness character, which the Forest is mandated by the Wilderness Act of 1964 and agency policy to protect, and there is a trend in increased wilderness visitation demonstrated between the two previous NVUM surveys. Current levels of overall wilderness visitation are not considered to be of concern, although some localized areas may be experiencing concentrated use that may diminish wilderness character. Wilderness character is a measure only applied to an entire wilderness, and may not be directed to only specific areas within, therefore any localized effects are an impact to overall wilderness character.

### Mineral Resource Extraction

Disturbances to the soil resource related to the extraction of mineral resources include erosion and contamination. The Gila NF has a long history of mining activities, which are described in greater detail in the Energy and Mineral Resources Chapter. Although large-scale mining did not occur prior to European settlement, Native Americans utilized the Forest's mineral resources for many things including pottery, jewelry and tool production. Ground disturbing activities were of relatively small extent and no contaminants were produced.

Mining on the Forest began in the late 1800s with gold, silver and copper being the primary minerals extracted. Mining practices that disturbed riparian communities has occurred to a very limited extent and was associated primarily with placer gold deposits in Bear Creek and isolated areas in the Burro Mountains. As a whole, mining activity has declined in recent years. At present, mineral extraction on the Forest is limited to crushed stone, construction sand and gravel, recreational gold panning and noncommercial collection outside of wilderness areas. Two large open-pit copper mines, Tyrone and Cobre, operated by Freeport McMoRan Inc. are located immediately adjacent Forest boundaries. While the potential for increased mining activities on the Forest exists for some minerals, mining activity trends follow the metal or commodity prices.

Abandoned Mine Lands (AMLs) are known abandoned mines and/or mining-related hazards in need of reclamation or restoration. These lands may contain arsenic, cadmium, copper, lead, mercury and zinc which cause human health and environmental hazards. An inventory of these lands, conducted in the late 1990s, identified 353 AMLs within the Gila NF. The work to reclaim these problem areas is conducted as time and money permits. Soil contamination concerns related to AMLs is documented qualitatively by the soil condition indicator from the watershed condition classification. Mining related soil contamination is noted in approximately three percent of subwatersheds, but is not known to affect overall soil quality. Water quality, on the other hand, is known to be affected by mining related pollutants. There are just over

7.5 stream miles in the context area, 1.7 of which occur on Forest, where cadmium and lead concentrations have resulted in a 303(d) listing where the likely cause is a nearby historic mining operation.

## Stakeholder Input

Stakeholder input received during the assessment regarding system drivers and stressors centered around fire and climate change and their relationships with the disturbance regimes described in this chapter such as non-fire vegetation management and herbivory. Invasive species and insects and disease were also topics of concern for some.

Most stakeholders that provided input recognize fire as a natural, ecological process and an important management tool, although a few suggest prevention, suppression of all wildfires and discontinued use of prescribed fire is warranted based on smoke related human health concerns. Of those that recognize fire as a natural ecological process, most agree that fuel loading, fire frequency and severity have been altered by Gila NF management actions and inactions. Some also point to the relationship between altered fire regimes, drought and climate change, and are concerned the negative and potentially long-term ecological and watershed impacts observed following recent large, high severity wildfires. Others suggest that while watershed impacts might be negative, the ecological impacts might be beneficial.

These fires have also limited stakeholder access to the Forest in some areas, either by Forest Service closure, or by deteriorating road and trail conditions. Some see these fires as a waste of natural and economic resources (such as timber) and suggest expedited, wide-spread salvage logging should be a priority. This group of stakeholders also suggests that increases in timber harvest and livestock grazing should be used to supplement or replace fire as a disturbance regime to promote ecosystem and economic health and that declines in both of these practices are responsible for current conditions.

On the other hand, there are others that provided references during the assessment, pointing to the body of science that suggests the legacy of historic livestock grazing practices and fire suppression both contributed to current conditions. This group of stakeholders also asserts that restoring natural fire regimes on the Forest is key to climate change adaptation and points to the science supporting restoration of process is more important that restoration of structure or composition.

In general, stakeholders view fire management on the Gila as largely reactive, not pro-active and note that this approach has a high cost in ecological and economic terms as observed by the increasing size and severity of wildfires. Some note the cost associated with large suppression efforts and question why those dollars are not spent instead on preventative measures such as thinning and prescribed fire. Others point to livestock grazing practices that reduce the fine fuels that carry fire as restricting fire. Still others are concerned about the combined effects of climate change and the large, high severity fires the Gila NF has seen in recent years and wonder if the Forest isn't already seeing ecosystem type conversions (e.g. mixed conifer to shrubland) that could be expected to accompany climate change. Stakeholders are also concerned about post-fire emergency stabilization treatments. Many support post-fire seeding of grasses as a method to reduce flooding, erosion, sedimentation hazards. A few wonder why the Gila NF doesn't re-plant trees after fire. Some are concerned about the use of non-native species and/or straw mulch.

Several comments asserting Forest managers should be demonstrating stronger consideration of climate change and a more active approach to increasing ecosystem adaptive capacity to climate change were received. Increasing extents of insect and disease outbreak were referenced in relationship to climate change and overgrown forests. A few suggested using timber harvest to remove existing bark beetle damaged trees. Some want to make sure that future desired conditions described in the revised Forest Plan are actually possible given "new climate normals" and stress the need for management to place emphasis on ecosystem resiliency. Others are concerned about climate change and the possibility of

threatened, endangered and otherwise at-risk species reaching extinction. Conversely, existing and future extents of invasive and noxious species, particularly saltcedar are worrisome to many as climate change could favor invasive species. These stakeholders indicate a need for more inventory, monitoring and treatment and some suggest the Forest work with Cooperative Weed Management Areas to coordinate efforts with New Mexico Department of Agriculture.

## Summary

This chapter reviews the best available information related to system drivers and stressors on the Gila NF. Major system drivers include the predominant climatic regime and cycles of drought, natural vegetation succession, and fire. Major system stressors include climate change and cycles of drought, water supply and demand, woody vegetation encroachment, fire, roads and trails, and herbivory. While insects and disease, and terrestrial and invasive species are not currently major system drivers, climate change projections could increase their significance in the future. Climate change and ecosystems are intricately connected and impacts on one will often feedback to affect the other. As the health of the ecosystem is a function of water availability, temperature, nutrient availability, and many other factors, it is difficult to determine the extent, type and magnitude of ecosystem change, and the associated changes in services provided, under future climate scenarios.

Regardless, the Gila NF has the opportunity to manage for ecosystem adaptation and resilience to climate change by integrating ecological and watershed restoration. Fire has and will remain the most important management tool in supporting sustainable, fire-adapted ecosystems in the face of climate change (Fulé 2008; Tarancón et al. 2014). Accounting for site specific variability in reference forest structure and fire frequency may become increasingly important given climate change projections of larger and more frequent wildfires (Korb et al. 2013). Accounting for watershed impacts to riparian and aquatic ecosystems will also become increasingly important, especially in those systems where cottonwood and alder are present.

Other than fire, which can be either a system driver or stressor, the available tools to accomplish restoration are all stressors. However, a balanced approach that considers site specific factors and the potential trade-offs associated with of each management tool, or combination of tools, may provide for restoration of some ecosystem characteristics and contribute to adaptation and resilience. Monitoring treatment effectiveness will be important to inform these decisions.

While there may be responsibility and opportunity related to Forest management, there are also limitations, budget and staffing being primary among them. These limitations may be overcome, in part, by collaborating with new and existing partners.