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Prescott National Forest

Ecological Sustainability Report

A mix of evergreen shrubs and ponderosa pine forest on Mingus Mountain.

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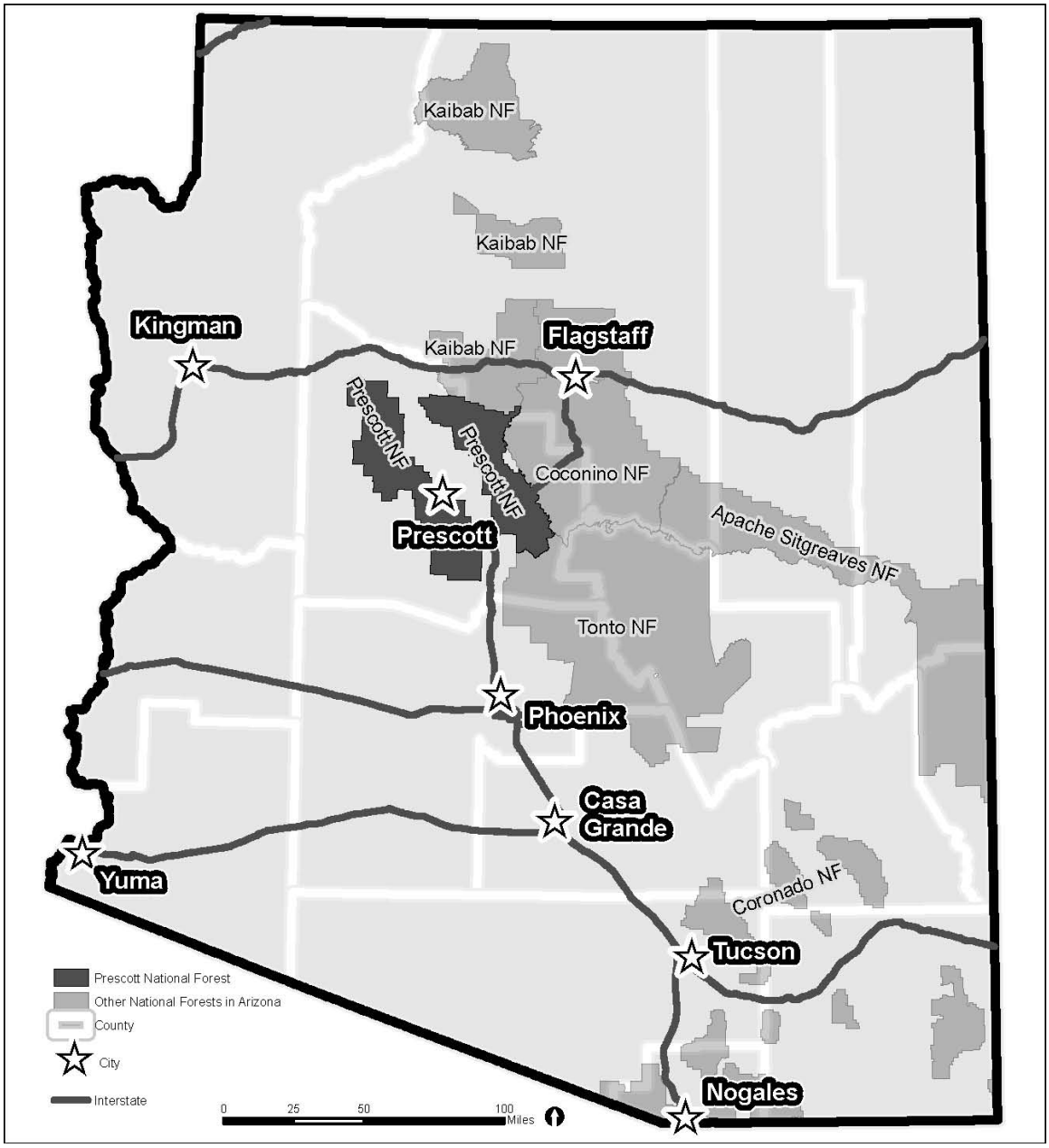
Figure 1. Prescott National Forest is located in central Arizona



Chapter 1 – Introduction

In this ecological sustainability report, we provide information on the biological and physical environment of the Prescott National Forest (PNF) and surrounding area. We profile the diversity of ecosystems and species known to occur within the PNF, and identify existing threats and associated risks to the long-term sustainability of those ecosystems and species.

This report is organized into two main sections, ecosystem diversity and species diversity. The ecosystem diversity section (chapter 2) summarizes conditions and trends of the vegetation communities and connected physical resources (soil, water, air). A section on climate change for the southwestern United States is also included. The species diversity section (chapter 3) discusses the mammals, birds, fish, amphibians, reptiles, invertebrates, and plants that occupy various habitats within the PNF. We identify which ecosystems and associated species are most at risk in chapter four and identify the threats creating the risk. The final section (chapter 5) summarizes our key findings on sustainability.

The findings from this report, along with information from the PNF Economic and Social Sustainability Assessment, Need for Change Evaluations, and public input will be summarized in a Comprehensive Evaluation Report (CER). The CER will integrate the social, economic and ecological components of sustainability and will identify portions of the existing PNF Land and Resource Management Plan (1986, as amended) that need revision.

Description of the Planning Unit

The PNF is one of six National Forests in Arizona, occupying 1.25 million acres within Yavapai and Coconino counties as shown in figure 1. The PNF borders three other National Forests: Coconino, Kaibab, and Tonto.

The PNF is located in a comparatively mountainous section of central Arizona between the forested plateaus to the north and the arid desert region to the south. Elevations range between 3,000 feet above sea level along the lower Verde Valley to 7,979 feet at the top of Mount Union, the highest natural feature on the Forest.

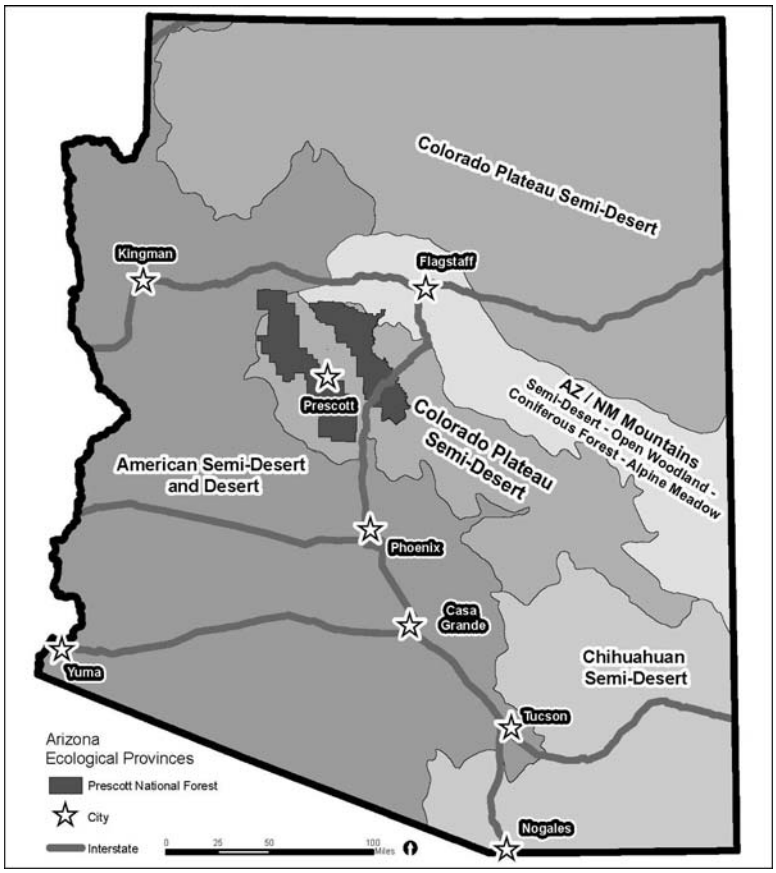
Roughly half of the PNF lies west of the city of Prescott, Arizona, in the Juniper, Santa Maria, Sierra Prieta, and Bradshaw Mountains. The other half of the PNF lies east of Prescott and takes in the terrain of Mingus Mountain, the Black Hills, and Black Mesa.

The rugged topography of the PNF provides important watersheds for both the Verde and Colorado Rivers. Within these watersheds are many important continuously or seasonally flowing stream courses and drainages. A portion of the Verde River has been designated as part of the National Wild and Scenic Rivers System.

The vegetation on the PNF is complex and diverse. South of the Bradshaw Mountains there is true Sonoran Desert dominated by saguaro cacti and paloverde trees. Less than 10 miles upslope from the desert, there are cool mountain forests where conifer and aspen trees grow. In between, there are a variety of plant and animal habitats including grasslands, hot steppe shrub, chaparral, pinyon-juniper woodlands, and ponderosa pine forests.

There are eight designated wilderness areas comprising more than 104,000 acres, located entirely or partially within the PNF. Portions of the PNF are located less than 90 miles from the Phoenix metropolitan area – a source of regional haze and wind-borne pollutants.

Figure 2. The ecological provinces of Arizona



Surrounding Landscape

The degree to which the PNF can provide for a diversity of ecosystems and species relative to the surrounding area is known as 'ecological niche'.

The ecological niche of the PNF can be defined by its location within the broader landscape and by examining the various ecological communities and processes that are represented within and outside the boundaries of the planning unit.

Using the national ecological hierarchy (Cleland and others 1997), ecosystems can be mapped and described as a series of nested units based on similar environmental factors. *Ecoregions* are areas of regional extent that share common climatic and vegetation characteristics.

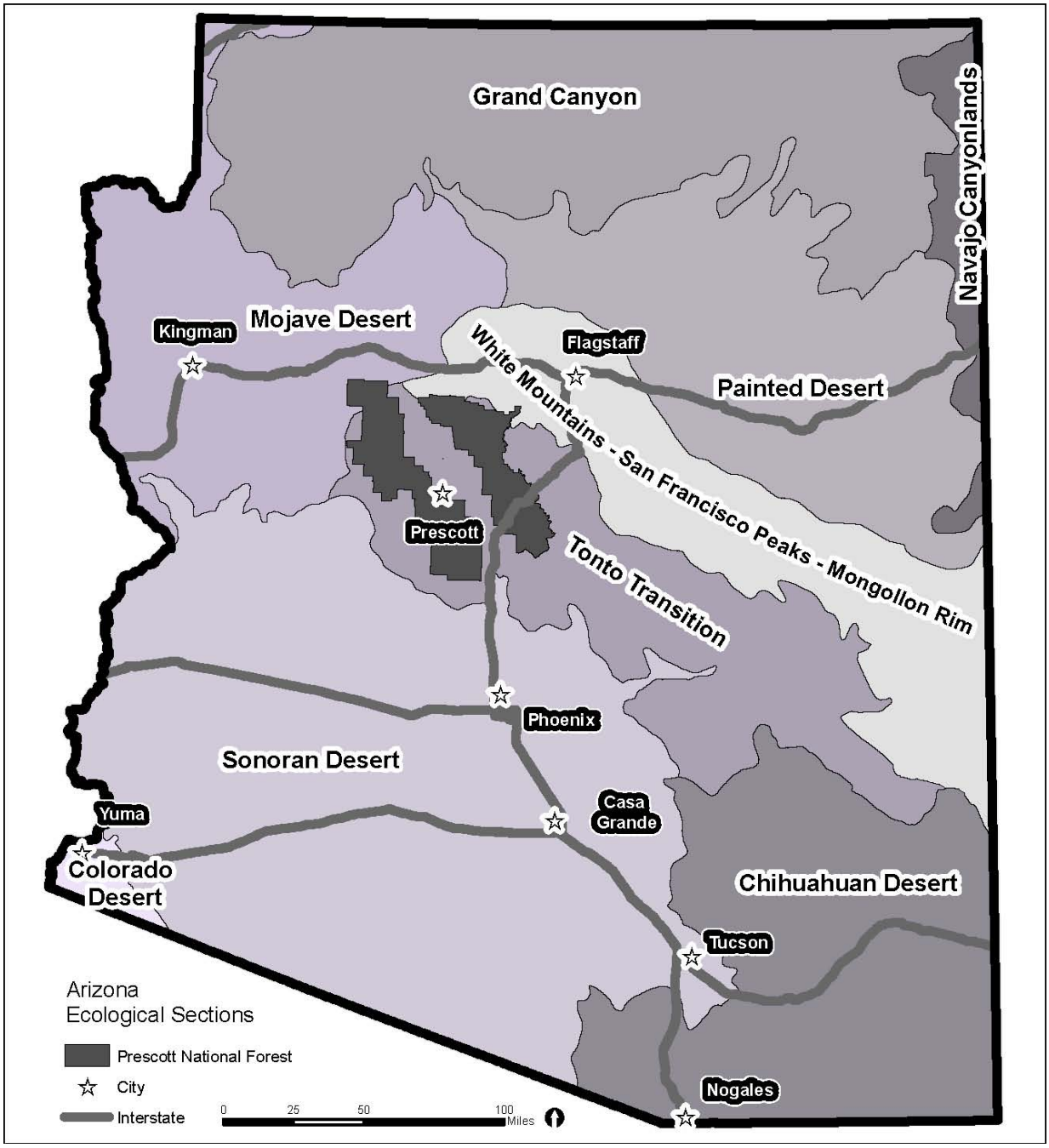
Areas within an ecoregion are sub-divided into provinces. *Provinces* are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soil orders and dominant potential natural vegetation (McNab and others 2007). Figure 2 shows the location of the PNF in relation to the ecological provinces identified for the state of Arizona.

Areas within a province are sub-divided into sections. *Sections* describe broad areas of similar sub-regional climate, geologic origin, composition, and development, local topography, and drainage networks. Figure 3 identifies the nine ecological sections nested within the four provinces of Arizona. For example, the Colorado Plateau Semi-Desert province includes the Grand Canyon, Painted Desert, Navajo Canyonlands, and Tonto Transition sections.

As shown in figure 3, almost all PNF lands (92 percent) are found in the Tonto Transition section of the Colorado Plateau Semi-Desert province. The remaining portion of the PNF (eight percent) is shared between the Mojave Desert and the White Mountains-San Francisco Peaks-Mongollon Rim ecological sections.

This means that the primary niche of the PNF is providing sustainable conditions for the ecological communities and processes that represent the Tonto Transition and secondarily protecting the additional ecosystem diversity within the PNF as represented by the other two ecological sections.

Figure 3. Ecological sections associated with the PNF



Ecological Sections

The following paragraphs characterize the three ecological sections found on the PNF and surrounding landscapes. Descriptions are summarized from McNab and Avers (1994). The Tonto Transition section is listed first because it describes the majority of the PNF.

Tonto Transition Section (describes 92% of PNF)

Geomorphology. The Tonto Transition section is located in the highlands of central Arizona below the Colorado Plateau and above the basins of the Sonoran Desert. Volcanic activity and sedimentary deposition were major geomorphic processes. Lava flows, plugs, dikes, and relatively flat sedimentary deposits resulted. Major landforms are mountains, hills, scarps, and some plains. Major landform features include the Mazatzal Mountains, Black Hills, Aquarius Mountains, Bradshaw Mountains, and the Superstition Mountains. Elevation ranges from 3,000 to 7,400 ft (915 to 2,255 m).

Climate. Precipitation ranges from 10 to 25 in (250 to 635 mm) annually, with more than half of the precipitation falling during the winter. Winters are mild below about 6,800 ft (2,075 m) and cold at higher elevations. The growing season lasts 70 to 170 days.

Vegetation. Vegetation consists of interior chaparral (mix of deciduous and evergreen shrubs) on coarse igneous parent materials and steep slopes. There are pinyon-juniper woodlands on elevations higher than about 4,200 ft (1,280 m); ponderosa pine occurs in frigid and limited mesic soil temperature regimes at higher elevations. Low elevation vegetation consists of semi-arid grasslands and desert shrub-scrub communities.

Disturbances. The natural fire frequency is highly variable, ranging from 2 to 100 years, depending on aspect, elevation, soil moisture, and plant composition. Flash floods and droughts are common.

White Mountain-San Francisco Peaks-Mogollon Rim Section (describes 5% of PNF)

Geomorphology. Located on the Colorado Plateau, this section is in central and eastern-central Arizona and west-central New Mexico. Geomorphic processes active in this section involve recent volcanism, including basaltic lava flows, cinder cone eruptions, and volcanic ash. Major landforms include mountains, plains, plateaus, and hills. Major landform features include the San Francisco Mountains, White Mountains, and Jemez and Mogollon Mountains. Elevation ranges from 6,000 to over 12,600 ft (1,820 to 3,860 m).

Climate. Precipitation ranges from 20 to over 32 in (500 to over 800 mm) annually, with more than half of the precipitation falling during the winter. The growing season ranges from less than 50 to 110 days, and winters are cold.

Vegetation. Plant communities vary over a soil temperature and moisture gradient with ponderosa pine and Gambel's oaks on the relatively warm and dry sites; white fir and Douglas-fir forests on cool, moist sites; and Engelmann spruce and corkbark fir on the coldest, wettest sites.

Disturbances. Natural fires occurred in ponderosa pine about every 3 to 10 years, but have mostly been prevented during the 20th century. This has led to a higher canopy cover and increased fuel loads, resulting in a less resilient ecosystem and increased hazard of wildfire.

Mohave Desert Section (describes 3% of PNF)

Geomorphology. This area comprises widely separated short ranges in desert plains located in Nevada, Utah, California, and in a small portion of west-northwest Arizona. It contains isolated mountains, plateaus, alluvial fans, playas, basins, and dunes. Elevation ranges from 300 ft below sea level (Death Valley) to 11,000 ft above sea level (-91 to 3,344 m).

Climate. Precipitation ranges from 3 to 10 in (80 to 250 mm). It mostly occurs as scattered high intensity storms of short duration. The growing season lasts 200 to 300 days.

Vegetation. Plant communities include creosote bush, blackbush, greasewood and saltbush on basins, plains, and hills; Joshua tree-dominated communities occur on plains and hills; and basin sagebrush, western juniper and pinyon pine communities occur on mountains.

Disturbances. Areas with less than about 8 in (200 mm) of rainfall rarely support enough vegetation to carry a fire. Fire occurrence in areas receiving more than about 8 in (200 mm) has been influenced by introduced grasses. Fires are variable in frequency and intensity. Flash floods are commonly associated with the irregular occurrence of precipitation events. Table 1 displays the relationship of the PNF to the three ecological sections found in central Arizona. Overall, the sections total nearly 54.4 million acres (column three). The PNF occupies only 2 percent of these three sections as presented in column six.

Table 1. Proportion of PNF lands within the ecological sections of central Arizona

Ecological Section Name	Section	Total Section Acres	Off-PNF Acres	PNF Acres	PNF Percent
Tonto Transition	313C	7,555,169	6,402,655	1,152,514	15.3
White Mountains-San Francisco Peaks-Mogollon Rim	M313A	13,475,096	13,405,710	69,386	0.5
Mojave Desert	322A	33,376,908	33,342,889	34,019	0.1
Grand Totals:		54,407,173	53,151,254	1,255,919	2.3

Data are from the Southwest Regional Gap Analysis Project (USGS 2004).

Information in table1 shows again that the ecological niche of the PNF is most prominent in the Tonto Transition section where the contribution towards ecological sustainability is measured as a small but important share of the entire section (15 percent).

Potential Natural Vegetation Types (PNVT)

We assessed the sustainability of vegetation and soil resources by evaluating ecosystem characteristics within the above mentioned ecological sections using potential natural vegetation types (PNVTs). PNVTs are coarse-scale groupings of non-contiguous land that share similar aspect, elevation, vegetation, soil parent material, and historic disturbances such as fire, frost and drought cycles, and insect and disease outbreaks.

Thirteen PNVTs have been identified for the PNF based on data available in the Terrestrial Ecosystem Survey (TES) of the Prescott National Forest (Robertson and others 2000). PNVT names and relative proportions for the PNF are shown in table 2.

The vegetation and soils diversity of these 13 PNVTs are summarized in chapter 2 under the terrestrial ecosystems section. More detailed information is provided in the *Vegetation Diversity Report* (Rasmussen 2008) and the *Soils Diversity Report* (Moore and others 2008).

Table 2. Potential natural vegetation types and their extent on the PNF

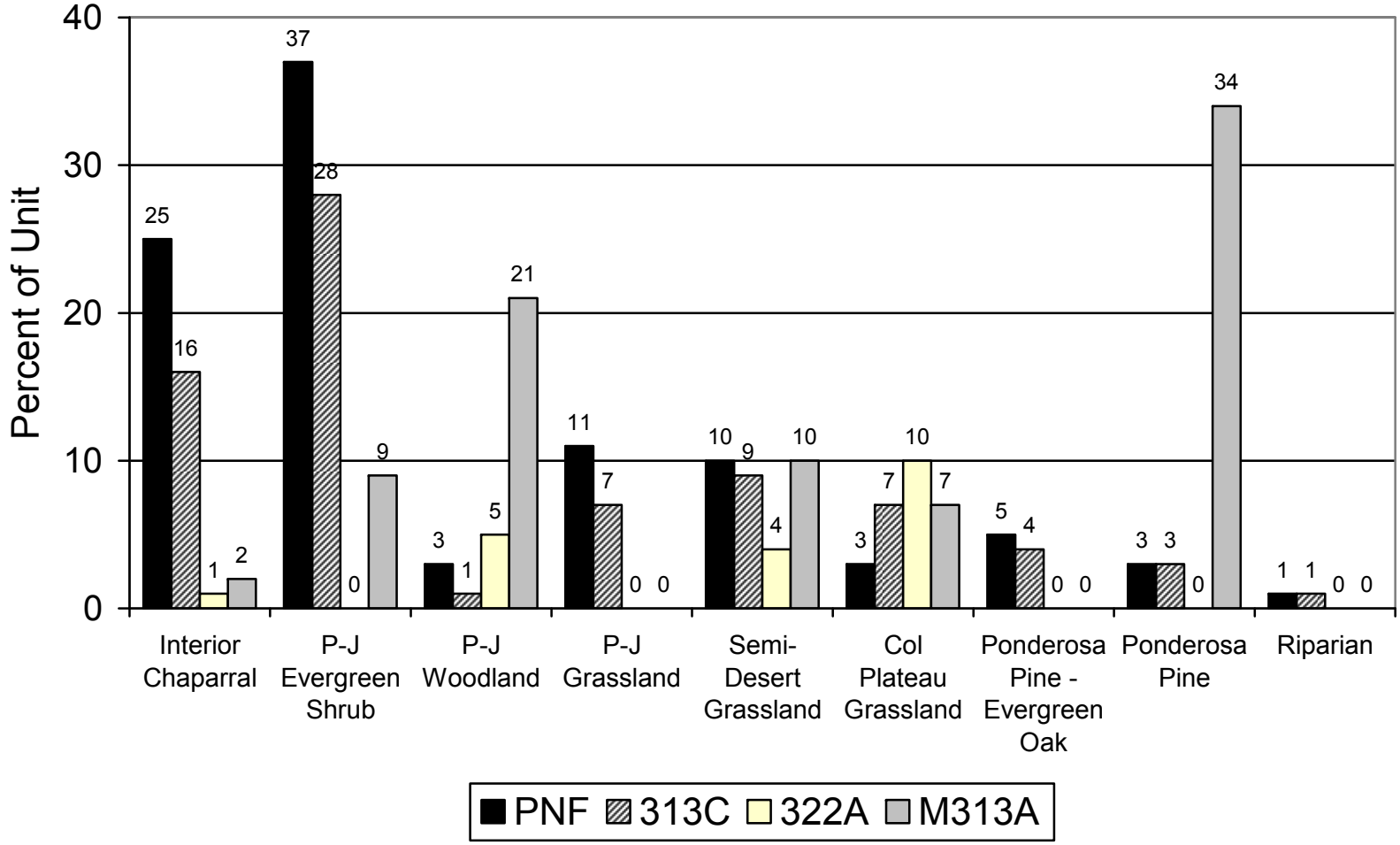
PNVT Name	Prescott National Forest	
	Acres	Percent
Interior Chaparral	315,620	25
Pinyon-Juniper Evergreen Shrub	460,660	37
Pinyon-Juniper Woodland	39,580	3
Pinyon-Juniper Grassland	137,450	11
Semi-Desert Grassland	125,760	10
Colorado Plateau Grassland	38,470	3
Ponderosa Pine-Evergreen Oak	63,540	5
Ponderosa Pine Forest	42,440	3
Mixed-Conifer Forest with Frequent Fire	6,670	<1
Mixed Conifer with Aspen	80	<1
Desert Communities	5,920	<1
Madrean Encinal Woodland	5,580	<1
Riparian Forest	12,400	1
Total	1,254,170	100

Source: (Forest Service 2007)

Figure 4 displays the proportions of the major PNVTs occurring on the PNF compared to the surrounding area (ecological sections). The information in this graph tells us how similar in composition, or how representative, the PNF vegetation types are with respect to the broader landscape within which the PNF is located.

The PNF has greater proportions of *Interior Chaparral, Pinyon-Juniper Evergreen Shrubland* and *Pinyon-Juniper Grassland* PNVTs than the surrounding landscapes, and lesser proportions of *Pinyon-Juniper Woodland* and *Ponderosa Pine Forest PNVTs*. The condition of these vegetation types found on-PNF relative to off-PNF will be a factor in determining the PNF's contribution to ecological sustainability. Vegetative conditions are discussed in further detail in Chapter 2.

Figure 4. Proportion of major PNVTs occurring on the PNF compared to surrounding Ecological Sections.
Ecological Section 313C = Tonto Transition, 322A = Mojave Desert, M313A = White Mountains San Francisco Peaks Mogollon Rim.



Watersheds

Watersheds are cataloged using a uniform hierarchical system developed by the United States Geological Survey (USGS). The United States is divided and sub-divided into successively smaller hydrologic units. The hydrologic units are nested within each other, from the largest (regions) to the smallest (cataloging units or subbasin). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

The first four fields (8 digits) that define the HUC are described as region, sub-region, basin, and subbasin. The PNF lies within the Lower Colorado River region (15), one of 20 regions that make up the entire United States. The PNF extends across three basins and resides within eight subbasins.

Table 3 lists the basins and subbasins associated with the PNF. Figure 5 displays the spatial extent of the PNF at the 4th HUC scale (subbasins), defining the ecological niche of the PNF with respect to aquatic ecosystems and water resources.

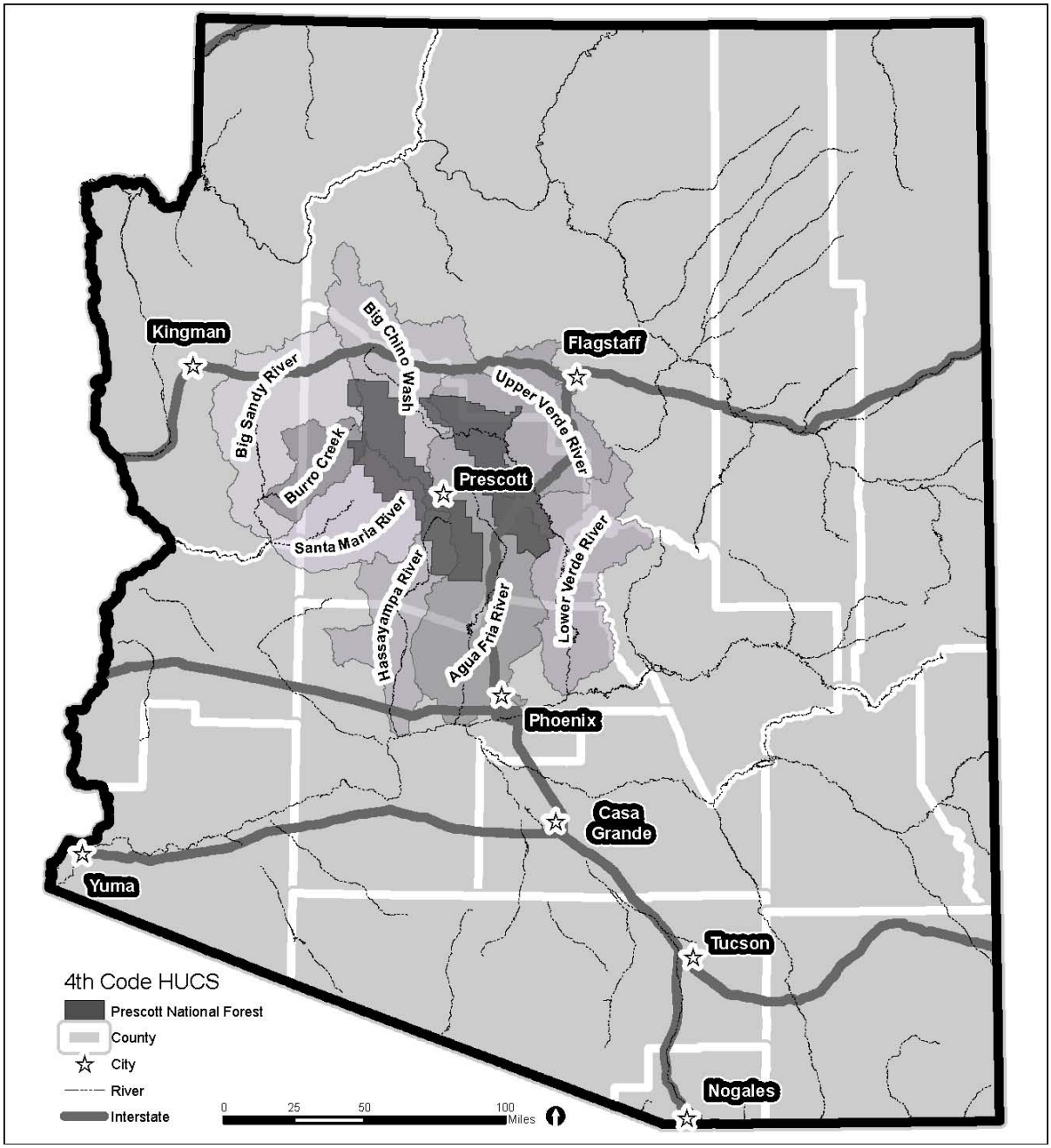
At the 4th HUC scale, the PNF has a relatively minor portion of watershed area, ranging from 13 to 22 percent of watershed area in five of the eight subbasins. The PNF occupies less than 1 percent of the total area in the Big Sandy subbasin and less than 5 percent in the Burro Creek and Lower Verde subbasins. Overall, the PNF contains 13 percent of the total extent of 4th HUC subbasins and contributes 11% of perennial stream miles.

We assessed the sustainability of aquatic ecosystems and water resources by evaluating conditions at the 5th HUC watershed scale which are delineated within subbasins. These results are summarized in chapter 2 in the aquatic ecosystems section. More detailed information is provided in the *Water Resources Report* (Jarnecke and others 2008).

Table 3. Basins and subbasins associated with the PNF

			Area in Square Miles			Perennial Stream Miles		
Basin Name	Subbasin Name	4th HUC	Subbasin	PNF	PNF as % of Subbasin	Subbasin	PNF	PNF as % of Subbasin
Bill Williams River	Big Sandy	15030201	2,154	18	1	86	0	0
	Burro Creek	15030202	713	29	4	27	0	0
	Santa Maria	15030203	1,433	227	16	41	1	3
Verde River	Big Chino Wash	15060201	2,153	344	16	12	1	5
	Upper Verde	15060202	2,507	553	22	187	37	20
	Lower Verde	15060203	1,965	65	3	297	18	6
Lower Gila/Aqua Fria Rivers	Agua Fria	15070102	2,785	531	19	57	9	16
	Hassayampa	15070103	1,454	195	13	32	13	42
	Totals		**15,165**	**1,962**	**13**	**739**	**79**	**11**

Figure 5. Subbasins (4th HUC watersheds) associated with the PNF



Airsheds

Airsheds are defined as geographic areas representing part of the atmosphere that behaves in a coherent way with respect to the dispersion of emissions. Airsheds serve as boundaries for establishing and monitoring air quality standards with respect to human health and the environment.

Airsheds are represented locally by watershed boundaries (e.g. mountain ridges). This is because daily airflow patterns generally move down stream drainages when land cools at night and move up stream drainages as land warms during the day.

Prescott National Forest lies within three airsheds as defined by the Arizona Department of Environmental Quality (ADEQ): the Verde River, the Gila River Basin, and the Colorado River/Mexico airsheds as shown in figure 6. The majority of the PNF falls within the Verde River airshed.

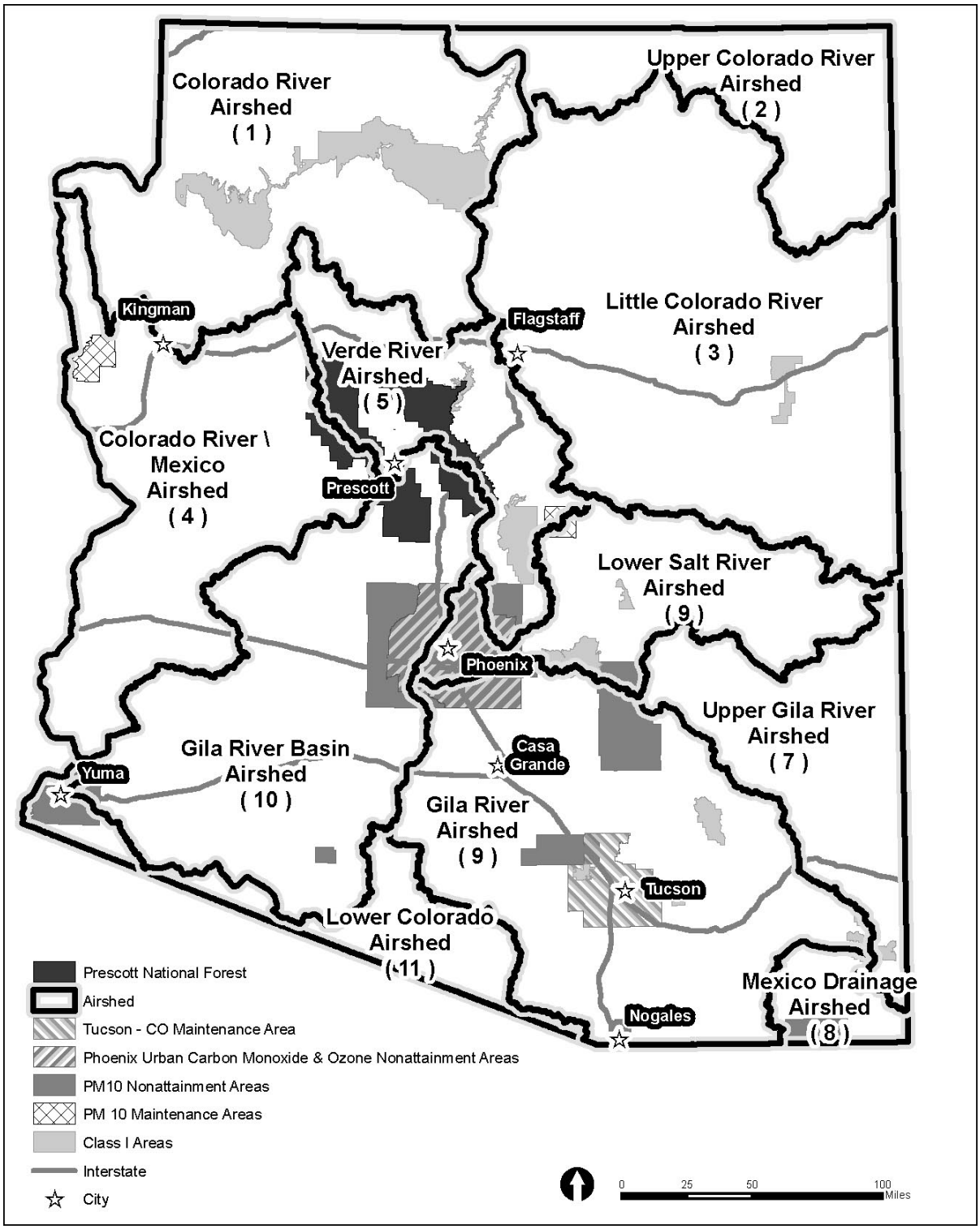
The Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six pollutants affecting human health (EPA 1990). The PNF is responsible for meeting these NAAQS, state standards, and other federal and state regulatory requirements for air quality. This includes managing and mitigating air pollution from PNF activities such as prescribed fire and the construction and use of roads and trails, or mineral activity such as rock and cement quarries.

The Clean Air Act (P. L. 84-159) was first approved by the U.S. Congress in 1955 and has been amended several times since. The Clean Air Act (CAA) assigns federal agencies including the Forest Service an “affirmative responsibility” to protect federal Class I areas from adverse impacts created by external sources of air pollution. This responsibility requires coordination with the EPA and state, county or tribal air regulatory agencies such as ADEQ.

Sycamore Canyon Wilderness and Pine Mountain Wilderness are the Class I areas designated within or adjacent to the PNF. They are located to the northeast and southeast of the PNF respectively. Class I airsheds are represented only by the air directly above each individual wilderness. Although this is a political boundary, air quality is affected by pollutants that are generated from within the wilderness, such as smoke from fires, and also by pollutants that flow into the airshed from other sources. This might include wood smoke from homes or prescribed fire, and dust from roads. Long range transport of pollutants from metropolitan areas and large industry many miles away is also possible.

An air quality assessment was conducted using the Interagency Monitoring of Protected Visual Environments (IMPROVE) system data. This includes visibility data for Class I areas adjacent to the PNF. These results are summarized in chapter 2 under the Atmospheric Ecosystems section. More detailed information is provided in the *Air Resources Report* (Fitch 2008).

Figure 6. Airsheds for the state of Arizona



Chapter 2 – Ecosystem Diversity

This chapter describes the results of the ecosystem diversity assessments for vegetation, soil, water and air resources associated with the PNF.

The primary questions we are attempting to answer through these assessments are:

1. What ecosystem characteristics have departed from historical conditions?
2. What ecosystem characteristics are rare or at risk or are otherwise inherently vulnerable to change?
3. What ecosystem characteristics are functioning and will likely continue to function in a way that contributes to ecosystem resiliency and diversity over time?

Terrestrial Ecosystems

To describe terrestrial ecosystem diversity, we selected **vegetation** and **soil** characteristics that could meaningfully describe the inherent structure, composition, and ecological processes of the system including disturbance patterns. The characteristics were also chosen based on their ability to serve as descriptors of habitats for species.

The vegetation and soil diversity assessments were organized by PNVT. As stated previously, PNVTs are coarse-scale units of non-contiguous land that share similar climate components, soil types, vegetation, and natural disturbances. Detailed characterizations of PNVTs, their historic range of variability (HRV) and vegetation state and transition modeling are included in the *Vegetation Diversity Report* (Rasmussen 2008). Soil characteristics, their current and reference conditions, and future trends are provided in the *Soils Diversity Report* (Moore and others 2008).

Reference and Current Conditions – Vegetation Methods

We evaluated vegetation characteristics using PNVT descriptions of HRV[1] to represent reference conditions and existing mid-scale vegetation mapping[2] to represent current conditions. Knowledge of PNVT HRV allows us to draw inferences about ecological sustainability, and is useful for evaluating how current vegetation conditions may be related to past and present management practices and climatic variability. For example, the presence of a large number of exotic species in grasslands and riparian communities is a clear indicator that those communities are outside their HRV and therefore, a potential threat to ecological sustainability of the ecosystem. The encroachment and establishment of woody species into grasslands is another indication that these communities may be outside their HRV. Ecosystem *processes* are also evaluated within the framework of HRV, including the disturbance patterns resulting from fire, drought and insects, blow-downs, flooding, etc.

To answer the question, “Which characteristics have departed from historical conditions,” we calculated the difference between current and reference conditions for individual vegetation characteristics. We refer to these differences as the *departure* from reference conditions. Departure is an estimate of the severity of the difference between conditions.

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[1] PNVT descriptions are from two sources: The Nature Conservancy (Schussman and Smith 2006a, 2006b) and the LANDFIRE Project (LANDFIRE 2007). PNVT descriptions include depictions of HRV. HRV portrays the change over time in the ecological condition of PNVTs including the ecological processes that shape them. A crosswalk was developed to link PNVT descriptions with map units of the Terrestrial Ecological Unit Inventory of the Prescott National Forest (Robertson and others 2000).

[2] Mid-scale vegetation mapping was conducted in 2005 and 2006 using satellite data and is mapped at the scale of 1:100,000 (Forest Service 2007).

For vegetation, the following categories were used to rank the departure of each PNVT: Trace = <1%; Low = 1-33%; Moderate = 34-66%; and High = 67-100%. The 'moderate' and 'high' ratings were considered substantial departure for the purpose of assessing risk in chapter 4.

The individual vegetation characteristics that we evaluated include species composition, structure (vegetation states) of the dominant life-forms (grass, shrub, and tree), and the disturbance regimes that define each PNVT.

Additionally, a separate assessment of grasses and grass-like species (graminoids) was made using data from the Ecological Classification for the Prescott National Forest (Girard and others 2008). We aggregated information on canopy cover and species richness[3] from individual TES map units[4] to arrive at average conditions for each PNVT. Estimates for current conditions were derived from plot data only while estimates for reference conditions were derived from plot data plus field observations outside of the plots. This assessment provided additional information on grass conditions within a PNVT and served as a link between the vegetation and soil assessments.

Reference and Current Conditions – Soils Methods

Analyses of soil characteristics also relied on data from the PNF Terrestrial Ecological Unit Inventory (Robertson and others 2000). The soil resource characteristics that were evaluated include soil condition/productivity, organic matter (surface and soil), and soil loss.

Soil condition is a qualitative rating system developed within the Forest Service Southwest Region that evaluates soil quality based on an interpretation of several factors that affect soil function. The primary soil functions evaluated are: the ability to resist erosion, the ability to infiltrate water, and ability to recycle nutrients. Soil condition classes are defined as:

- *Satisfactory* - Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of soil to maintain resource values and sustain outputs is high.
- *Impaired* - Indicators signify a reduction of soil function. The ability of soil to function properly has been reduced and/or there exists an increased vulnerability to degradation. An impaired category should signal land managers that there is a need to further investigate the ecosystem to determine causes and degrees of decline in soil functions. Changes in management practices or other preventative actions may be appropriate.
- *Unsatisfactory* - Indicators signify that loss of soil function has occurred. Degradation of vital soil functions result in the inability of soil to maintain resource values, sustain outputs, and recover from impacts. Soils rated in the unsatisfactory category are candidates for improved management practices or restoration designed to recover soil functions.

Very little data exists on the PNF to measure historical soil conditions and productivity. However, some qualitative and quantitative inferences can be made using knowledge about soil taxonomy, disturbances and their effect on soil function. Existing soil condition has been

[3] Species richness is defined as the total count of species observed to occur in the sample area.

[4] The Terrestrial Ecological Unit Inventory identifies ecological units for the PNF that are distinct from each other in terms of their soil, vegetation, and climate components. The ecological units (TEUI or TES units) are mapped at the scale of 1:24,000. There are 147 TES units mapped for the PNF. TES units were aggregated into 13 PNVTs for purposes of assessing vegetation and soil characteristics across the PNF. We use the term "TES map unit" throughout this document.

estimated for each TES map unit. Reference soil conditions are soils that function within their ecological capability. Therefore, we used the TES “satisfactory” soil condition rating as the reference condition for this assessment (Moore and others 2008). In addition, we considered the inherent productivity of soils based on soil-climate relationships and biomass production ratings for TES map units as documented in the Terrestrial Ecosystems Survey of the Prescott National Forest (Robertson and others 2000), and the Forest Service Region 3 TES Handbook (Forest Service 1986).

Organic matter (OM) was assessed as two components: surface and soil. *Surface organic matter* (i.e. rooted plant material and detached plants parts) provides protection from erosion by: protecting the soil surface from rainfall impacts, minimizing overland flow while promoting infiltration, attenuating soil temperature, retaining soil moisture, and providing a source of material for soil organic matter. *Soil organic matter* (i.e. plant material incorporated into the top layers of soil) enhances soil function by: binding soil particles together into stable aggregates, improving the ability of the soil to store and supply nutrients, water, and air, providing habitat and food for soil organisms, and sequestering carbon from the atmosphere.

Organic matter departure was assessed on soils with “impaired” and “unsatisfactory” condition ratings by looking at field documentation for each classified soil type. The existing surface organic matter levels were compared to natural condition levels to determine if the surface organic matter was contributing to impaired or unsatisfactory conditions. Soil organic matter was analyzed by assessing the depth of the A-horizon.

Soil loss is a result of erosion which is the detachment and removal of soil material by running water, wind, ice, or other geological agents. Soil loss is a natural process but the acceleration of soil loss can negatively impact soil productivity. Soil loss can result in the loss of the topsoil which is the layer of soil with the greatest amount of organic matter, biological activity, and nutrients. Erosion breaks down soil structure, exposing organic matter within the soil to decomposition and loss. Degraded soil structure reduces the rate of water infiltration. Erosion can also decrease the thickness of the root zone and the amount of air, water, and nutrients available to plants. All of these elements can change the capacity of the soil to function and restrict its ability to sustain productivity and provide ecological services.

Very little data exists on the PNF to measure historical soil loss. However, some qualitative and quantitative inferences can be made using knowledge about disturbances and their effects on soil erosion processes. Reference soil conditions are soils that function within their ecological capability. Therefore, we used the TES “satisfactory” soil condition rating as the reference condition for this assessment (Moore and others 2008). To determine the departure from the reference soil conditions, we examined ecological classifications and field datasheets by soil type to determine the soil loss contributions to impaired and unsatisfactory soil conditions. In addition, we considered the erosion hazard ratings for TES map units as documented in the Terrestrial Ecosystems Survey of the Prescott National Forest (Robertson and others 2000), to assign a probability of soil function impairment from soil loss for each PNVT.

We used the same ratings for departure of soil characteristics as we did for the vegetation departure: Trace = <1%; Low = 1-33%; Moderate = 34-66%; and High = 67-100%. The ‘moderate’ and ‘high’ ratings were considered substantial departure for the purpose of assessing risk in chapter 4.

The pages that follow summarize reference and current conditions for the soil and vegetation characteristics for each PNVT on the PNF. In addition, there is some information on projected trends. A complete discussion of projected trends follows this section.

Interior Chaparral PNVT

Extent:	315,620 acres (25% of PNF)
Elevation:	3,400-6,600 ft
Landforms:	Elevated plains, hills and mountain slopes
Parent Material:	Granite and metamorphic rock with some minor inclusions of basalt, sandstone, and alluvium (mixed sediments deposited by flowing water)

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: 9% high, 17% moderate, 74% low

Soils – Current Condition and Trend:

Soil Condition: 91% satisfactory, 8% impaired, 1% unsatisfactory
Organic Matter (OM): Soil OM 1% departed; Surface OM 9% departed
Soil Loss: 9% departed from reference condition
Future Trend: 70% stable

Vegetation Composition – Reference and Current Conditions:

Interior chaparral communities include a mix of shrubs that have dense compact crowns and small evergreen leaves. They occur where low-elevation desert landscapes transition into pine-oak woodlands. Typical shrub associations include shrub live oak, manzanita, desert ceanothus, mountain mahogany, silktassles, cliffrose, and hairy sumac. Some incidental grasses occur including several species of grama, three-awn and muttongrass.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Grass, forb regeneration; open canopy	1	2	1	
B	Grass, early shrub; open canopy	3	5	3	
C,D	Dense, mid to late development shrub; no understory; closed canopy	96	93	93	
		100	100	97	3%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
23 of 24	8%	0-17	12%	0-22	2	0-5	6	0-10

Ecological Disturbances - Reference and Current:

Reference: Stand-replacing fire frequency of 1 in 20-100 years.
Current: Stand-replacing fire frequency is 1 in 84 years including prescribed fire treatments.

Ecological Niche:

PNVT Occurrence in Eco-section: 73% off-PNF vs. 27% on-PNF
PNVT Vegetation Departure Values: 44% off-PNF vs. 3% on-PNF

Pinyon-Juniper Evergreen Shrub PNVT

Extent:	460,660 acres	(37% of PNF)
Elevation:	4,500-7,500 ft	
Landforms:	Rolling hills and mountain slopes	
Parent Material:	Variety of granite, limestone, basalt, sandstone, and alluvium	

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: 29% high, 45% moderate, 26% low

Soils – Current Condition and Trend:

Soil Condition: 40% satisfactory, 46% impaired, 14% unsatisfactory
Organic Matter (OM): Soil OM 25% departed; Surface OM 60% departed
Soil Loss: 49% departed from reference condition
Future Trend: 55-58% away from reference conditions, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

This mix of vegetation occurs in transition zones between interior chaparral and montane forests. Tree canopy consists of two-needle pinyon, single-leaf pinyon, Utah juniper, or alligator juniper. Shrubs include manzanita, mountain mahogany, antelope bushes, silktassles, cliffrose, hairy sumac, and shrub live oak.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development - herbaceous and resprouting woody plants; open canopy	9	5	5	
B	Mid development – young to mature trees and shrubs; closed canopy	28	55	28	
C,D	Late development – mature and old trees and shrubs; open to closed canopy	63	40	40	
		100	100	73	27%

[1] The Lesser Value = smaller of the Current or Reference values for each structural class.
[2] The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
33 of 33	9%	1-25	14%	4-24	3	1-4	7	3-10

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 60 years with mixed severity.
Bark beetle outbreaks were episodic and drought-synchronous.
Current: Fire frequency is 1 in 233 years (including prescribed fire treatments). Bark beetle outbreaks remain episodic and drought-synchronous.

Ecological Niche:

PNVT Occurrence in Eco-section: 81% off-PNF vs. 19% on-PNF
PNVT Vegetation Departure Values: 47% off-PNF vs. 27% on-PNF

Pinyon-Juniper Woodland PNVT

Extent: 39,580 acres (3% of PNF)
Elevation: 4,500-7,500 ft
Landforms: Elevated and lowland plains, hills and lower mountain slopes
Parent Material: Limestone with some basalt

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: Trace% high, 20% moderate, 80% low

Soils – Current Condition and Trend:

Soil Condition: 25% satisfactory, 45% impaired, 30% unsatisfactory
Organic Matter (OM): Soil OM 62% departed; Surface OM 75% departed
Soil Loss: 75% departure from reference condition
Future Trend: 63-71% away from reference conditions, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

The most common trees in P-J woodlands include the Colorado pinyon with single-leaf pinyon occurring in limited areas. The juniper component includes one-seed juniper, Utah juniper, and Rocky Mountain juniper. Annual and perennial grasses and graminoids, forbs and some shrubs are found scattered beneath the tree canopy.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development – post-fire community of forbs/grasses/shrubs; open canopy	10	10	10	
B	Mid/late development – dense pinyon-juniper woodland with understory vegetation lacking; >40% canopy cover	61	75	61	
C	Mid/late development – pinyon-juniper woodland with mixed shrub/herbaceous understory; <40% canopy cover	29	15	15	
		100	100	86	14%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
7 of 7	12%	7-20	23%	12-47	3	1-4	7	4-8

Ecological Disturbances – Reference and Current:

Reference: Stand-replacing fire frequency of 1 in 400 years.
Bark beetle outbreaks were episodic and drought-synchronous.
Current: Fire frequency is less than 1 in 1,000 years for the years 1950-2006.
Bark beetle outbreaks remain episodic and drought-synchronous.

Ecological Niche:

PNVT Occurrence in Eco-section: 71% off-PNF vs. 29% on-PNF
PNVT Vegetation Departure Values: 65% off-PNF vs. 14% on-PNF

Pinyon-Juniper Grassland PNVT

Extent: 137,450 acres (11% of PNF)
Elevation: 4,500-7,500 ft
Landforms: Elevated and lowland plains, hills and lower mountain slopes
Parent Material: Basalt and limestone

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: 61% high, 30% moderate, 9% low

Soils – Current Condition and Trend:

Soil Condition: 13% satisfactory, 25% impaired, 62% unsatisfactory
Organic Matter (OM): Soil OM 72% departed; Surface OM 87% departed
Soil Loss: 87% departure from reference condition
Future Trend: 47-86% away from reference conditions, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

Scattered juniper and pinyon trees and shrubs occur amongst dense grass cover with other forbs. Grass species composition and dominance varies by the soils and topography encountered including: blue and side-oats grama, muttongrass, junegrass, galleta, and western wheatgrass.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development – post-fire community of forbs and perennial grasses; open canopy	44	20	20	
B	Mid development – dense juniper-pinyon woodland with understory vegetation lacking; >40% canopy cover	16	10	10	
C	Mid development – juniper-pinyon woodland with mixed shrub/herbaceous understory; <40% canopy cover	15	20	15	
D	Late development – juniper-pinyon woodland with mixed shrub/herbaceous understory; <40% canopy cover	21	40	21	
E	Late development – juniper-pinyon forest with understory vegetation lacking; >40% canopy cover	4	10	4	
		100	100	70	30%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
17 of 17	21%	9-72	30%	18-47	4	2-7	6	1-10

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 31 years with mixed severity.
Native herbivory from insects, rodents, rabbits and hares, prairie dogs, antelope and deer.
Current: Fire frequency is 1 in 714 years (including prescribed fire treatments). Bark beetle outbreaks remain episodic and drought-synchronous. Non-native (cattle and sheep) and native herbivory coexist.

Ecological Niche:

PNVT Occurrence in Eco-section: 76% off-PNF vs. 24% on-PNF
PNVT Vegetation Departure Values: 49% off-PNF vs. 30% on-PNF

Semi-Desert Grassland PNVT

Extent:	125,760 acres	(10% of PNF)
Elevation:	3,000-4,500 ft	
Landforms:	Hills, mountain slopes, lowland plains and alluvial fans	
Parent Material:	Limestone and basalt with minor amounts of metamorphic schist and mixed alluvium	

Soils – Reference Condition:

Reference Biomass Production Rating: Low
Soil Productivity: 19% high, 35% moderate, 46% low

Soils – Current Condition and Trend:

Soil Condition: 11% satisfactory, 85% impaired, 4% unsatisfactory
Organic Matter (OM): Soil OM 58% departed; Surface OM 87% departed
Soil Loss: 89% departed from reference condition
Future Trend: 28-56% stable, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

These grasslands are bounded by Sonoran desert at lower elevations and woodlands or chaparral at higher elevations. Composition varies by the soils and topography encountered including several grama grasses: black, blue, side-oats and hairy; with tobosa and giant sacaton. Shrubs also occupy these grasslands including: creosote bush, catclaw acacia, mimosa, burroweed, broom snakeweed, and mesquite.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Grass regeneration	1	24	1	
B	Open perennial bunchgrass	20	76	20	
C	Perennial bunchgrass with shrubs & trees: open canopy	61	0	0	
D	Shrubs and trees w/ perennial bunchgrasses: closed canopy	18	0	0	
		100	100	21	79%

[1] The Lesser Value = smaller of the Current or Reference values for each structural class.
[2] The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
14 of 15	21%	4-34	27%	13-52	4	2-7	7	4-9

Ecological Disturbances – Reference and Current:

Reference: Stand-replacing fire frequency of 1 in 2-10 years.
Native herbivory from insects, rodents, rabbits and hares, prairie dogs, antelope and deer.
Current: Fire frequency is 1 in 94 years (including prescribed fire treatments). Native and non-native herbivory coexist.

Ecological Niche:

PNVT Occurrence in Eco-section: 81% off-PNF vs. 19% on-PNF
PNVT Vegetation Departure Values: 91% off-PNF vs. 79% on-PNF

Colorado Plateau Grassland PNVT

Extent: 38,470 acres (3% of PNF)
Elevation: 4,700-7,600 ft
Landforms: Lowland, elevated, and valley plains
Parent Material: Limestone and mixed alluvium

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: 68% high, 16% moderate, 16% low

Soils – Current Condition and Trend:

Soil Condition: Trace% satisfactory, 46% impaired, 54% unsatisfactory
Organic Matter (OM): Soil OM 74% departed; Surface OM 100% departed
Soil Loss: 95% departed from reference condition
Future Trend: 56-89% away, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

These grasslands consist of perennial grasses and occasional drought-resistant shrubs. Grasses include Indian ricegrass, three-awn, grama grasses, needle grass, bottlebrush squirreltail, dropseed, and tobosagrass. Shrubs may include sagebrush, saltbush, Ephedra, snakeweed, and winterfat.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development – recently burned/ sparsely vegetated; open canopy cover	7	5	5	
B	Mid development – grass & forbs; open canopy cover	56	70	56	
C	Late development - grass & forbs with some shrubs; Open canopy cover	23	20	20	
D	Mid development – many shrubs with less grass & forbs; closed canopy cover	14	5	5	
		100	100	86	14%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
8 of 9	24%	19-33	49%	37-61	4	2-6	8	5-12

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 25 years with mixed severity. Native herbivory from insects, rodents, rabbits and hares, prairie dogs, antelope and deer.
Current: Fire frequency is zero considering all sources of ignition for the years 1950-2006. Native and non-native herbivory coexist.

Ecological Niche:

PNVT Occurrence in Eco-section: 95% off-PNF vs. 5% on-PNF
PNVT Vegetation Departure Values: 25% off-PNF vs. 14% on-PNF

Ponderosa Pine-Evergreen Oak PNVT

Extent:	63,540 acres	(5% of PNF)
Elevation:	6,000-9,000 ft	
Landforms:	Hills, mountain slopes, and some elevated plains	
Parent Material:	Granite with some metamorphic schist	

Soils – Reference Condition:

Reference Biomass Production Rating: High
Soil Productivity: 9% high, 30% moderate, 61% low

Soils – Current Condition and Trend:

Soil Condition: 92% satisfactory, 8% impaired, trace% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 8% departed
Soil Loss: 8% departure from reference condition
Future Trend: 78% stable

Vegetation Composition – Reference and Current Conditions:

These open forests are dominated by ponderosa pine with evergreen oaks (Emory and Arizona white oak) forming a shrubby understory along with some alligator juniper and pinyon pine. Grasses and forbs occur as scattered ground cover.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion Current	% Proportion Reference	Lesser Value[1]	Departure Value[2]
A	Grass, seedling & sapling; < 10% tree canopy cover	12	4	4	
B	Young forest with grass understory; closed canopy cover	47	3	3	
C	Young forest with grass understory; open canopy cover	1	24	1	
D	Mature to old forest with grass understory; open canopy cover	2	60	2	
E	Mature to old forest with grass understory; closed canopy cover	35	4	4	
F	Resprouter species dominated	3	5	3	
		100	100	17	83%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
11 of 11	4%	1-9	11%	3-26	2	1-4	5	2-10

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 6-12 years with mixed severity. Bark beetle outbreaks were episodic and drought-synchronous.
Current: Fire frequency is 1 in 51 years (including prescribed fire treatments). Bark beetle outbreaks remain episodic and drought-synchronous.

Ecological Niche:

PNVT Occurrence in Eco-section: 75% off-PNF vs. 25% on-PNF
PNVT Vegetation Departure Values: 83% off-PNF vs. 83% on-PNF

Ponderosa Pine Forest PNVT

Extent: 42,440 acres (3% of PNF)
Elevation: 5,500-8,500 ft
Landforms: Hills, mountain slopes, and some elevated plains
Parent Material: Basalts with some metamorphic schist

Soils – Reference Condition:

Reference Biomass Production Rating: High
Soil Productivity: 83% high, 2% moderate, 15% low

Soils – Current Condition and Trend:

Soil Condition: 89% satisfactory, 11% impaired, trace% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 11% departed
Soil Loss: no departure from reference condition
Future Trend: 68-83% stable, depending on the soil characteristic

Vegetation Composition – Reference and Current Conditions:

Ponderosa pine forests are dominated by ponderosa pine. Other trees such as Gambel oak, pinyon pine and juniper species may be present. The understory is typically shrubby and mixed with grasses and forbs.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A,J	Grass, seedling & sapling; or uncharacteristic grassland	7	0	0	
F	Seedling & sapling; > 10% tree cover	2	0	0	
B	Young forest; < 30% canopy cover	0	0	0	
C	Mid-age forest; < 30% canopy cover	1	0	0	
D,E	Mature old forest with regeneration; < 30% canopy cover	0	100	0	
G	Young forest; > 30% canopy cover	38	0	0	
H	Mid-age forest; > 30% canopy cover	49	0	0	
I	Mature old forest with regeneration; > 30% canopy cover	3	0	0	
		100	100	0	100%

[1] The Lesser Value = smaller of the Current or Reference values for each structural class.
[2] The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
8 of 11	10%	1-23	12%	5-26	2	1-4	5	2-8

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 5-36 years with non-lethal severity. Bark beetle outbreaks were episodic and drought-synchronous.
Current: Fire frequency is 1 in 74 years (including prescribed fire treatments). Bark beetle outbreaks remain episodic and drought-synchronous.

Ecological Niche:

PNVT Occurrence in Eco-section: 80% off-PNF vs. 20% on-PNF
PNVT Vegetation Departure Values: 94% off-PNF vs. 100% on-PNF

Mixed Conifer Forest (with frequent fire) PNVT

Extent:	6,670 acres	(<1% of PNF)
Elevation:	6,000-9,000 ft	
Landforms:	Hills and mountain slopes	
Parent Material:	Granite with metamorphic schist and gneiss	

Soils – Reference Condition:

Reference Biomass Production Rating: Very High
Soil Productivity: 35% high, 55% moderate, 10% low

Soils – Current Condition and Trend:

Soil Condition: 100% satisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 0% departed
Soil Loss: no departure from reference condition
Future Trend: 100% stable

Vegetation Composition – Reference and Current Conditions:

Mixed-conifer forests occur at elevations above ponderosa pine, pine-oak, and p-j woodlands. Vegetation varies by elevation and moisture availability. At lower, drier sites, Gambel oak and ponderosa pine may co-dominate. At higher, moister sites ponderosa pine may co-dominate with Douglas-fir and white fir. The understory is comprised of a variety of shrubs, grasses, and forbs depending on aspect, elevation, and soils.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A,J	Grass, seedling & sapling; or uncharacteristic grassland	4	0	0	
F	Seedling & sapling; > 10% tree cover	2	0	0	
B	Young forest; < 30% canopy cover	0	0	0	
C	Mid-age forest; < 30% canopy cover	0	0	0	
D,E	Mature old forest with regeneration; < 30% canopy cover	0	100	0	
G	Young forest; > 30% canopy cover	30	0	0	
H	Mid-age forest; > 30% canopy cover	64	0	0	
I	Mature old forest with regeneration; > 30% canopy cover	0	0	0	
		100	100	0	100%

[1] The Lesser Value = smaller of the Current or Reference values for each structural class.
[2] The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
5 of 5	3%	1-5	4%	2-7	2	1-2	2	1-3

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 5-36 years with non-lethal severity. Bark beetle outbreaks were episodic and drought-synchronous.
Current: Fire frequency is less than 1 in 1,000 years considering all sources of ignition for the years 1950-2006. Bark beetle outbreaks remain episodic and drought-synchronous.

Ecological Niche:

PNVT Occurrence in Eco-section:	80% off-PNF vs. 20% on-PNF
PNVT Vegetation Departure Values:	99% off-PNF vs. 100% on-PNF

Mixed Conifer with Aspen PNVT

Extent:	82 acres	(<1% of PNF)
Elevation:	5,500-9,500 ft	
Landforms:	Hills and some lowland plains	
Parent Material:	Granite and metamorphic schist	

Soils – Reference Condition:

Reference Biomass Production Rating: Very High
Soil Productivity: 100% high, trace% moderate, trace% low

Soils – Current Condition and Trend:

Soil Condition: 100% satisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 0% departed
Soil Loss: no departure from reference condition
Future Trend: 100% stable

Vegetation Composition – Reference and Current Conditions:

These upland forests are dominated by quaking aspen and may or may not have a significant conifer component, depending upon the amount of time since the last disturbance. The understory may have shrubs and an herbaceous layer, or just an herbaceous layer including grasses and sedges.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion Current	% Proportion Reference	Lesser Value[1]	Departure Value[2]
A	Early development - grass, forb with aspen or oak ramets; regeneration of seedlings & saplings; open canopy	2	1	1	
B	Early development closed; aspen/mixed conifer young forest; small size trees; > 40% canopy cover	12	21	12	
C,F	Mid development; medium size trees & regeneration with open or closed canopy	86	29	29	
D,G	Late development; old forest with large size trees & regeneration; open or closed canopy	0	49	0	
E	Early development; young forest, no aspen; shade intolerant conifers; 10-40% canopy cover	0	0	0	
		100	100	42	58%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1 of 1	12%	n/a	20%	n/a	2	n/a	5	n/a

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 10-22 years with non-lethal severity and 1 in 150 years with stand-replacing severity.
Current: Fire frequency is less than 1 in 1,000 years considering all sources of ignition for the years 1950-2006.

Ecological Niche:

PNVT Occurrence in Eco-section:	99% off-PNF vs. 1% on-PNF
PNVT Vegetation Departure Values:	24% off-PNF vs. 58% on-PNF

Desert Communities PNVT

Extent:	5,920 acres	(<1% of PNF)
Elevation:	2,000-3,600 ft	
Landforms:	Mountain slopes and hills	
Parent Material:	Metamorphic schist	

Soils – Reference Condition:

Reference Biomass Production Rating: Very Low
Soil Productivity: trace% high, trace% moderate, 100% low

Soils – Current Condition and Trend:

Soil Condition: 57% satisfactory, 43% impaired, trace% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 43% departed
Soil Loss: 43% departed from reference condition
Future Trend: 100% stable

Vegetation Composition – Reference and Current Conditions:

Desert communities have sparse to dense vegetation cover that includes succulent species, desert grasses, desert scrub, and some herbaceous cover. Dominant plants include giant saguaro, palo verde trees, cholla and prickly pear cacti, ocotillo, velvet mesquite, catclaw acacia, and jojoba.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development – initial post-disturbance herbaceous community; open canopy	1	5	1	
B	Mid development – shrubs and woody plants; open canopy	34	20	20	
C	Late development – succulents and small trees; open canopy cover	65	75	65	
		100	100	86	14%

[1] The Lesser Value = smaller of the Current or Reference values for each structural class.
[2] The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
2 of 2	7%	6-9	8%	6-10	2	1-2	5	4-6

Ecological Disturbances – Reference and Current:

Reference: Fire frequency is rare at 1 in 998 years with stand-replacing severity. Infrequent disturbance from drought, frost, and wind.
Current: Human-caused fire frequency is 1 in 106 years with mixed and stand-replacing fire severity. Infrequent disturbance continues from drought, frost, and wind.

Ecological Niche:

PNVT Occurrence in Eco-section: 99% off-PNF vs. 1% on-PNF
PNVT Vegetation Departure Values: 68% off-PNF vs. 14% on-PNF

Madrean Encinal Woodland PNVT

Extent: 5,580 acres (<1% of PNF)
Elevation: 3,600-6,500 ft
Landforms: Mountain slopes and lowland/valley plains
Parent Material: Granite and mixed alluvium

Soils – Reference Condition:

Reference Biomass Production Rating: Moderate
Soil Productivity: 34% high, 66% moderate, trace% low

Soils – Current Condition and Trend:

Soil Condition: 64% satisfactory, trace% impaired, 36% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 36% departed
Soil Loss: 36% departure from reference condition
Future Trend: 100% stable

Vegetation Composition – Reference and Current Conditions:

These evergreen oak woodlands occur between semi-desert grasslands at lower elevations and pine-oak woodlands at higher elevations. Dominant tree species include Emory, Arizona white, gray, and Mexican blue oaks. Pine and juniper trees and chaparral shrub patches may intermingle in minor amounts. Some areas have moderate cover of warm-season grasses.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development – initial post-disturbance herbaceous and shrub community; open canopy	51	20	20	
B	Mid development – woodlands with closed canopy; northerly aspects	41	40	40	
C	Mid development – grasslands with some trees; open canopy; southerly aspects	1	25	1	
D	Late development – woodland with grasses; open canopy cover	7	15	7	
E	Late development – woodlands with very large trees; closed canopy cover	0	0	0	
		100	100	68	32%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

TES Map Units Involved	Graminoid Canopy Cover (Percent)				Graminoid Richness (Species Count)			
	Current		Reference		Current		Reference	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
2 of 2	26%	10-42	31%	14-49	4	2-6	7	7-8

Ecological Disturbances – Reference and Current:

Reference: Fire frequency of 1 in 23 years with mixed severity.
Current: Fire frequency is zero considering all sources of ignition for the years 1950-2006.

Ecological Niche:

PNVT Occurrence in Eco-section: 83% off-PNF vs. 17% on-PNF
PNVT Vegetation Departure Values: 17% off-PNF vs. 32% on-PNF

Riparian PNVT

Extent:	12,400 acres	(<1% of PNF)
Elevation:	2,000-8,000 ft	
Landforms:	Valley plains, seeps and springs	
Parent Material:	Granite and mixed alluvium	

Soils – Reference Condition:

Cottonwood Willow TES Map Units:
Reference Biomass Production Rating: Low
Soil Productivity: trace% high, trace% moderate, 100% low
Mixed Broadleaf Deciduous TES Map Units:
Reference Biomass Production Rating: Moderate
Soil Productivity: 6% high, trace% moderate, 94% low

Soils – Current Condition and Trend:

Cottonwood Willow TES Map Units:
Soil Condition: 42% satisfactory, 58% impaired, trace% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 58% departed
Soil Loss: 58% departure from reference condition
Mixed Broadleaf Deciduous TES Map Units:
Soil Condition: 11% satisfactory, 53% impaired, 36% unsatisfactory
Organic Matter (OM): Soil OM 0% departed; Surface OM 89% departed
Soil Loss: 43% departure from reference condition

Vegetation Composition – Reference and Current Conditions:

Dominant woody vegetation will vary with elevation, substrate, stream gradient, and depth to groundwater forming a mix of riparian forests, woodlands, and shrublands. Common species include Fremont cottonwood, various willow such as narrowleaf, Gooding, and Bebb; Arizona sycamore, velvet and green ashes, Arizona alder, Arizona walnut, and box elder. Several forbs and grasses are usually present.

Vegetation Structure – Reference and Current Conditions:

Class	Vegetation Structure	% Proportion		Lesser Value[1]	Departure Value[2]
		Current	Reference		
A	Early development - herbaceous, shrubs, & tree seedlings	18	20	18	
B	Mid development – tall shrubs, small trees; open canopy	48	25	25	
C	Late development – multi-storied forest; closed canopy	12	35	12	
D,E	Late development – single or multi-storied forest with large trees; closed canopy	22	20	20	
F	Riparian invaded state (tamarisk, olive, etc.)	unknown	0	n/a	
		100	100	75	≥25%

[1] *The Lesser Value = smaller of the Current or Reference values for each structural class.*
[2] *The Departure Value (%) = (100 - Sum of the Lesser Values). Departure values greater than 33% are considered substantial for assessing risk to sustainability.*

Graminoid Assessment – Reference and Current Conditions:

No data were available to assess graminoid cover and richness within the Riparian Forest PNVT.

Disturbances – Reference and Current:

Reference: Flood frequency of 1 in 2-50 years with mixed severity. Fire frequency of 1 in 666 years with stand-replacing severity for intermittent flow areas; 1 in 20 years with mixed severity for areas under Native American influence such as perennial stream courses.
Current: Seven of the 10 highest flood flows dating back to 1889 have occurred since 1978 on the Verde River. Flood events on other streams and rivers for the PNF are unknown.
Fire frequency is 1 in 76 years when prescribed fire treatments are included.

Ecological Niche:

PNVT Occurrence in Eco-section:	84% off-PNF vs. 16% on-PNF
PNVT Vegetation Departure Values:	32% off-PNF vs. 25% on-PNF

Comparison of Current Conditions and Future Trends
This section summarizes current conditions of the vegetation and soil characteristics, and our estimates of probable future conditions (i.e. projected trends) based on a continuation of the current level and types of existing management activity. This comparison provides a contrast between PNVT current conditions and likely future conditions.

Estimating Future Trends
For ***vegetation***, we used the unique combinations of the predominant vegetation type and structural stage as *states* to model each PNVT. Movements between *states* were described by two types of pathways or *transitions*: changes driven by probabilistic shifts (e.g., fire, climate, insect outbreaks, and management activities like tree thinning) and deterministic changes due to the passage of time (e.g., regeneration, succession, growth, or self-thinning).

Data used to model future trends for the PNF were derived from management activities including prescribed burning, fuels removal, timber harvest, tree and shrub thinning, and tree planting at rates that occurred within each PNVT for the period 1985 through 2006. Wildfire events were also modeled at the frequencies and severities that occurred for the period 1950 through 2006. We placed these data into an electronic spreadsheet where simple calculations such as the *type of activity by frequency* could be computed. These activities (transitions) were applied to the vegetation states representing current conditions for each PNVT and modeled through time to project future conditions using the Vegetation Dynamics Development Tool or VDDT (ESSA Technologies 2006). We assessed the future trends and conditions over several time frames: 20-years, 40-years, 50-years, 100-years, 250-years and 500-years. We did not project trends in ecosystem characteristics that exist outside of PNF boundaries. Our trend analyses are limited to PNVTs on PNF lands.

For ***soils***, professional judgment was used to project trends based on the given soil characteristic departure values and estimates of graminoid canopy cover. Graminoid canopy cover was chosen as an indicator because of its inherent ability to provide surface and soil organic matter, to maintain soil stability, and to sustain soil function and productivity. The possible combinations of the specific soil characteristic departure (yes/no) and graminoid departure (yes/no) resulted in several scenarios to project future trends. Possible trends for each soil characteristic were: stable, towards, or away from reference conditions. Soil trends were assessed for each TES map unit and then summarized as the proportion of TES map units within the PNVT having each outcome.

Interior Chaparral

Current Conditions: This PNVT has low soil productivity potential within a moderate biomass productivity class. Current soil and vegetation conditions are similar to reference conditions. This is the least altered vegetation type on the PNF. On-PNF vegetation conditions are considerably less departed than off-PNF (3% versus 44%).

Trends: Soil characteristics are estimated to remain stable. Based on the VDDT modeling, continuation of current management will shift the vegetation of this PNVT closer to its HRV and then stabilize after 40 years. This suggests that future conditions would be very similar to reference conditions and a properly functioning ecosystem.

Pinyon-Juniper Evergreen Shrub

Current Conditions: This PNVT has moderate soil productivity potential within a moderate biomass productivity rating. Current soil conditions show a moderate departure from reference conditions due to soil loss and inadequate surface OM. Vegetation has a low departure from reference conditions. On-PNF vegetation conditions are less departed than off-PNF (27% versus 47%).

Trends: Soil conditions are estimated to trend away based on the high proportion of impaired and unsatisfactory soils present. Based on the VDDT modeling, continuation of current management will move the vegetation of this PNVT closer to its HRV for the first 40-50 years and then the trend would become static at a level that is within HRV. This suggests that future conditions would be similar to reference conditions and a properly functioning ecosystem.

Pinyon-Juniper Woodland

Current Conditions: This PNVT has low soil productivity potential within a moderate biomass productivity class. Current soil conditions show a high departure from reference conditions due to soil loss and inadequate surface and soil OM. Vegetation conditions are similar to reference conditions with low departure. On-PNF vegetation conditions are considerably less departed than off-PNF (14% versus 65%).

Trends: Soil conditions are estimated to trend away based on the high proportion of impaired and unsatisfactory soils present and the influence of low graminoid cover. Based on the VDDT modeling, continuation of current management will gradually shift vegetation closer to its HRV. Over the next 100 years, there would be an increase in dense old stands of pinyon-juniper forest and decreases in the other vegetation classes. After 100 years, there would be a reduction in the forbs/grasses/shrubs class, starting a trend away from reference conditions.

Pinyon-Juniper Grassland

Current Conditions: This grassland PNVT exhibits high soil productivity within a moderate biomass productivity class. Current soil conditions show a high departure from reference conditions due to soil loss and inadequate surface and soil OM. The current vegetation shows a low departure from reference conditions, however, there is a substantial difference between the reference and current fire frequencies. On-PNF vegetation conditions are less departed than off-PNF (30% versus 49%).

Trends: Soil conditions are expected to trend away based on the high proportion of impaired and unsatisfactory soils present and the influence of low graminoid canopy cover. Based on the VDDT modeling, continuation of current management will shift the vegetation closer to its HRV for the first 40-50 years and then the trend will reverse and begin moving away from reference conditions to a moderate level of departure.

Semi-Desert Grassland

Current Conditions: This grassland PNVT has low soil productivity potential within a low biomass productivity class, making it less productive than other grassland PNVTs. Current soil conditions are highly departed from reference conditions due to soil loss and inadequate surface and soil OM. The vegetation has a high departure from reference conditions. There

is a substantial difference between the reference and current fire frequencies. The current lack of fire disturbance has allowed trees and shrubs to encroach into areas historically occupied by native bunchgrasses. On-PNF vegetation conditions are less departed than off-PNF (79% versus 91%).

Trends: Soil conditions are expected to remain stable over most areas. Based on the VDDT modeling, continuation of current management will move the vegetation of this PNVT farther away from its HRV into the foreseeable future. Vegetation attributes (composition and structure) have been significantly altered from the historical range. Similar to the other grassland types, fire was a frequent disturbance for maintaining high proportions of native bunchgrasses.

Colorado Plateau Grassland

Current Conditions: This PNVT has high soil productivity potential within a moderate biomass productivity class. Current soil conditions are entirely departed from reference conditions due to soil loss and lack of surface OM. The current vegetation shows a low departure from reference conditions, however, there is a substantial difference between the reference and current fire frequencies. On-PNF vegetation conditions are less departed than off-PNF (14% versus 25%).

Trends: Soil conditions are expected to remain stable over most areas. No VDDT model currently exists to project trends for this PNVT. However, considering the total absence of fire between the years 1950 and 2006, the long-term trend is more likely away from reference conditions rather than towards. Allowing the current fire frequency to continue will create shifts in the vegetation proportions, allowing shrubs to encroach into areas historically occupied by native bunchgrasses.

Ponderosa Pine-Evergreen Oak

Current Conditions: This woodland PNVT exhibits low soil productivity within a high biomass productivity class. Current soil conditions are almost entirely satisfactory with low departure (<10%). The vegetation of this PNVT shows a high departure from reference conditions. There is a substantial difference between the reference and current fire frequencies. Lack of frequent fire has favored the regeneration of oak and other sprouting species resulting in higher canopy cover and less understory. On- and off-PNF vegetation conditions are similarly departed (83% versus 83%).

Trends: Soil conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will improve the current vegetation conditions slightly, moving this PNVT towards its HRV over the first 20 years, but then conditions become static at a level that is moderately departed. Vegetation attributes (composition and structure) have been substantially altered from the historical range. The current frequency and amount of fire is insufficient to transition the vegetative states in a manner consistent with the historic fire regime.

Ponderosa Pine Forest

Current Conditions: This forest PNVT exhibits high soil productivity within a high biomass productivity class. Current soil conditions are almost entirely satisfactory with low departure (<12%). The vegetation of this PNVT shows a high departure from reference conditions.

There is a substantial difference between the reference and current fire frequencies. Fire exclusion has resulted in higher proportions of even-aged stands with high tree density and less grass cover. On- and off-PNF vegetation conditions are similarly departed (100% versus 94%).

Trends: Soil conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will move this PNVT slightly towards its HRV, but after 100 years this system remains in a condition that is highly departed. Vegetation attributes (composition and structure) have been substantially altered from the historical range. The current frequency and amount of fire is insufficient to transition the vegetative states in a manner consistent with the historic fire regime.

Mixed-Conifer Forest w/ Frequent Fire

Current Conditions: This PNVT has moderate soil productivity potential within a very high biomass productivity class. Current soil conditions are entirely satisfactory with no departure. Conversely, vegetation attributes of this PNVT show a high departure from reference conditions. There is a substantial difference between the reference and current fire frequencies. Most areas of this PNVT have been impacted by fire exclusion over the last sixty or more years. As a result, there are higher proportions of vegetation having a closed-canopy, high tree density, and a corresponding sparse herbaceous layer. On- and off-PNF vegetation conditions are similarly departed (100% versus 99%).

Trends: Soil and graminoid conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will move this PNVT slightly towards its HRV, but after 100 years this system remains in a condition that is highly departed. Vegetation attributes (composition and structure) have been substantially altered from the historical range. The current frequency and amount of fire is insufficient to transition the vegetative states in a manner consistent with the historic fire regime.

Mixed Conifer with Aspen

Current Conditions: This PNVT exhibits high soil productivity within a very high biomass productivity class. Current soil conditions are entirely satisfactory with no departure. Vegetation attributes of this PNVT show a moderate departure from reference conditions. Currently there are low proportions of late-development forest with large trees and early-development forest with aspen regeneration. On-PNF vegetation conditions are considerably more departed than off-PNF (58% versus 24%).

Trends: Soil conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will move the vegetation of this PNVT closer to its HRV for the first 40-50 years and then the trend would become static at a low level of departure from HRV.

Desert Communities

Current Conditions: This semi-arid PNVT exhibits low soil productivity within a very low biomass productivity class. Current soil conditions are moderately departed due to soil loss and inadequate surface OM. Current vegetation conditions are similar to reference conditions with low departure. On-PNF vegetation conditions are considerably less departed than off-PNF (14% versus 68%).

Trends: Soil conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will maintain the vegetation of this PNVT near to its HRV. This suggests that future conditions would remain similar to reference conditions and a properly functioning ecosystem.

Madrean Encinal Woodland

Current Conditions: This PNVT exhibits moderate productivity within a moderate biomass productivity class. Current soil conditions are moderately departed due to soil loss and inadequate surface OM. The vegetation attributes show a low departure from reference conditions. There is a substantial difference between the reference and current fire frequencies. On-PNF vegetation conditions are more departed than off-PNF (32% versus 17%).

Trends: Soil conditions are expected to remain stable. Based on the VDDT modeling, continuation of current management will move this PNVT towards its HRV over the first 20 years with shifts to desired vegetation classes through the process of ecological succession. After 20 years, the vegetation structure trends away from HRV reflecting the lack of disturbance (primarily fire) to transition the vegetation towards desired proportions within the various vegetation classes.

Riparian Forest

Current Conditions: Soils found within Riparian PNVTs are highly variable but generally have a low to moderate biomass production potential. Current soil conditions are moderately departed due to soil loss and inadequate surface OM. Vegetation conditions show a low departure from reference conditions. The departure that currently exists includes the presence of tamarisk and other invasive plants, and a disproportionate amount of mid-development vegetation with tall shrubs and small trees, and a lack of late-development multi-storied forest. On-PNF vegetation conditions are less departed than off-PNF (25% versus 32%).

Trends: There were no data to estimate trends for soil and graminoid conditions. No VDDT model currently exists to project over-story vegetation trends for this PNVT. Because the amount of riparian vegetation invaded by tamarisk and other invasive plants is not known with certainty, it is possible that the actual departure of PNF Riparian Forests is higher, and more similar to estimates for riparian areas off-PNF. Additional information on riparian vegetation occurrence and condition would clarify these estimates of risk to riparian ecosystem sustainability.

PNVT Spatial Contributions to Sustainability

As part of the sustainability assessment, we measured the relative amounts of each PNVT that occur on- and off-PNF. Then we compared the vegetation conditions occurring on- and off-PNF to determine the relative contributions to ecological sustainability that the PNF portions provide.

The PNF contribution to ecosystem sustainability will increase as the proportion and departure of vegetation located off-PNF increases. Where the PNF has segments of PNVTs that are in good condition (low departure), regardless of their size, these PNVTs will provide a greater contribution to ecological sustainability than their off-PNF counterparts, because they offer patches of refugia at the species, organism, and genetic scales.

We concluded that the PNF offers “high” contributions to ecological sustainability in six of the 13 PNVTs as shown in table 4.

Table 4. Summary of PNVT vegetation conditions and sustainability contributions

Potential Natural Vegetation Type (PNVT)	Proportion of Eco-section[1]: Off-PNF vs. On-PNF (%)	Vegetation Departure: Off-PNF vs. On-PNF (%)	PNF contribution to sustainability	Explanation of Sustainability Contribution Rating
Interior Chaparral	73/27	44/3	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.
Pinyon-Juniper Evergreen Shrub	81/19	47/27	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.
Pinyon-Juniper Woodland	71/29	65/14	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.
Pinyon-Juniper Grassland	76/24	49/30	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.
Semi-Desert Grassland	81/19	91/79	Moderate	On-PNF conditions better than off-PNF, but high departure.
Colorado Plateau Grassland	95/5	25/14	Moderate	Low departure off and on-PNF. On-PNF conditions better than off-PNF.
Ponderosa Pine-Evergreen Oak	75/25	83/83	Low	On-PNF conditions same as off-PNF with high departure.
Ponderosa Pine Forest	80/20	94/100	Low	On-PNF conditions same as off-PNF with high departure.
Mixed-Conifer Forest w/ Frequent Fire	80/20	99/100	Low	On-PNF conditions same as off-PNF with high departure.
Mixed Conifer with Aspen	99/1	24/58	Low	On-PNF conditions more departed than off-PNF.
Desert Communities	99/1	68/14	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.
Madrean Encinal Woodland	83/17	17/32	Low	On-PNF conditions more departed than off-PNF.
Riparian Forest	84/16	32/25	High	Low departure on-PNF. On-PNF conditions much better than off-PNF.

[1] Only the Tonto Transition Section (313c) is reported because it accounts for 92% of the PNF area.

The “high” rating was applied to PNVTs having both a low departure from their reference conditions and where the on-PNF conditions are much better than the off-PNF conditions. The “low” rating was applied to PNVTs with high departure and where on-PNF conditions were similar or worse than off-PNF conditions. The “moderate” rating applied to PNVTs with conditions in-between the other two ratings.

Key Findings

Table 5 summarizes the severity of departure and associated trends for vegetation and soil characteristics, reference and current fire frequency by PNVT, and ecological sustainability contributions. This information is used in Chapter 4 to evaluate risks to sustainability and in Chapter 5 as grounds for determining which PNVTs call for change.

Table 5. Summary of soil and vegetation conditions and trends, and fire frequency by PNVT

Potential Natural Vegetation Type (PNVT)	Soil Condition Departure[1] & Trend	Soil Loss Departure[1] & Trend	Soil Organic Matter Departure[1] & Trend		Vegetation Structure		Fire Frequency (in years)		PNF Contribution to Sustainability
			Surface	Soil	Departure[1]	Trend	Reference	Current	
Interior Chaparral	Low: Stable	Low: Stable	Low Stable	Low Stable	Low	Stable	1:20-100	1:84	High
Pinyon-Juniper Evergreen Shrub	Moderate: Away	Moderate: Away	Moderate: Away	Low Away	Low	Stable	1:60	1:233	High
Pinyon-Juniper Woodland	High: Away	High: Away	High: Away	Moderate: Away	Low	Toward	1:400	0	High
Pinyon-Juniper Grassland	High: Away	High: Away	High: Away	High: Away	Low	Away	1:31	1:714	High
Semi-Desert Grassland	High: Stable	High: Stable	High: Stable	Moderate: Stable	High	Stable	1:2-10	1:94	Moderate
Colorado Plateau Grassland	High: Away	High: Away	High: Away	High: Away	Low	No data	1:25	0	Moderate
Ponderosa Pine-Evergreen Oak	Low: Stable	Low: Stable	Low: Stable	Trace: Stable	High	Stable	1:6-12	1:51	Low
Ponderosa Pine Forest	Low: Stable	Trace: Stable	Low: Stable	Trace: Stable	High	Stable	1:5-36	1:74	Low
Mixed-Conifer Forest w/ Frequent Fire	Trace: Stable	Trace: Stable	Trace: Stable	Trace: Stable	High	Stable	1:5-36	1:1000	Low
Mixed Conifer with Aspen	Trace: Stable	Trace: Stable	Trace: Stable	Trace: Stable	Moderate	Toward	variable	1:1000	Low
Desert Communities	Moderate: Stable	Moderate: Stable	Moderate: Stable	Trace: Stable	Low	Stable	1:998	1:106	High
Madrean Encinal Woodland	Moderate: Stable	Moderate: Stable	Moderate: Stable	Trace: Stable	Low	Away	1:23	0	Low
Riparian Forest[2]	Moderate-High	Moderate	Moderate-High	Trace	Low	No data	1:20	1:76	High

[1] Departure Ratings: Trace = <1%, Low = 1-33%, Moderate = 34-66%, High = 67-100%.
[2] No trend data were available for Riparian PNVT. Departure ratings vary by TES map unit.

Aquatic Ecosystems

The section that follows summarizes information on the historic and current disturbances associated with the watersheds that intersect with the PNF. A more detailed discussion is provided in the Water Resources Report (Jarnecke and others 2008). Historic conditions analyzed here generally estimate Pre-European settlement conditions unless otherwise noted.

This overview sets the stage for understanding our methods and findings for the aquatic ecosystem assessment that follows.

Current and Historic Disturbances

Mining – Current Disturbances: Mining activities began in the 1860's and created the first European settlement within much of the PNF. This was especially the case in the Agua Fria and Hassayampa drainages. Starting with placer mining in streams, many stream channels were altered with sluicing and hydraulic mining – using high powered streams of water to break down alluvial banks and direct them into various sluices and rocker boxes in order to sort out the small volume of valuable minerals, with gold being the first attractant. Subsequently mining with shafts, adits, and small mills became more common, with associated piles of waste rock and tailings.

In addition to direct impacts on channels as described above, mining activities engendered many other activities impacting the water resource. Numerous roads and travel ways were constructed, including railroads (Wilson 1990). The demand for wood for mine props and especially for firing mills and smelters and residential heating and cooling resulted in removal of the majority of accessible trees in some areas, e.g., portions of Mingus Mountain. As discussed in more detail under water quality, the leftover waste after mill and smelter operations often contained concentrations of elements and compounds that had hazardous or toxic properties when washed into aquatic ecosystems.

Mining – Historic Disturbances: No mining occurred previous to European settlement.

Road Location – Current Disturbances: Roads located adjacent to and connected to stream courses serve to concentrate and accelerate water flow and may increase peak flows over natural levels causing decreased channel stability, riparian area function and water quality.

Road Location – Historic Disturbances: Roads were not located and constructed prior to European settlement.

Dams and impoundments – Current Disturbances: Dams and impoundments block the normal flow of streams and capture some of the streamflow, usually from periods of high flow or flood periods. There are no large impoundments on perennial streams on the PNF. The Verde River, downstream from the PNF has two major impoundments – Horseshoe Reservoir and Bartlett Reservoir – operated by the Salt River Project which capture water during periods of high flows and release it downstream during low flow periods. The majority of dams and impoundments are earthen stock tanks constructed to provide water for permitted livestock – and which are also used by a number of wildlife species. Dams also trap sediment which would otherwise move down through the channel system. Some of this is the result of natural geologic processes and its entrapment may affect the ability of downstream channels to replenish alluvial banks and terraces. Other sediment may be the result of human disturbances such as from roads or mining operations. Sullivan Dam, located on Big Chino Wash just above the beginning of perennial streamflow on the Verde

River, traps the majority of the bedload sediment from the Big Chino 4th HUC and the Williamson Valley 5th HUC.

Dams and impoundments – Historic Disturbances: No dams or impoundments existed previous to European settlement.

Water Withdrawals – Current Disturbances: Withdrawals from both surface water streams and connected groundwater aquifers may affect streamflow. In the middle Verde Valley (Clarkdale to Camp Verde) diversions for irrigation use have been present since the 1870's and sometimes reduce portions of the Verde River to a trickle during irrigation season. Increasing urban and "ranchette" development with wells is also impacting the streamflow. Local short segments of perennial streams which are downstream from wells or within their cones of depression – both used for irrigation and for residential, commercial, or recreational development – are subject to impact and loss or diminution of perennial flow. Groundwater withdrawals upstream from Del Rio Springs in the Granite Creek 5th HUC have reduced the historic flow by more than 50 percent, resulting in the loss of approximately one mile of perennial stream (Blasch and others 2006). Similarly, the loss of perennial flow on approximately five miles of stream associated with Big Chino Wash above Sullivan Dam are also documented (Wirt and others 2005).

Water Withdrawals – Historic Disturbances: No water withdrawals occurred previous to European settlement. As a result, the groundwater system likely maintained a long-term equilibrium based on climatic conditions (Wirt and others 2005).

H*erbivory - Current Disturbances:* Livestock grazing has occurred throughout the PNF, since the late 1800's. Both cattle and sheep have grazed portions of the Forest; however, sheep grazing currently makes up only a very small percent of permitted use. Because of the limited distribution of water and the adjacent lush herbaceous vegetation, cattle commonly concentrate grazing along perennial and intermittent streams, in riparian areas and wetlands around seeps and springs. Unmanaged herbivory has been observed to reduce effective vegetative ground cover and riparian vegetation and contribute to accelerated erosion, soil compaction and sedimentation to connected perennial waters and reduce or impair water quality.

Herbivory - Historic Disturbances: Available information indicates that domestic livestock grazing was not present prior to European settlement and thus had no disturbance effect. Pronghorn antelope, mule deer and desert bighorn sheep were present on the PNF. According to Davis (2001, p 174), there is "no evidence that bison occurred in the wild in Arizona in historic times."

Drought – Current Disturbances: Periodic droughts have been reported since European settlement. Severe drought in the 1890s resulted in large scale mortality of livestock. An extended drought occurred from about 1942-57. Recently the PNF has experienced a number of years of drought (roughly since about 1996) with occasional levels of seasonal moisture at or above the long-term mean. Reduced precipitation results in reduced upland vegetative growth, reduced surface organic matter and ineffective vegetative ground cover putting the soil at risk of accelerated erosion and sediment delivery to connected streams during storm events. As vegetation dries out, there is increased risk of wildfire spread and subsequent accelerated erosion and watershed degradation.

Perennial stream riparian vegetation is very resilient to drought and has not been shown to be drastically altered during periods of drought. Riparian vegetation in wetland sites at springs and seeps has been observed to dramatically decrease during periods of drought resulting in less-ponded and available water for those species that rely on it for their survival.

Drought – Historic Disturbances: Drought patterns are known to have occurred throughout at least the last millenium as evidenced through tree ring studies. Recent studies report that the drought of the 1950's was equaled or exceeded in duration and severity several times. Major droughts of prolonged duration have been reported in the 13th, 16th, and 18th centuries (Swetnam and Betancourt 1998). Some studies suggest periods of drought are believed to have contributed to higher levels of soil loss and sediment delivery than periods of normal or above moisture due to reduced effective vegetative ground cover soil protection.

Flooding – Current Disturbances: Flooding affects Riparian Forest Potential Natural Vegetation Types (PNVTs) as well as unmapped stream courses throughout all PNVTs. Flooding may cause localized soil loss, sediment delivery and reduced water quality in the stream channel, streambanks and floodplains if not well protected with vegetative ground cover. Frequent and flash flooding is a natural process and disturbance. Flash flooding can occur in perennial, intermittent and ephemeral streams in all PNVTs, especially in large watersheds where short duration, high intensity storms occur.

Although anecdotal stories reported that flooding occurred only following overgrazing by livestock (Willard 1975), reports of flood events affecting channels and vegetation began with the initial settlement (Allyn 1863-66). Major flood events were reported in area newspapers in 1874, several times in the 1890's and early 1900's (Dobyns 1981). Peak flow data on the Verde River extends back to about 1889 with the highest recorded flood peak occurring in 1891. A 2002 study (Huckleberry and Cornmeyer 2002) reported that 7 of the 10 highest flood flows in that 100+ year period had occurred since 1978.

Flooding – Historic Conditions: Floods can have both beneficial and deleterious effects on riparian vegetation. Some flooding is necessary to help regenerate cottonwoods and willows, because near-channel silt deposition creates the appropriate soil and moisture conditions for germination and growth of these species.

Paleohydrology studies on the Verde River have found evidence of periodic large floods prior to European settlement. Ely and others (1993) and Ely (1997) evaluated flood history over the last 5,000 years in the Southwest and reported fluctuations in frequency of "extreme floods" apparently correlated with changing climatic conditions. They reported that frequency of these floods increased during periods of relatively cool, wet climate while generally warmer periods had reduced frequency. The last 600 years showed an increase in flood frequency with the early part of the 20th century being a period of "anomalously high streamflow and floods in the southwest…" They also found a correlation with periods of more frequent El Niño events.

Several paleohydrology studies have been conducted on the Verde River in the last 20 years. Ely and Baker (1985) reported at least one flood on the lower Verde within the last one thousand years with a peak flow substantially greater than the largest since records began in 1891. Subsequently, House and others (2001) studied a reach a few miles downstream and reported deposits of 11 major floods in the last 1600 years, with two appearing to be slightly larger than the 1891 flood. Within and just above the middle Verde

Valley several floods in the last 300-650 years were calculated to be equal to or greater (near Chasm Creek) than the largest measured historical flows (Pearthree 2007). Huckleberry and Cornmeyer (2002) studied the Verde River within the middle Verde Valley between Cottonwood and Camp Verde. They found evidence of a number of large floods in the last 1000 years with the greatest frequency in the last 600 years.

Assessing Aquatic Ecosystem Diversity

To describe aquatic ecosystem diversity, we selected several characteristics that could meaningfully assess watershed vitality and serve as descriptors of habitats for aquatic-dependent species (Forest Service 2008).

The selected characteristics were evaluated at the 5th HUC watershed scale. This scale reflects the variation in local geomorphology, climatic gradients (temperature and precipitation), and chemical and hydrologic regimes within the PNF. The watershed characteristics were then summarized and reported at the 4th HUC subbasin scale to provide a context for understanding the ecological niche of the PNF with respect to aquatic ecosystems. Detailed watershed characteristics, their current and reference conditions, future trends and threats are provided in the *Water Resources Report* (Jarnecke and others 2008).

The individual watershed characteristics that were evaluated include perennial streams, water yield, water quality, riparian/wetland features, seeps/springs/stock tanks, and aquatic species.

Reference Conditions

Limited information is available on the historical range of variation (HRV) for most of the watershed characteristics that we assessed. We did use the following sources: Historical occurrence information for aquatic species was compiled from published literature. Reference conditions for water quality are defined as category 1 of the water quality standards set by the State, under authority of the Clean Water Act (P.L. 92-500). A list of the State water quality standards are provided in the *Water Quality* section of this chapter.

We evaluated watershed characteristics using alternatives to HRV for perennial streams, riparian/wetland features, and seeps/springs.

Alternatives to HRV

There is little data for HRV for many hydrologic characteristics, such as mileage of perennial streams or number of seeps and springs, and there is not enough information to estimate departure from HRV. Therefore we tried to gain a general understanding of ecological conditions needed to sustain a given characteristic using *representativeness* and *redundancy* as metrics to indicate the relative health of each subbasin (Forest Service 2008).

Characteristics of Representativeness:

- Designed to indicate representation of the full array of potential conditions and variations of conditions (states) of an ecosystem characteristic on the landscape.
- Accomplished by evaluating the proportional occurrence of an ecosystem characteristic at the PNF (watershed) scale compared to that found at a scale above the planning unit (subbasin), and then evaluating whether these characteristics are under or over-represented within the PNF.
- Is based on three assumptions:

1. There is a “representative” range of specific hydrologic feature conditions associated with an ecosystem characteristic across the larger landscape.
2. A wide range of hydrologic feature conditions will sustain the greatest percentage of the component species which utilize that characteristic.
3. A higher representativeness, leading to presence of more variety of conditions, creates a more sustainable ecosystem.

- Is calculated in this application using two methods:
  1. For riparian areas, the proportion of applicable wetland/riparian vegetation acreage on the PNF was compared to that found in the subbasin. The resulting ratios were evaluated as follows: <0.8 (80 %) = underrepresented. 0.8 to 1.2 (80 to 120%) = proportional, and >1.2 (120%) is over- represented.
  2. For seeps and springs and perennial stream miles, the density of the hydrologic feature in the watershed was divided by the density of hydrologic feature in subbasin; <0.8 = underrepresented. 0.8 to 1.2 = proportional, and >1.2 = over-represented.

Characteristics of Redundancy:

- Ensures that there are multiple occurrences of representative conditions across the landscape.
- Assumes that finding the occurrence of an ecosystem characteristic in multiple places across the landscape increases the likelihood of maintaining representativeness by decreasing the risk of eliminating the characteristic or a specific condition of the characteristic through a single disturbance event.
- Is calculated by comparing percent contribution of an ecosystem characteristic by watershed within a subbasin. Subbasin ratings were described as low, moderate, and high redundancy: *low* = hydrologic feature is not found in each watershed within the subbasin; *moderate* = hydrologic feature is found in each watershed but is not evenly distributed between watersheds; *high* = hydrologic feature is found in each watershed and is approximately evenly distributed between them.

We assessed the spatial distribution or occurrence of wetland/riparian areas, seeps and springs, and perennial stream miles. However, the occurrence of perennial streams and seeps and springs is primarily controlled by geologic structures or landscape features. The occurrence of these features in deep alluvial valleys in the lower portions of the subbasins is likely to be of low density. Therefore there may be some difficulty defining whether low representativeness is due to geologic structure and landscape features or other impacts, such as reductions in perennial stream mileage or number of seeps and springs due to the indirect effects of ground water withdrawal.

Current Conditions

We estimated the current conditions of the hydrologic characteristics using various sources of data:

Perennial streams data were taken from a combination of the National Hydrologic Dataset (USGS no date) and the Arizona Department of Water Resources database (Jarnecke and others 2008). The National Hydrologic Dataset (NHD) was updated for perennial streams for the 4th and 5th HUC watersheds that included a portion of the PNF. We found that there is only one major perennial stream with continuous flow from headwaters to mouth – the Verde River. Other perennial streams within the PNF are predominately *discontinuous*, meaning that they are segments separated by intermittent reaches; or that they cease to be perennial

prior to confluence with a larger stream with flow sinking into underlying porous soil or fault/fracture conditions.

Water yield is the amount of water which leaves the immediate site to become surface water flow or groundwater recharge. Essentially, it is the difference between total precipitation and evapotranspiration. Water yield for the PNF portion of 4th HUC subbasins and 5th HUC watersheds was not calculated. Because water yield is primarily influenced by precipitation and elevation, we used data from the PRISM (Parameter-elevation Regressions on Independent Slopes Model from 1971-2000) to compare water yield potential for the 4th and 5th Level HUCs. Average annual precipitation for the PNF portions of each subbasin and watershed were compared to the averages of the entire watershed or subbasin to identify areas of high water yield potential. This analysis shows that for a number of the 4th and 5th HUC watersheds, the PNF typically includes the upper elevations and, as a result, receives higher amounts of precipitation than off-PNF areas.

Water quality data is based on recent ADEQ assessments from most of the major perennial and intermittent stream reaches and lakes on the PNF (Jarnecke 2008). The general classification used for surface water quality by ADEQ is *Attaining*, *Impaired*, and *Inconclusive* for the identified uses.

The classification designates each water body in one of five categories:
Category 1: Attaining All Uses – There is sufficient data to determine that all designated uses are supported.
Category 2: Attaining Some Uses – At least one designated use assessed as “attaining” and all other uses are assessed as “inconclusive” due to a lack of sufficient sampling data.
Category 3: Insufficient data – All designated uses are “inconclusive” (by default, any surface water not assessed due to lack of credible data is actually included in this category)
Category 4: Impaired or threatened for at least one use but a TMDL not required. There are several subcategories of Category 4:

4A – A TMDL has already been completed
4B – Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard
4C – The impairment is caused by pollution but not a pollutant, or
4N – The impairment is caused *solely* by natural conditions (an Arizona list only)

Category 5: Impaired or threatened for one or more designated uses by a pollutant, and a TMDL needs to be developed or revised.

A TMDL or *Total Maximum Daily Load* analysis is designed to help an impaired stream or lake meet its water quality standards and support its designated uses. ADEQ is responsible for preparing TMDL analyses which include measures designed to reduce the pollutants causing impairment to levels where water quality standards can be met. Implementation of mitigation measures identified in a TMDL is the responsibility of the landowner or manager; however, ADEQ administers a water quality improvement grant program to assist in accomplishment.

Knowing which waters are *Impaired* or *Not Attaining* is important. These lakes and stream reaches have been identified by ADEQ as those with the most severe water quality problems. Permit requirements for discharge into these waters is very strict and ADEQ and the PNF must make sure that any new discharges or modifications will not further degrade water quality.

Riparian and emergent wetlands acreage was taken from the Southwest Regional Gap Analysis Project (USGS 2004). We recognize that this dataset may under-represent the actual acreage or poorly capture the distribution of riparian vegetation due to the scale and resolution of the mapping involved. The value of this dataset lies in the fact that complete coverage was available for both the PNF and for all of the lands within the subbasins that intersect with the PNF. This completeness allowed us to calculate redundancy and representativeness values as an alternative to HRV. We assume that any inaccuracies in mapping occurred without regard to land ownership status.

The *Water Resources Report* (Jarnecke and others 2008) also summarizes riparian information from the U.S. Fish and Wildlife Service National Wetlands Inventory (USFWS 2004) for each 5th HUC watershed. Information from the National Wetlands Inventory covered all of the PNF and neighboring National Forests and but lacks complete coverage of all subbasins needed for the alternative HRV analysis.

Seeps/springs/stock tanks information came from multiple sources. The NHD was used to identify seeps and springs at the subbasin and watershed levels. Information on stock tanks was gathered from the Arizona Department of Water Resources, *Statement of Claim* filings for water rights. The data show that higher than expected amounts of seeps and springs occur on the PNF lands within seven of the eight subbasins assessed.

Aquatic species data were gathered from multiple sources including species abstracts located on the NatureServe and Arizona Game and Fish Department websites. A complete list is provided in the *Aquatic Species Diversity Report* (Sillas 2008). Native fish populations within the Lower Colorado River Basin have experienced declines in their distribution because of loss or modification of habitat and from competition and predation by introduced nonnative fishes. Only nine of the 15 native fish species known to occur in the Lower Colorado River Basin currently occur within the PNF. Aquatic invertebrates have a very limited distribution in the planning area.

Subbasin Conditions

The pages that follow summarize reference and current conditions for watershed characteristics on the PNF. The information is organized alphabetically by 4th HUC subbasin with the subbasin labels displayed at the top of each page.

Subbasin: Agua Fria River (PNF spatial contribution = 19%)

5th HUC Watersheds:		
Agua Fria R/Lake Pleasant	PNF sq mi: 25	PNF %: 7
Ash Creek/Sycamore Creek	PNF sq mi: 232	PNF %: 89
Big Bug Creek/Agua Fria R	PNF sq mi: 90	PNF %: 28
Bishop Creek	PNF sq mi: 26	PNF %: 11
Black Canyon Creek	PNF sq mi: 158	PNF %: 65

Ecological Niche:

The Agua Fria subbasin drains to the Middle Gila downstream from its confluence with the Salt River. The Prescott and Tonto National Forests contribute 28% of subbasin area. The PNF provides 18% of riparian area, 44%, of seeps/springs, and 16% of perennial stream miles. The PNF has 19% of area, but 26% of average annual precipitation within the subbasin. This indicates a high recharge potential for the PNF portion of the subbasin.

Perennial Streams:

Of 57 perennial stream miles in the subbasin, 9 miles are located on the PNF.
Watersheds offer the following predominantly discontinuous perennial stream mileage:
Agua Fria R/Lake Pleasant 0.39 mi Big Bug Creek/Agua Fria R 0.88 mi Black Canyon Creek 0.38 mi
Ash Creek/Sycamore Creek 7.68 mi Bishop Creek 0.38 mi
Perennial stream miles on the PNF are proportionally represented to that found in the subbasin as a whole. Redundancy is moderate.

Water Yield:

The natural disturbances of droughts and floods are within the HRV while water withdrawals via diversions or groundwater pumping are beyond the HRV. The locations of Agua Fria/Lake Pleasant, Big Bug Ck/Agua Fria, and Black Canyon Ck. watersheds on the south portion of the Bradshaw Mountains, with abrupt uplift of occasional tropical moist air from the southwest results in higher precipitation amounts on PNF portions of the subbasin. Streams in subbasin generally have low base flows and large variations in flow.
PNF Proportion of watershed avg. annual precipitation:
Agua Fria R/Lake Pleasant 10% Big Bug Creek/Agua Fria R 32% Black Canyon Creek 72%
Ash Creek/Sycamore Creek 90% Bishop Creek 12%

Water Quality:

The Black Canyon Creek watershed includes 19.7 miles on the PNF within Turkey Creek that has been classified as Category 5 impaired waters due to copper and lead levels. Remediation, including removing tailings from the floodplain, capping tailings with vegetation, and control of pollutant escape from shafts and adits was completed in July 2007. Lynx Ck tributaries (0.5 mi on PNF) have had some sample exceedances for zinc, copper, and cadmium, however data was inconclusive. Little Ash Creek is also assessed as inconclusive; limited sampling detected no exceedances.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:
Agua Fria R/Lake Pleasant 46 ac Big Bug Creek/Agua Fria R 7 ac Black Canyon Creek 349 ac
Ash Creek/Sycamore Ck 930 ac Bishop Creek 93 ac
Riparian area is estimated as proportional on the PNF compared to the subbasin. Redundancy is moderate showing riparian acreage present in each watershed, but not evenly distributed between watersheds.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy is high; seeps and springs are found in each WS and are well distributed.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
AF R/Lk Pleasant	18	18	0.73
Ash Ck/ Sycamore Ck	82	20	0.77
Big Bug Ck/AF R	39	178	1.12
Bishop Ck	7	134	1.50
Black Canyon Ck	54	267	1.15

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed:

WS	Native Species: Historic &Current	Native Species: Historic but absent now	Native Species: Historic and re-introduced	Non-native species present
AF R/Lk Pleasant	1	0	0	2
Ash/Sycamore Ck	6	2	0	6
Big Bug Ck/AFR	2	0	0	0
Bishop Ck	7	0	0	2
Black Canyon Ck	3	0	0	2

Subbasin: Big Chino Wash (PNF spatial contribution = 16%)

5th HUC Watersheds:

Lower Big Chino Wash	PNF sq mi:	136	PNF %:	38
Lower Partridge Creek.	PNF sq mi:	1	PNF %:	<1
Middle Big Chino Wash	PNF sq mi:	38	PNF %:	13
Williamson Valley Wash	PNF sq mi:	169	PNF %:	53

Ecological Niche:

The Big Chino Wash, Upper Verde and Lower Verde subbasins are sequential, moving down drainage, and form the Verde River Basin which joins the Salt River near Phoenix.
The PNF provides 54% of riparian areas, 83%, of seeps and springs, and 5% of perennial stream miles within the subbasin. PNF areal contribution is 16%, but has 18% of average annual subbasin precipitation. Precipitation is roughly proportional to area contribution.

Perennial Streams:

Of 12 perennial stream miles in the subbasin, 1 mile is located on the PNF. Watersheds within the subbasin provide the following predominantly discontinuous perennial stream mileage:

Lower Big Chino Wash	0.45 mi	Middle Big Chino Wash	0.0 mi
Lower Partridge Creek	0.0 mi	Williamson Valley Wash	11.5 mi

Perennial stream miles on the PNF are under-represented compared to that found in the subbasin as a whole. Redundancy is low.

Water Yield:

The natural disturbances of droughts and floods are within the HRV while water withdrawals via diversions and groundwater pumping are beyond the HRV. Watersheds in the subbasin generally have lower precipitation for their elevation due to gentler terrain. This subbasin is one that has more direct use of water yield through both surface and groundwater withdrawals. Streams in the subbasin generally have low base flow and large variations in flow.
PNF Proportion of watershed avg. annual precipitation:

Lower Big Chino Wash	42 %	Middle Big Chino Wash	15 %
Lower Partridge Creek	<1%	Williamson Valley Wash	58%

Water Quality:

No streams have been assessed in 3 of 4 watersheds. The Lower Big Chino Wash contains 1.8 miles of Category 3 mileage in Walnut Creek. Assessment was inconclusive due to inadequate number of samples, with no exceedances.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:

Lower Big Chino Wash	223 ac	Middle Big Chino Wash	0 ac
Lower Partridge Creek	0 ac	Williamson Valley Wash	295 ac

Riparian area is estimated as over-represented on the PNF compared to the subbasin, but redundancy is low showing riparian acreage present in 2 of 4 watersheds.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy is also low; seeps and springs are found in 2 of 4 watersheds.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Lower Big Chino Wash	17	99	0.73
Lower Partridge Ck	0	0	0.00
Middle Big Chino Wash	0	22	0.57
Williamson Valley Wash	46	184	1.09

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species: Historic and Current occurrence	Native Species: Historic but not now present	Native Species: Historic and re-introduced	Non-native Species present
Lower Big Chino Wash	3	0	0	0
Lower Partridge Creel	0	0	0	0
Middle Big Chino Wash	2	0	0	0
Williamson Valley Wash	3	0	0	2

Subbasin: Big Sandy River **(PNF spatial contribution = 1%)**

5th HUC Watershed:

Muddy Creek PNF sq mi: 18 PNF %: 10

Ecological Niche:

The Big Sandy River subbasin flows into the Bill Williams River Basin which empties into the main stem of the Colorado River near Parker, AZ. The PNF provides 0% of riparian areas, 0% of seeps and springs, and 0% of perennial stream miles within the subbasin.
PNF areal contribution is 1% and 1% of average annual subbasin precipitation falls on the PNF. Precipitation is proportional to area contribution.

Perennial Streams:

Of 86 perennial stream miles in the subbasin, none are located on the PNF. The portion of the one watershed within the subbasin that intersects with the PNF has no perennial stream miles. Representativeness and redundancy could not be assessed since there are no stream miles within the PNF portion of the watershed and only one watershed within the subbasin that intersects the PNF.

Water Yield:

The natural disturbances of droughts and floods are within HRV; The subbasin is in the northwest part of the PNF where precipitation is generally lower given the elevation, due to gentler terrain.
PNF proportion of watershed avg. annual precipitation:
Muddy Creek 10%

Water Quality:

No streams were assessed by ADEQ in the Muddy Creek Watershed.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:
Muddy Creek 0 ac
Representativeness and redundancy could not be assessed since there are no riparian acreages within the PNF portion of the watershed and only one watershed within the subbasin that intersects with the PNF.

Seeps/Springs/Stock Tanks

No seeps and springs are documented on the PNF although 138 are found in the watershed. Redundancy was not estimated with only one watershed that intersects the PNF.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Muddy Creek	0	1	0.05

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species			Non-native species present
	Historic and Current occurrence	Historic but not now present	Historic and re-introduced	
Muddy Creek	0	0	0	0

Subbasin: Burro Creek **(PNF spatial contribution = 4%)**

5th HUC Watersheds:

Boulder Creek	PNF sq mi:	16	PNF %:	11
Upper Burro Creek	PNF sq mi	13	PNF %	8

Ecological Niche:

The Burro Creek subbasin flows to the Bill Williams River Basin, which empties into the main stem of the Colorado River near Parker, AZ. The PNF provides 0% of riparian acreage, 6% of seeps and springs, and 0% of perennial stream miles within the subbasin.
PNF areal contribution is 4% and 5% of average annual subbasin precipitation falls on the PNF. PNF precipitation input is roughly proportional to area contribution.

Perennial Streams:

Of 27 perennial stream miles in the subbasin, 0 miles are located on the PNF. The Upper Burro Creek watershed includes 19.2 total perennial stream miles, Boulder Creek watershed includes 0 perennial stream miles, and no perennial stream miles are found on the PNF within either watershed. With no perennial stream miles contributed by the PNF, representativeness and redundancy was not assessed.

Water Yield:

The natural disturbances of droughts and floods are within HRV; precipitation is about proportional to area of the watershed within the PNF.
PNF proportion of watershed avg. annual precipitation:
Boulder Creek 12% Upper Burro Creek 8%

Water Quality:

While the Boulder Creek watershed includes 27.3 miles of ADEQ category 2 or 3 (some uses assessed as inconclusive due to insufficient data), no PNF streams have been assessed. No streams have been assessed within Upper Burro Creek watershed.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:
Boulder Creek 6 ac Upper Burro Creek. 0 ac
There are approximately 6 riparian acres within the Boulder Creek watershed, however, with rounding, the overall contribution of the PNF to riparian conditions is zero. With 0% PNF riparian acreage contribution to the subbasin, representativeness was not estimated. Redundancy is low: only one of two watersheds offers any riparian acreage.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy is low; seeps and springs are not found in each watershed.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Boulder Ck	3	0	0.0
Upper Burro Ck.	0	0	0.0

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species			Non-native species present
	Historic and Current. occurrence	Historic but not now present	Historic and re-introduced	
Boulder Ck	5	0	0	5
Upper Burro Ck.	5	0	0	5

Subbasin: Hassayampa River **(PNF spatial contribution = 13%)**

5th HUC Watersheds:

Middle Hassayampa R	PNF sq mi: 3	PNF %: 1
Upper Hassayampa R.	PNF sq mi: 192	PNF %: 63

Ecological Niche:

The Hassayampa subbasin drains to the Middle Gila downstream from its confluence with the Salt River. The PNF provides 11% of riparian areas, 59%, of seeps and springs, and 42% of perennial stream miles within the subbasin. PNF areal contribution is 13%, while 21% of average annual subbasin precipitation falls on the PNF. This indicates a high recharge potential for the PNF portion of the subbasin, primarily due to high elevation acreages.

Perennial Streams:

Of 32 perennial stream miles in the subbasin, 13 miles are located on the PNF. Watersheds within the subbasin provide the following predominantly discontinuous perennial stream mileage:

Middle Hassayampa R 0.0 mi Upper Hassayampa R 13.35 mi

Perennial stream miles on the PNF are over-representative compared to that found on the subbasin as a whole, but redundancy is low. PNF perennial stream miles were found in only one watershed.

Water Yield:

The natural disturbances of droughts and floods are within HRV. The PNF contributes 13% of land area and 21% of precipitation providing a high proportion of the surface water yield and groundwater recharge potential. This is due generally to higher elevations and location on the south portion of the Bradshaw Mountains where abrupt uplift of occasional tropical moist air masses result in unusually high precipitation. Streams in subbasin have generally low base flow and large variations in flow due to changes in surface runoff due to precipitation.

PNF Proportion of watershed avg. annual precipitation:

Middle Hassayampa River 1% Upper Hassayampa River 66%

Water Quality:

While the Middle Hassayampa R. watershed includes 36.3 miles of ADEQ category 2 or 3 (some uses assessed as inconclusive due to insufficient data), no PNF streams have been assessed. The upper reach of the Hassayampa River (includes 9.3 mi on PNF) is assessed as impaired with a TMDL for copper, cadmium, and zinc—Category 4A. Remediation has begun by treating the McCleur Mine tailings on both PNF and private land. The Senator Mine, on private land, is being evaluated by EPA. The same portion of the river is also impaired due to pH; however a TMDL has not been completed (Category 5).

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:

Middle Hassayampa R 0 ac Upper Hassayampa R. 269 ac

PNF riparian area is estimated as proportional to the subbasin and redundancy is low since riparian acreage is not present in each portion of the watershed that intersects with the PNF.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Middle Hassayampa R	2	0	0.0
Upper Hassayampa R.	102	43	0.22

Redundancy is high; seeps and springs are found in each WS and are well distributed.

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed:

WS	Native Species			Non-native species present
	Historic and Current occurrence	Historic but not now present	Historic and re-introduced	
Middle Hassayampa R	0	0	0	1
Upper Hassayampa R.	4	0	0	1

Subbasin: Santa Maria River (PNF spatial contribution = 16%)

5th HUC watersheds:

Kirkland Creek	PNF sq mi: 74	PNF %: 18
Sycamore Creek	PNF sq mi: 152	PNF % : 64

Ecological Niche:

The Santa Maria River subbasin flows into the Bill Williams River Basin, which empties into the main stem of the Colorado River near Parker, AZ. The PNF provides 7% of riparian areas, 40%, of seeps and springs, and 3% of perennial stream miles within the subbasin. PNF areal contribution is 16% and 19% of average annual subbasin precipitation falls on the PNF. This indicates a high recharge potential within the PNF portion of the subbasin, primarily due to high elevation acreages.

Perennial Streams:

Of 41 perennial stream miles in the subbasin, 1 mile is also located on the PNF. Watersheds within the subbasin provide the following predominantly discontinuous perennial stream mileage:

Kirkland Creek 0.39 mi. Sycamore Creek 0.88 mi.

Perennial stream miles per square mile on the PNF are under-represented compared to density found on the subbasin as a whole. Redundancy is moderate with perennial stream mileage present in each watershed but not evenly distributed.

Water Yield:

The natural disturbances of droughts and floods are within HRV. The PNF contributes 16% of land area and 19% of precipitation providing a proportional amount of the surface water yield and groundwater recharge potential. This is due generally to higher elevations and location on the southwestern side of the Bradshaw Mountains where abrupt uplift of occasional tropical moist air masses from the southwest result in unusually high precipitation. Streams in the subbasin have generally low base flow and large variations in flow due to changes in surface runoff following precipitation events.

PNF Proportion of watershed avg. annual precipitation:

Kirkland Creek 19% Sycamore Creek 66%

Water Quality:

Copper Basin Wash in the Kirkland Creek watershed is the only stream assessed in the Bill Williams Basin (3rd Code HUC). It includes 3.4 miles on the PNF assessed as Category 3, inconclusive, due to limited sampling. The one sample analyzed suggested high levels of copper, lead, and selenium. No streams have been assessed in Sycamore Creek watershed.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:

Kirkland Creek 28 ac Sycamore Creek 245 ac

Riparian area density is estimated as under-represented on the PNF compared to the subbasin. Redundancy is moderate showing riparian acreage present in each watershed, but not evenly distributed between watersheds.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy is high; seeps and springs are found in each watershed and are well distributed.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Kirkland Ck	25	1	0.01
Sycamore Ck	52	2	0.01

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species			Non-native species present
	Historic and Current occurrence	Historic but not now present	Historic and re-introduced	
Kirkland Ck	5	0	0	2
Sycamore Ck	5	0	0	2

Subbasin: Verde River – Upper				**(PNF spatial contribution = 22%)**
5th HUC Watersheds:				
Cherry Creek/Upper Verde	PNF sq mi:	117	PNF %:	52
Granite Creek/Upper Verde	PNF sq mi:	70	PNF %:	20
Grindstone Wash/Upper Verde	PNF sq mi:	227	PNF %:	74
Hell Canyon	PNF sq mi:	104	PNF %:	44
Sycamore Creek	PNF sq mi:	35	PNF %:	7

Ecological Niche:

The Big Chino Wash, Upper Verde and Lower Verde subbasins are sequential, moving down drainage, and form the Verde River Basin which joins the Salt River near Phoenix. Major portions of the subbasin are also found on the Coconino and Kaibab National Forests. About 56% of the Verde River Basin (HUC 3) is found on a National Forest.

The PNF provides 22% of riparian areas, 33%, of seeps and springs, and 20% of perennial stream miles within the subbasin. PNF areal contribution is 22%, while 19% of average annual precipitation within the subbasin falls on the PNF. Precipitation contribution is proportionally less than on the adjacent Coconino and Kaibab National Forests which contain more high elevation acreages within the subbasin.

Perennial Streams:

Of 187 perennial stream miles in the subbasin, 37 miles are located on the PNF. A majority of perennial stream mileage occurs on the Coconino National Forest. Of importance is that there is only one major perennial stream with continuous flow from headwaters to mouth—the Verde River. From its headwaters springs near the confluence with Granite Creek, it flows approximately 195 miles to downstream reservoirs and eventually its confluence with the Salt River. Watersheds within the subbasin provide the following perennial stream mileage:

Cherry Creek/Upper Verde 3.39 mi. Grindstone Wash/Upper Verde 27.9 mi. Sycamore Creek 0.84 mi.
Granite Creek/Upper Verde 4.09 mi. Hell Canyon 0.54 mi.

Representativeness of perennial stream miles on the PNF is proportional to that found on the subbasin as a whole. Redundancy is moderate; perennial stream mileage occurs in each watershed but is not evenly distributed.

Water Yield:

Natural disturbances of droughts and floods are within HRV. Withdrawals through surface water diversions and groundwater pumping are beyond HRV. Watersheds in the northwest portion of the PNF tend to have lower precipitation for the same elevation due to gentler terrain. In addition, the PNF portions of the Hell Canyon, Sycamore Creek and Grindstone Wash watersheds have lower precipitation because they occupy the lower elevations of the watersheds. Base flow typically constitutes a relatively small proportion of annual average streamflow for most watersheds. The primary exception is the Verde River at Paulden gauge where base flow makes up nearly 60 percent of the average annual flow (Blasch and others 2006).

PNF Proportion of watershed avg. annual precipitation:

Cherry Creek/Upper Verde 55 % Grindstone Wash/Upper Verde 69 % Sycamore Creek 7 %
Granite Creek/Upper Verde 22 % Hell Canyon 38 %

Subbasin: Verde River – Upper (cont'd)

Water Quality:

There are approximately 52 miles of the Verde River within and/or forming the boundary of the PNF. Of this, the upper 11.6 miles are assessed as Category 1 (attaining all uses). The next 6.7 miles are omitted in the assessment, and the remaining 34 miles are assessed as Category 4--attaining all designated uses except for warm water aquatic life due to exceedances of turbidity. Continued turbidity levels are the result of natural background levels. A TMDL was completed and approved in 2002. ADEQ recommended that the turbidity standard be replaced with a suspended sediment standard. This proposed standard has been exceeded only during flood flows—a natural occurrence in the system. Bio-assessment data indicate that turbidity levels are not impairing invertebrate communities. Contribution to turbidity from the PNF is probably small since PNF reaches are no longer listed for turbidity.

Granite Basin Lake is assessed as attaining the standard for fish consumption but inconclusive for other designated uses. Eleven miles of Sycamore Creek have been assessed as Category 1. No streams have been assessed in Hell Canyon watershed.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:

Cherry Creek/Upper Verde 966 ac Grindstone Wash/Upper Verde 685 ac Sycamore Creek 245 ac
Granite Creek/Upper Verde 91 ac Hell Canyon 84 ac

Riparian area density is estimated as proportional on the PNF compared to the subbasin and redundancy is moderate showing PNF riparian acreage present in each watershed, but not evenly distributed between watersheds.

Seeps/Springs/Stock Tanks:

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy is moderate. Seeps and springs are found in each watershed but are not evenly distributed between watersheds.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Cherry Ck/UV	60	106	0.91
Granite Ck/UV	21	32	0.46
Grindstone Wash	2	147	0.65
Hell Canyon	2	64	0.61
Sycamore Creek	6	20	0.57

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species			Non-native species present
	Historic and current occurrence	Historic but not now present	Historic and re-introduced	
Cherry Ck/UV	8	4	0	14
Granite Ck/UV	8	0	0	11
Grindstone Wash	9	2	0	11
Hell Canyon	0	0	0	2
Sycamore Ck	3	0	0	5

Subbasin: Verde River Lower (PNF spatial contribution = 3%)

5th HUC Watershed:

Fossil Creek/Lower Verde PNF sq mi: 65 PNF %: 22

Ecological Niche:

The Big Chino Wash, Upper Verde and Lower Verde subbasins are sequential, moving down drainage, and form the Verde River Basin which joins the Salt River near Phoenix. A large proportion of acreage in this subbasin is located within the Coconino and Tonto National Forests.
The PNF provides 11% of riparian areas, 6% of seeps and springs, and 6% of perennial stream miles within the subbasin. PNF areal contribution is 3% and 3% of average annual subbasin precipitation falls on the PNF. PNF precipitation input is proportional to areal contribution.

Perennial Streams:

The Lower Verde subbasin has a large amount of perennial stream mileage on the Coconino and Tonto National Forests. Of 297 perennial stream miles in the subbasin, 18 miles are located on the PNF.
Watersheds within the subbasin provide the following perennial stream mileage:
Fossil Creek/Lower Verde 18.37 mi
Perennial stream miles on the PNF are over-represented compared to the subbasin as a whole. Redundancy was not analyzed since only one watershed intersects with the PNF.

Water Yield:

Precipitation contribution for the portion of Fossil Creek/Lower Verde watershed that is located on the PNF is lower than the proportion of area contributed by the PNF in the watershed. Higher levels of precipitation are found in higher elevations on the Coconino National Forest. The Lower Verde River subbasin is estimated to have a high direct use of water yield through both surface and groundwater withdrawals.
PNF Proportion of watershed avg. annual precipitation:
Fossil Creek/Lower Verde 20%

Water Quality:

The 5.4 mile reach of Gap Creek from Government Springs to the Verde River is assessed as Category 1, attaining all uses. The Verde River from Camp Verde to the boundary between the PNF and the Tonto National Forest is assessed as Category 4A for turbidity as discussed previously for the Upper Verde River subbasin. This 15.5 mile stretch is also a boundary with the Coconino National Forest.

Riparian Features:

Riparian Acreage on PNF by HUC 5 watershed:
Fossil Creek/Lower Verde 1,540 ac
Riparian area is estimated as over-representative on the PNF compared to the subbasin and redundancy was not analyzed since only one watershed intersects with the PNF.

Seeps/Springs/Stock Tanks

Seeps and springs on the PNF are over-represented compared to the subbasin. Redundancy was not analyzed as only one watershed intersects with the PNF.

WS	# Spr/Sps PNF	# Stk Tks. PNF	Density Stk Tks/sq mi.
Fossil Ck/Lower Verde	25	67	1.03

Aquatic Species:

Number of native and non-native fish and other aquatic species that occur within each watershed in the subbasin:

WS	Native Species			Non-native species present
	Historic and current occurrence	Historic occurrence but not now present	Historic and re-introduced	
Fossil Ck/Lower Verde	10	1	5	15

Projected Trends for Watershed Features
We have limited information on projected trends for watershed features. The following projections are based on available literature.

Perennial Streams - There has been documented regression of perennial streamflow downstream from Del Rio Springs, in a number of tributary segments in the Upper Verde River above Sullivan Dam, and in the Verde Valley (Blasch and others 2006). Proposed and projected increases in groundwater pumping from the Big Chino aquifer have become controversial in terms of their potential impact on baseflows in the Verde River within the Middle Verde 4th HUC subbasin.

Water Yield - Water withdrawals through surface water diversions and groundwater pumpage are well beyond the historical range of variation. The natural disturbances of droughts and floods are within the historical range of variation.

Because total water yield is directly related to precipitation, the current drought (and projections of its potential continuance for a number of years) may result in a continuation of the recent trend of reduced streamflow and somewhat reduced base flows. Predictions from global climate models suggest warmer temperatures and slightly reduced total precipitation, with a high incidence of both droughts and floods. Current trends of a reduced proportion of winter precipitation being snowfall, with earlier spring melt, are predicted to continue and possibly increase in effect. These factors may result in reduced groundwater recharge and changes in the magnitude, frequency, and duration of streamflows.

Ground water levels have declined due to both withdrawals and recent drought conditions, primarily on the private lands outside the PNF boundary. Potential ground water withdrawals from the Big Chino aquifer authorized by the Arizona Ground Water Transportation Act, along with potential new consumptive uses in the area, could potentially and substantially affect streamflows in the Verde River and headwater tributaries. The Big Chino aquifer has been reported as providing more than 80 percent of the flow for the Verde River headwater springs (Wirt and others 2005). Monitoring and mitigation to reduce effects have been promised by the municipalities proposing to import water from this aquifer. Distinguishing the timing and amount of effects between this pumping and that attributed to other new uses on the aquifer will be difficult.

Water Quality - Water quality that has been degraded by historic mining operations (Hassayampa and Aqua Fria watersheds) is being addressed by a number of remediation projects leading to a trend toward reference condition in those waters.

Key Findings

Table 6 summarizes the hydrologic features and the watershed conditions found within the 4th HUC subbasins associated with the PNF. (See *Appendix B* for maps of subbasins and watersheds).

The uplands within the *Big Chino Wash, Big Sandy River, Burro Creek, and Upper Verde River* subbasins have reduced watershed condition integrity due to departed soil conditions.

Several subbasins (*Aqua Fria River*, and *Upper* and *Lower Verde River*) exhibit moderate to high levels of redundancy and proportional to over-represented amounts of hydrologic features (riparian areas, seeps/springs, and perennial streams) occurring on the PNF lands within the subbasins. The abundance and distribution of these hydrologic features increases the probability that these subbasins will continue to function in a way that contributes to ecosystem resiliency and diversity over time.

The PNF lands within the *Big Chino Wash* subbasin play a significant role with respect to providing a high proportion of the riparian and seeps/springs features within the subbasin (54 and 83 percent respectively). The PNF lands within the *Hassayampa River* subbasin play a similar significant role with respect to providing a high proportion of the seeps/springs and discontinuous perennial stream miles within the subbasin (59 and 42 percent respectively).

The amount of precipitation occurring on PNF lands is higher than the PNF areal proportions within the *Aqua Fria River, Hassayampa River,* and *Santa Maria River* subbasins. This hydrologic condition contributes more water and potential for ecosystem resiliency by providing a source for surface flows, groundwater recharge, and maintenance of groundwater dependent seeps and springs.

The *Aqua Fria River*, *Hassayampa River*, and *Upper* and *Lower Verde River* subbasins show a possible loss of sustainability due to water quality departures within one or more stream reaches.

The *Santa Maria River*, and *Upper* and *Lower Verde River* subbasins show a possible loss of sustainability due to a departure in the number of aquatic-dependent species (fish, reptiles, amphibians, invertebrates) historically present versus currently present.

We have limited information on the conditions within the *Big Sandy River* and *Burro Creek* subbasins. We do know that the PNF occupies a very small proportion of these subbasins (1 and 4 percent respectively) suggesting that the PNF contribution to sustainability is minimal. The PNF contribution towards surface water yield and groundwater recharge is proportional to its area within these subbasins. Seeps and springs are over-represented on the PNF within the *Burro Creek* subbasin.

Table 6. Summary of watershed conditions by Subbasin

Subbasins (HUC 4) Watersheds (HUC 5)	Uplands	Riparian/ Wetland Areas			Springs/Seeps			Perennial Streams			Water Yield		Water Qual.	Aquatic Species
	Watershed Condition Integrity[1] Reduced? Soils | Veg	% Sub Basin[2] & ac on PNF	PNF Rep. in subbasin[3]	Redundancy on PNF[4]	No. in PNF by WS & % of Sub Basin[5]	PNF Rep. in Sub basin	Redundancy on PNF	Miles on PNF by WS & % Sub Basin[6]	PNF Rep. in subbasin	Redundancy on PNF	PNF% of WS & Sub Basin precip[7]	Water Yield Potential[8]	Miles Cat. 4 or 5 on PNF[9]	No. species no longer present/ No. Non-native spp.[10]
Agua Fria River		**18%**	**Prop.**	**Mod**	**44%**	**Over**	**High**	**16%**	**Prop**	**Mod**	**26%**		**19.7**	
Agua Fria R/L. Pleasant	No | No	46			18			0.39			9.6	High	*	0/2
Ash Ck / Sycamore Ck	Yes | No	930			82			7.68			90.0	Mod		2/6
Big Bug Ck/Agua Fria R.	No | No	7			39			0.88			32.1	High		0/0
Bishop Ck	Yes | No	93			7			0.38			12.4	Mod	*	0/2
Black Canyon Ck	No | No	349			54			0.38			72.0	High	19.7	0/2
Big Chino Wash		**54%**	**Over**	**Low**	**83%**	**Over**	**Low**	**5%**	**Under**	**Low**	**18%**		**--**	
Lower Big Chino Wash	Yes | No	223			17			0.45			42.1	Low		0/0
Lower Partridge Ck	Yes | No	0			0			0			0.5	Mod	*	0/0
Middle Big Chino Wash	Yes | Yes	0			0			0			15.2	Mod	*	0/0
Williamson Valley Wash	Yes | No	295			46			0.08			57.6	Low	*	0/2
Big Sandy River		**0%**	**N/A**	**N/A**	**0%**	**N/A**	**N/A**	**0%**	**N/A**	**N/A**	**1%**		**--**	
Muddy Ck	Yes | Yes	0			0			0			10.0	Low	*	0/0
Burro Creek		**0%**	**N/A**	**Low**	**6%**	**Over**	**Low**	**0%**	**None**	**N/A**	**5%**		**--**	
Boulder Ck	Yes | Yes	6			3			0			12.3	Mod	*	0/5
Upper Burro Ck	Yes | Yes	0			0			0			8.7	Mod	*	0/5
Hassayampa River		**11%**	**Prop.**	**Low**	**59%**	**Over**	**High**	**42%**	**Over**	**Low**	**21%**		**9.3**	
Middle Hassayampa R.	No | No	0			2			0			1.0	Mod	*	0/1
Upper Hassayampa R.	No | No	269			102			13.35			65.7	High	9.3	0/1
Santa Maria River		**7%**	**Under**	**Mod**	**40%**	**Over**	**High**	**3%**	**Under**	**Mod**	**19%**		**--**	
Kirkland Ck	No | No	28			25			0.89			19.4	Mod		0/2
Sycamore Ck	Yes | No	245			52			0.16			65.7	Mod	*	5/2
Verde River Upper		**22%**	**Prop.**	**Mod**	**33%**	**Over**	**Mod**	**20%**	**Prop**	**Mod**	**19%**		**18.4**	
Cherry Ck/Upper Verde	Yes | No	966			60			3.39			55.1	Mod	3.2	4/14
Granite Ck/Upper Verde	Yes | Yes	91			21			4.09			22.7	Mod	--	0/11
Grindstone Wash/UV	Yes | No	685			2			27.91			68.5	Low	15.2	2/11
Hell Canyon	Yes | No	84			2			0.54			38.3	Low	*	0/2
Sycamore Creek	Yes | No	245			6			0.84			6.6	High	*	0/5
Verde River Lower		**11%**	**Over**	**N/A**	**6%**	**Over**	**N/A**	**6%**	**Over**	**N/A**	**3%**		**15.5**	
Fossil Ck/Lower Verde	No | No	1,540			25			18.37			19.5	Mod	15.5	1/15

See footnotes on next page.

Table 6 footnotes:

[1] A reduction in watershed condition integrity is a level of impairment to biological and/or physical characteristics or processes as summarized in column 2 of Table 15 in the *Water Resources Report* (Jarnecke and others 2008). See also FSH 2521.05 and 2521.01 for explanations of watershed condition integrity.

[2] Data source for riparian acres, representativeness, and redundancy is Southwest Regional Gap Analysis Project (USGS 2004). The proportion of PNF riparian acres within the subbasin is shown on same row as the subbasin name (shaded row).

[3] The Representativeness of PNF riparian acreage was compared to the subbasin as a whole. Calculation: Acres of riparian/wetland vegetation types on PNF in 4th HUC divided by total acres of riparian/wetland vegetation types in 4th HUC. Underrepresented = <0.8, Proportional = 0.8 to 1.2, Overrepresented = >1.2

[4] The Redundancy of PNF riparian acreage was calculated as presence/absence within each subbasin and the distribution across WS within the subbasin. Ratings: High = hydrologic feature found in each WS and relatively well distributed among them. Mod = Riparian feature found in each WS but not well distributed. Low = Occurrences of riparian feature were not found in all WS within the subbasin.

[5] Number of seeps and springs on PNF are provided for each watershed. The proportion of PNF seeps and springs within the subbasin is shown on shaded row.

[6] Miles of PNF perennial streams are provided for each WS. The proportion of PNF perennial stream miles within the subbasin is shown on shaded row.

[7] The PNF proportions of average annual precipitation are taken from tables 3 and 4 (Jarnecke and others 2008).

[8] Water Yield = the total net amount of water produced on the PNF, including streamflow and groundwater recharge.

[9] Miles of streams classified as Categories 4 or 5 by the ADEQ. Category 4 = Impaired or threatened for at least one use but a TMDL (Total Maximum Daily Load) analysis is not required. Category 5 = Impaired or threatened for one or more designated uses by a pollutant and a TMDL needs to be developed or revised. * = No PNF streams assessed.

[10] Number of aquatic species that historically were present but are not currently found in watersheds on the PNF and the number of non-native aquatic species found within the watershed. Example: 5/15 = 5 species are no longer found/15 non-native spp present. 0/ND=no species extirpated/No data on non-natives.

Atmospheric Ecosystems

Particulate matter aerosols and sulfate and nitrate acidic deposition compounds serve as the primary measures of air quality, visibility and atmospheric deposition in the Southwest. Particulate matter affects human health and impairs visibility regardless of chemical species or emission sources. Acidic compounds that deposit on landscapes alter the chemistry of surface and ground waters, soils, vegetation, and cultural resources. Uncharacteristic chemical changes also affect aquatic and soil biota.

We evaluated air quality characteristics using national standards and thresholds to represent reference conditions and existing monitoring data to represent current conditions.

Air Quality Standards

Air quality standards across the nation are directed by the Clean Air Act (CAA). The CAA identifies the roles of Federal and State governments in maintaining healthy air quality and delegates responsibility for implementation and enforcement of CAA regulations to the states. Many states, including Arizona, augment the regulations of the CAA with additional rules and guidelines.

The CAA defines standards to protect human and environmental health. Those areas that meet these standards are defined as “attainment areas”; those that do not are referred to as “non-attainment areas”. The CAA directs the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment.

The CAA also specifies that the Forest Service and other federal land management agencies are responsible for protecting Class I federal lands from adverse impacts created by external sources of air pollution.

Forest Service responsibility to meet air quality regulations requires coordination with the EPA and other air regulatory agencies (state, county and tribal) including ADEQ. Coordination efforts involve managing and mitigating air pollution from Forest Service activities through adherence to state-specific regulations in addition to EPA standards.

The EPA has established NAAQS for six principal pollutants which are called "criteria" pollutants: Carbon Monoxide (CO), Lead (Pb), Nitrogen Dioxide (NO_2), Ozone (O_3), Particulate Matter ($PM_{2.5}$ and PM_{10}), and Sulfur Dioxide (SO_2). The standards are listed in table 7. Specific descriptions of these pollutants are provided in the *Air Resources Report* (Fitch 2008).

Each year EPA tracks the levels of these pollutants in the air and how much of each pollutant (or the pollutants that form them) is emitted from various pollution sources. Information about how the levels of pollutants have changed over time is posted on the EPA website by region, state, county and metropolitan area.

Areas of the country such as counties or municipalities that exceed the standards are placed in ‘non-attainment’ or ‘maintenance’ status. Areas that meet the standards are labeled as ‘attainment’ areas.

Table 7. National Ambient Air Quality Standards

Pollutant	Primary Standards	Averaging Times	Remarks
Carbon Monoxide	9 ppm (10 mg/m3)	8-hour	Not to be exceeded more than once per year
	35 ppm (40 mg/m3)	1-hour	Not to be exceeded more than once per year
Lead	1.5 µg/m3	Quarterly Avg.	--
Nitrogen Dioxide	0.053 ppm (100 µg/m3)	Annual (Arith. Mean)	--
Particulate Matter (PM_{10})	150 µg/m3	24-hour	Not to be exceeded more than once per year on average over 3 years
Particulate Matter ($PM_{2.5}$)	15.0 µg/m3	Annual (Arith. Mean)	The 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3
	35 µg/m3	24-hour	The 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3
Ozone	0.08 ppm	8-hour	The 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	--
	0.14 ppm	24-hour	Not to be exceeded more than once per year

Class I Visibility

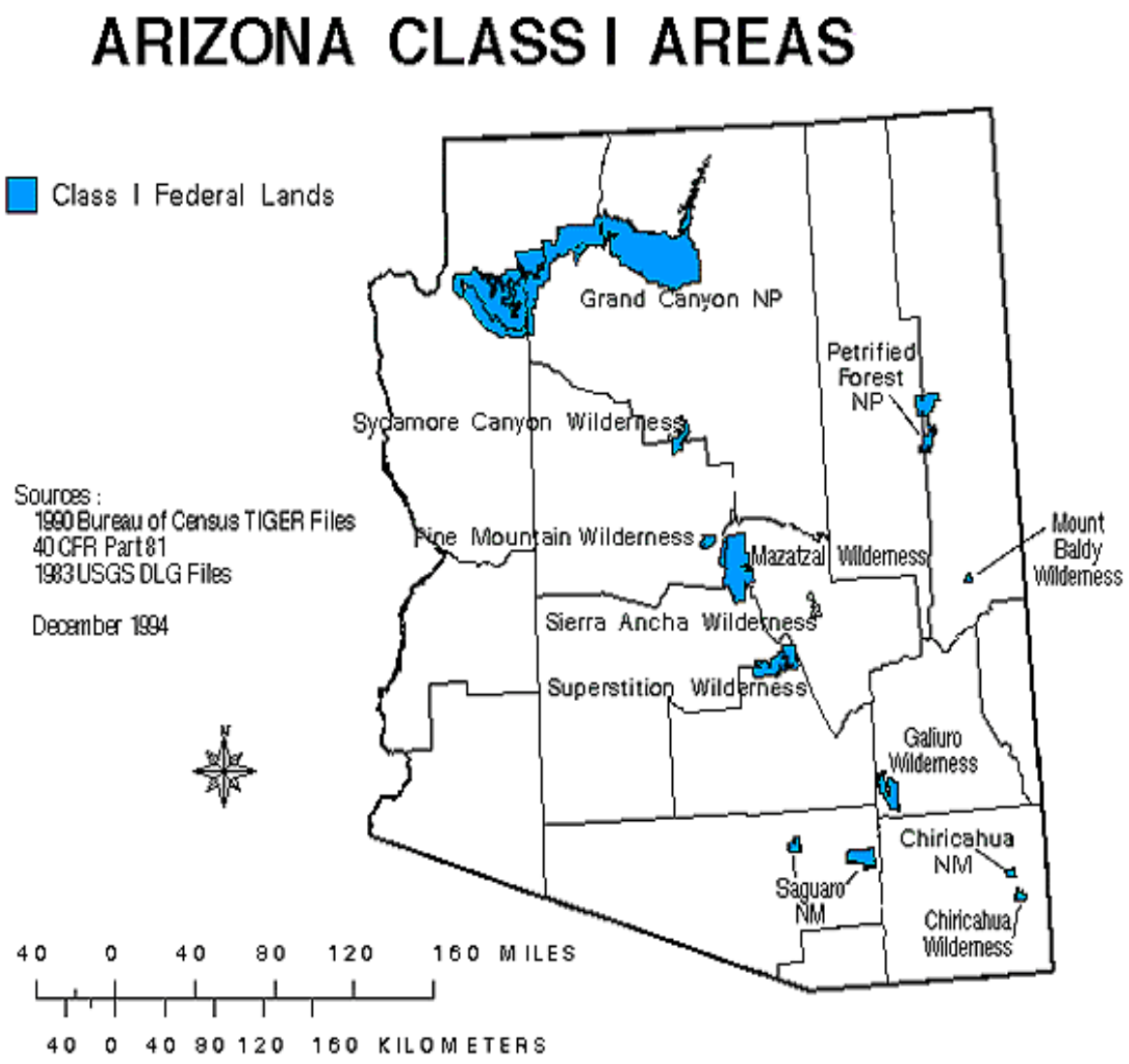
Class I federal lands include areas such as national parks, national wilderness areas, and national monuments. These areas are granted special protections against manmade air pollution under Section 169(a) of the CAA.

Particulate matter pollution is the major cause of reduced visibility (haze) in many parts of the United States. Haze is caused when sunlight encounters tiny pollution particles in the air, which reduce the clarity and color of what we see, particularly during humid conditions.

In 1999, EPA announced a major effort to improve air quality in national parks and wilderness areas. The Regional Haze Rule (40 CFR Part 51) calls for state and federal agencies to work together to improve visibility in all Class I areas by establishing emission reduction strategies. The national visibility goal is to return each Class I area to natural visibility conditions by 2064.

Arizona has 12 Class I areas as shown in figure 7. Two Class I areas within or adjacent to the PNF were assessed for this report: Sycamore Canyon Wilderness (47,757 ac) and Pine Mountain Wilderness (20,061 ac).

Figure 7. Federal lands designated as Class I Areas in Arizona

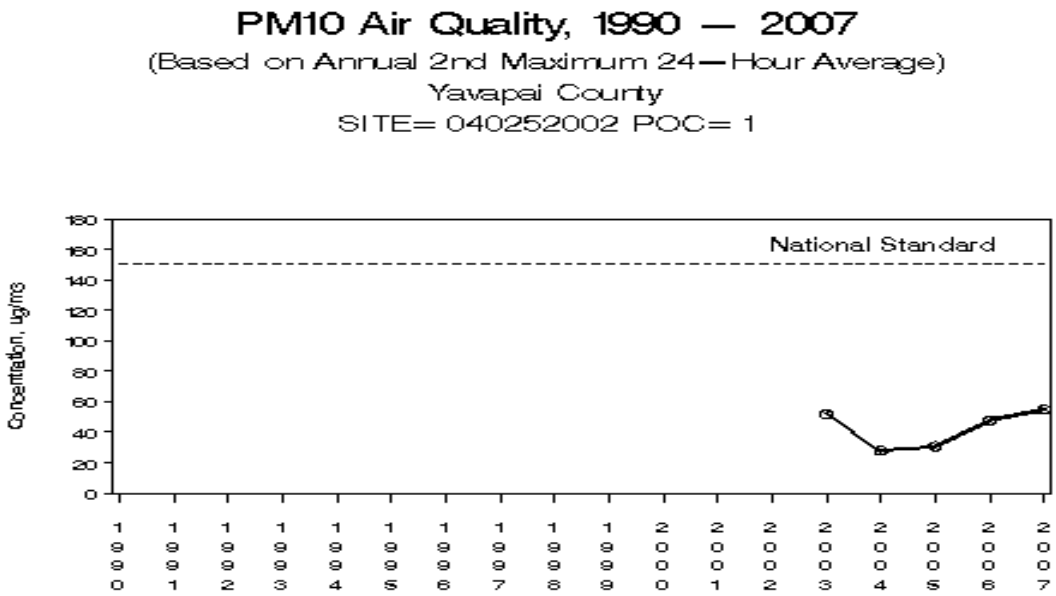


Reference and Current Conditions

NAAQS

The reference conditions for air quality within airsheds associated with the PNF are defined by the NAAQS (see table 7). As demonstrated by air quality monitoring data displayed in figure 8 below, and in published EPA monitoring reports (EPA 2007, EPA 2008), there are no 'non-attainment' or 'maintenance' areas for counties occupied by the PNF. Current conditions are below the national standards established for all six criteria pollutants. This means that there is no departure in air quality related to airsheds associated with the PNF.

Figure 8. Yavapai County Particulate Matter (PM10) Monitoring Results



Class I Visibility

Current and reference visibility conditions, as well as trends, are documented through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Table 8 displays the baseline visibility (reference and current conditions) and desired conditions (year 2064) for Pine Mountain and Sycamore Canyon.

Visibility is the distance it is possible to see under the prevailing atmospheric or weather conditions and is measured in deciviews (dv). A deciview is a measurement of haze that gauges the impact air pollutants have on visibility. Zero deciviews are an indicator of clear conditions with no visibility impairment

Table 8. Baseline conditions and projected 2064 natural conditions for Class I Areas associated with the Prescott National Forest

Class I Airsheds	Baseline Data		2064 as Measured by Deciview
	Measured by Deciview	Years	
Pine Mountain Wilderness	13.4 dv	2000-2004	6.68 dv
Sycamore Canyon Wilderness	15.2 dv	2001-2004	6.96 dv

Source: IMPROVE Data (CSU 2006)

Trends and Projected Conditions

Currently, there is a measurable difference between baseline visibility conditions (reference conditions) and the natural visibility conditions (2064 goal). If the Regional Haze Rule and State Implementation Plan (SIP) conditions are met, visibility conditions within Arizona Class I areas will steadily improve. By 2064, visibility on the 20% average worst days should improve to 6.68 dv for Pine Mountain Wilderness and to 6.96 dv for Sycamore Canyon Wilderness.

The pollutants that contribute to visibility impairment also contribute to atmospheric deposition and other ecosystem effects. The National Atmospheric Deposition Program (NADP) network contains nitrate and sulfate data for the Petrified Forest National Park site, located approximately 140 miles northeast of the PNF (NADP/NTN 2006). Nitrate and sulfate are acidic compounds that precipitate out of air contaminated with Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) aerosols. For 2005, the precipitation-weighted mean concentration was 1.15 mg/L for nitrate and 0.90 mg/L for sulfate (NADP/NTN 2006). To reach the milestone target for the year 2018, sulfur dioxide emissions would need to be reduced by 36% and nitrogen dioxide emissions by 16% in Arizona (Western Regional Air Partnership 2003).

In general, wet sulfate deposition is stabilizing in the west, but wet nitrate deposition is increasing. At some NADP sites, nitrate concentrations are increasing, but sulfate concentrations are more stable. If visibility conditions are improved, then atmospheric deposition levels should also decline (Fitch 2008).

Key Findings

Among the various PNF land management programs, fire management has the most notable activities (planned and unplanned ignitions) that involve air quality.
The level of fire activity on the PNF varies year to year but can be expressed as an average annual quantity. According to records on file at the PNF Fire Center, wildfire activity (unplanned ignitions) averaged 2,277 acres from 1980 through 2006. Prescribed fire activity (planned ignitions) averaged 6,641 acres from 1985 through 2006.

Air quality resulting from unplanned ignitions is monitored by ADEQ for potential human health impacts using data recorders located in several local communities including Prescott, Prescott Valley, Cottonwood, and Camp Verde. Health advisories are issued during an incident to affected communities and smoke-sensitive groups as necessary.

All federally managed lands and all state lands, parks, and forests are under jurisdiction of ADEQ in matters relating to air pollution from prescribed burning (planned ignitions). To minimize air pollution and smoke impacts, the PNF works with ADEQ Air Quality Division and follows Arizona's Forest and Range Management Burn rule (A.R.S. 18-15-1500). The PNF also employs emission reduction techniques to avert emission and smoke impacts to Class I areas in accordance with the ADEQ smoke management program.

Such mitigations ensure that air quality standards are maintained and visibility conditions are trending towards desired conditions. Under current management, airsheds that involve the PNF are functioning and will likely continue to function in a way that contributes to ecosystem resiliency and diversity over time. Adjustments in management are not needed.

The Southwest and Climate Change

The state of knowledge needed to address climate change at the planning unit (PNF) scale is still evolving. Most global climate models are not yet precise enough to apply to land management at the eco-regional or planning unit scale. This limits regional and forest-specific analyses of potential effects from climate change. Additionally, industrial society, during the past 200 years, has likely placed unprecedented pressures on ecosystems, increasing the unpredictable quality of future environmental change (Millar and others 2007). However, there are a number of efforts currently underway to step down projections of Global Circulation Models (GCMs) to sub-regional levels.

At a more regional scale, paleo-environmental studies of changing southwestern climate may provide at least a limited historical ecological context for ecosystem variability and climate change. Such studies can provide a limited range of knowledge about past climate change, strengthening or weakening El Niño or La Niña events, patterns of precipitation, drought severity, and changes in vegetation patterns (Swetnam and Betancourt 1997, Swetnam and others 1999). A recurrent trend in the literature suggests that predicting the future effects of climate change and subsequent challenges to land management in the Southwest remains inexact, and will no doubt require a combination of approaches.

Current Conditions and Future Trends

Currently there appears to be broad agreement among climate modelers that the Southwestern United States is experiencing a drying tend that will continue well into the later part of 21st century (Sprigg 2000). Regional drying and temperature trends have occurred twice during the twentieth century (1930s Dust Bowl and the 1950s Southwest Drought), and may have been even more severe during what is known as the Medieval Climate Anomaly, an interval of warm, dry conditions with regional variability from A.D. 900 to 1350 (Hughes and Diaz 1994). According to model scenarios, the slight warming trend observed in the last 100 years in the Southwest may continue into the next century, with the greatest warming to occur during winter. These climate models depict temperatures rising approximately 4º to 5º F (~2º to 3º C) by 2030 and between 7º and 12º F (4º and 7º C) by 2090 (Seager and others 2007). This trend would increase pressures on the region's already limited water supplies, as well as increase energy demand, alter fire regimes and ecosystems, create risks for human health, and affect agriculture (Swetnam and Betancourt 1997, Sprigg 2000).

Effects to Ecosystems

Climate may influence the distribution and abundance of plant and animal species through changes in resource availability, fecundity, and survivorship. Climate research suggests that new disturbance regimes under climate change are likely to result in significant perturbations to National Forest lands, with lasting ecological and socioeconomic impacts (Forest Service 2001, Forest Service 2005). The potential ecological implications of climate change trends in the Southwest indicate:

- More extreme disturbance events, wildfires, intense rain and wind events, etc. (Swetnam and others 1999).
- Greater vulnerability to invasive species, including insects, plants, fungi, and vertebrates.
- Long-term shifts in vegetation patterns (Westerling and others 2006, Millar and others 2007).

- Cold-tolerant vegetation moving upslope or disappearing in some areas. Migration of some tree species north of their existing range (Clark 1998).
- Climate models suggest the reduced precipitation will act as a limiting factor to overall forest productivity (Forest Service 2005).
- There are already observed shifts in the timing of snowmelt in the American West, which, along with increases in summer temperatures, have serious implications for the survival of fish species and may challenge efforts to reintroduce species into their historic range (Joyce and others 2007, Millar and others 2007).
- Increasing temperatures, water shortages, and changing ecological conditions will likely affect biodiversity, and put pressure on wildlife populations, distribution, viability, and migration patterns.

Effects to Water Yield and Use

Development in the Southwest has been primarily dependent upon technology to deliver this vital resource. In the Forest Service's Southwest Region, 13 municipal watersheds in New Mexico and 19 municipal watersheds in Arizona are located on National Forest administered lands. Additionally, the locations of most snow pack and upland reservoirs are on National Forests in the Southwest (Smith and others 2001, State of New Mexico 2005).

- Some studies predict water shortages and lack of storage capabilities to meet seasonally changing river flow, transfers of water from agriculture to urban uses, and other critical impacts (Barnett and others 2008).
- There has been a decreased amount of water used by agriculture, as Arizona's booming populations demand more water for municipal and other uses (Lenart 2007). This has been an on-going trend, and could affect future agricultural uses.
- High precipitation, occurring after extended drought, may increase the number and severity of floods; and accelerate rates of soil erosion. The timing and extent of increased rainfall will play a key role in determining the degree to which people and the environment are affected (Swetnam and Betancourt 1997, Swetnam and others 1999, Lenart 2007).

Key Findings

The state of knowledge needed to address climate change within the Southwest is still evolving. We lack detailed information at the planning unit scale (PNF) to assess what ecosystem characteristics have declined or are at risk or are otherwise inherently vulnerable to change due to the effects of past, current, or future climate change. We do not address this topic in any further detail in our assessment of ecosystem sustainability.

Chapter 3 – Species Diversity

Species diversity is used in conjunction with ecosystem diversity to help assess the current risks to overall ecological sustainability. This chapter summarizes the results from the process used to establish which species are associated with the ecosystems found on the PNF.

Several specialists' reports (Hartwig 2008, Phillips and Jarnecke 2008, Sillas 2008) summarize by taxa, information about individual species occurrence and habitat within the planning unit (PNF). These reports include lists of species associations with potential natural vegetation types (PNVTs), hydrologic units (watersheds), special features and threats. We have compiled the information from these reports and present it below.

Species Screening Process

A composite list of species was developed to understand and address species diversity on the PNF. According to national direction (Forest Service 2008), various databases were used to compile a list of all known species on the PNF (NatureServe 2007, AGFD 2007). A current listing of Threatened and Endangered (T&E) species was verified with U.S. Fish and Wildlife Service (Forest Service 2007). The non-T&E species were then checked for Global and State rankings from the NatureServe website (NatureServe 2007). As required by the 2008 Planning Rule, if Global (or taxonomic) ranking was G1-3[5] (T1-3) species were included on the list of Species of Concern (SOC). Species of Concern is defined as species for which the Responsible Official determines that management actions may be necessary to prevent listing under the Endangered Species Act (P.L. 93-205). If species do not meet this criteria and the state (or national) ranking was S1-2[6] (N1-2), they were included on the potential list of Species of Interest (SOI), which includes species that may have a significant local risk or high public interest. Some species were not ranked on the NatureServe site, and information from the State Heritage System, expert knowledge, and literature reviews were used to determine their relative status and inclusion on the SOI list. Other databases were evaluated to determine additional species to consider, including the USFWS Birds of Concern (USFWS 2002), the Arizona Partners in Flight Bird Conservation Plan (Latta and others 1999), Partners in Amphibian and Reptile Conservation website (PARC 2004), the Arizona Comprehensive Wildlife Conservation Strategy (AGFD 2006), and the Regional Forester's Sensitive Species list.

The PNF initially evaluated 388 vertebrate species; 36 fish, 10 amphibian, 22 reptile, 222 bird, and 98 mammal species. In addition, there were 303 plant species and 124 invertebrate species evaluated.

From the initial lists, species were dropped from further consideration based on three additional criteria: 1) the species is secure in the plan area; 2) PNF management activities do not affect the species; or, 3) there is so little information known about the species that no management direction can be made at this time. Table 9 lists the 118 species that warrant consideration in the PNF Plan Revision.

[5] Global or Taxonomic ranking: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable to extirpation or extinction.
[6] State or National ranking: 1 = critically imperiled; 2 = imperiled.

Table 9. Species Carried Forward for Consideration in Plan Revision

Scientific Name	Common Name	Status†
Mammals		
Antilocapra americana	Pronghorn antelope	SOI
Castor canadensis	Beaver	SOI
Corynorhinus townsendii pallescens	Pale townsend's big-eared bat	SOI
Cynomys gunnisoni	Gunnison's prairie dog	SOI
Euderma maculatum	Spotted bat	SOI
Idionycteris phyllotis	Allen's lappet-browed bat	SOI
Lasiurus blossevillii	Western red bat	SOI
Myotis occultus	Arizona myotis	SOI
Nyctinomops femorosaccus	Pocketed free-tailed bat	SOI
Nyctinomops macrotis	Big free-tailed bat	SOI
Reithrodontomys montanus	Plains harvest mouse	SOI
Birds		
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	SOC
Falco peregrinus anatum	American peregrine falcon	SOC
Accipiter gentiles	Northern goshawk	SOI
Ammodramus savannarum perpallidus	Western grasshopper sparrow	SOI
Athene cunicularia hypugaea	Western burrowing owl	SOI
Baeolophus ridgwayi	Juniper titmouse	SOI
Buteo regalis	Ferruginous hawk	SOI
Buteo swainsoni	Swainson's hawk	SOI
Buteogallus anthracinus	Common black hawk	SOI
Cardellina rubrifrons	Red-faced warbler	SOI
Colaptes chrysoides	Gilded flicker	SOI
Dendroica graciae	Grace's warbler	SOI
Empidonax occidentalis	Cordilleran flycatcher	SOI
Gymnorhinus cyanocephalus	Pinyon jay	SOI
Melanerpes uropygialis	Gila woodpecker	SOI
Micrathene whitneyi	Elf owl	SOI
Oporornis tolmiei	MacGillivray's warbler	SOI
Otus flammeolus	Flammulated owl	SOI
Picoides villosus	Hairy woodpecker	SOI
Pipilo aberti	Abert’s towhee	SOI
Piplio maculatus	Rufous-sided (spotted) towhee	SOI
Progne subis	Purple martin	SOI
Sitta pygmaea	Pygmy nuthatch	SOI
Toxostoma bendirei	Bendire’s thrasher	SOI
Toxostoma crissale	Crissal thrasher	SOI
Vermivora celata	Orange-crowned warbler	SOI
Vermivora luciae	Lucy's warbler	SOI
Vermivora virginiae	Virginia's warbler	SOI
Vireo bellii	Bell's vireo	SOI
Vireo vicinior	Gray vireo	SOI
Empidonax traillii extimus	Southwestern willow flycatcher	T&E
Haliaeetus leucocephalus	Bald eagle	T&E
Strix occidentalis lucida	Mexican spotted owl	T&E
Reptiles and Amphibians		
Bufo microscaphus	Arizona toad	SOI
Rana yavapaiensis	Lowland leopard frog	SOI
Thamnophis equips	Mexican gartersnake	SOI

Thamnophis rufipunctatus	Narrow-headed gartersnake	SOI
Fish		
Catostomus insignis	Sonora sucker	SOC
Gila robusta	Roundtail chub	SOC
Agosia chrysogaster	Longfin dace	SOI
Catostomus clarki	Desert sucker	SOI
Rhinichthys osculus	Speckled dace	SOI
Gila intermedia	Gila chub	T&E
Meda fulgida	Spikedace	T&E
Oncorhynchus gilae	Gila trout	T&E
Poeciliopsis occidentalis occidentalis	Gila topminnow	T&E
Ptychocheilus lucius	Colorado pikeminnow	T&E
Tiaroga cobitis	Loach minnow	T&E
Xyrauchen texanus	Razorback sucker	T&E
Invertebrates		
Cicindela oregona maricopa	Maricopa tiger beetle	SOC
Pyrgulopsis glandulosa	Verde rim springsnail	SOC
Pyrgulopsis sola	Brown springsnail	SOC
Plants		
Agastache rupestris	Thread-leaf giant-hyssop	SOC
Agave delamateri	Tonto basin agave	SOC
Agave phillipsiana	Phillip’s agave	SOC
Allium bigelovii	Bigelow's onion	SOC
Anulocaulis leiosolenus var. leiosolenus	Southwestern ringstem	SOC
Arenaria aberrans	Mt. Dellenbaugh sandwort	SOC
Astragalus calycosus var. scaposus	King's milk-vetch	SOC
Astragalus troglodytus	Creeping milk-vetch	SOC
Carex ultra	Cochise sedge	SOC
Cleome lutea var. jonesii	Jones' spider-flower	SOC
Cystopteris utahensis	Utah bladder fern	SOC
Draba asprella var. stelligera	Rough whitlow-grass	SOC
Ephedra fasciculata	Nevada Mormon-tea	SOC
Erigeron anchana	Mogollon fleabane	SOC
Erigeron saxatilis	Cliff Fleabane	SOC
Eriogonum corymbosum var. glutinosum	Wild buckwheat	SOC
Eriogonum ericifolium var. ericifolium	Heathleaf wild buckwheat	SOC
Eriogonum ericifolium var. pulchrum	Yavapai wild buckwheat	SOC
Eriogonum ripleyi	Ripley's wild-buckwheat	SOC
Hedeoma diffusa	Flagstaff pennyroyal	SOC
Heuchera eastwoodiae	Senator mine alum-root	SOC
Heuchera novomexicana	New Mexico alum-root	SOC
Lepidium montanum var. glabrum	Mountain pepperweed	SOC
Leptodactylon caespitosum (var. or sp. Nov.)	Matted prickly-phlox	SOC
Lesquerella arizonica	Arizona bladderpod	SOC
Lesquerella cinerea	Basin bladder-pod	SOC
Lesquerella pinetorum	White Mountain bladderpod	SOC
Lotus mearnsii var. mearnsii	Mearns lotus	SOC
Lupinus latifolius ssp. leucanthus	Broadleaf lupine	SOC
Mertensia macdougalii	Macdougal's bluebells	SOC
Pediomelum mephiticum	Skunk-top scurfpea	SOC
Penstemon nudiflorus	Flagstaff beardtongue	SOC
Penstemon oliganthus	Apache beardtongue	SOC
Perityle congesta	Compacted rock daisy	SOC

Phlox amabilis	Arizona phlox	SOC
Polygala rusbyi	Rusby's milkwort	SOC
Puccinellia parishii	Parish's alkali grass	SOC
Salvia dorrii ssp. mearnsii	Verde valley sage	SOC
Sporobolus interruptus	Black dropseed	SOC
Stachys rothrockii	Rothrock's hedge-nettle	SOC
Talinum validulum	Western flame-flower	SOC
Thelypodiopsis ambigua var. ambigua	Long Valley tumblemustard	SOC
Triteleia lemmoniae	Oak creek triteleia	SOC
Abronia nana	Dwarf sand verbena	SOI
Apodanthera undulate	Melon-loco	SOI
Cupressus arizonicus (pygmy)	Arizona cypress pygmy form	SOI
Desmodium metcalfei	Metcalfe's ticktrefoil	SOI
Echinocereus yavapaiensis	Yavapai claret-cup	SOI
Eriogonum arizonicum	Arizona wild-buckwheat	SOI
Eriogonum heermannii var. floccosum	Heermann's woolly wild-buckwheat	SOI
Fremontodendron californicum	California flannelbush	SOI
Margaranthus solanaceus	Netted globecherry	SOI
Nicotiana quadrivalvis var. bigelovii	Native tobacco	SOI
Phacelia rupestris	Rock scorpionweed	SOI
Thelypteris puberula	Showy maidenfern	SOI

† Status: Threatened and Endangered **(T&E)** – these are species that are federally listed as T&E under the Endangered Species Act (ESA); Species of Concern **(SOC)** – these are species for which management actions may be necessary to prevent listing under the ESA; Species of Interest **(SOI)** – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives. They may be species for which there are local concerns resulting from declines in habitat, population, and/or distribution, species that are of public interest.

Key Findings

Table 10 summarizes the number of species by taxonomic grouping and status of species carried forward for consideration in plan revision.

Table 10. Number of Species by Taxonomic Grouping and Status

Status	Mammals	Reptiles	Amphibians	Birds	Inverts	Plants	Fish	Total
T&E	--	--	--	3	--	--	7	10
SOC	--	--	--	2	3	43	2	50
SOI	11	2	2	28	--	12	3	58
Total	**11**	**2**	**2**	**33**	**3**	**55**	**12**	**118**

Species and Habitat Associations

Species cannot be managed apart from the habitats to which they are tied. An accepted premise in wildlife management is that habitat attributes can be used to predict presence or abundance of wildlife species (Cooperrider and others1986). Habitats are affected by management and other actions that occur within them, or in some cases, actions occurring far from those habitats. This premise is also evident in the Forest Service planning regulations which assume that by providing habitats and the critical habitat attributes, managers would provide for the wide array of species associated with the habitats and/or their attributes.

The following table summarizes the taxonomic groups carried forward. They are sorted by associated habitats/features and status.

Table 11. Summary of Associated Species by Status

Associated Habitats (PNVT/4th Level HUC/ Special Feature)	Taxonomic Group	Status
Desert Communities	7 Bird Species 2 Plant Species	7 SOI 2 SOC
PJ Grassland	3 Mammal Species 4 Bird Species 2 Plant Species	3 SOI 4 SOI 2 SOC
Semi-Desert Grassland	3 Mammal Species 4 Bird Species 2 Plant Species	3 SOI 4 SOI 1 SOC; 1 SOI
Dry Mixed Conifer	3 Plant Species	3 SOC
Ponderosa Pine	9 Bird Species 2 Plant Species	1 T&E; 8 SOI 2 SOC
Ponderosa Pine Evergreen Oak	9 Bird Species 4 Plant Species	1 T&E; 8 SOI 4 SOC
PJ Evergreen Shrub	8 Bird Species 1 Plant Species	8 SOI 1 SOI
PJ Woodland	8 Bird Species 7 Plant Species	8 SOI 4 SOC; 3 SOI
Aspen	8 Bird Species	1 T&E; 7 SOI
Riparian	2 Mammal Species 15 Bird Species 1 Invertebrate Species 10 Plant Species	2 SOI 3 T&E; 1 SOC; 11 SOI 1 SOC 8 SOC; 2 SOI
Aqua Fria River	2 Amphibian Species 1 Reptile Species 5 Fish Species 1 Invertebrate Species	2 SOI 1 SOI 2 T&E; 3 SOI 1 SOC
Big Chino Wash	2 Fish Species 2 Amphibian Species	1 T&E 3 SOI
Big Sandy	No Species are Associated	--
Burro Creek	3 Fish Species 2 Amphibian Species	1 SOC; 2 SOI 2 SOI
Hassayampa	2 Fish Species 2 Amphibian Species	2 SOI 2 SOI
Santa Maria River	3 Fish Species 2 Amphibian Species	1 SOC; 2 SOI 2 SOI
Verde River-upper	9 Fish Species 1 Amphibian species 2 Reptile Species	4 T&E; 3 SOC; 2 SOI 1 SOI 2 SOI
Verde River - lower	11 Fish Species 2 Amphibian Species 2 Reptile Species 1 Invertebrate Species	6 T&E; 2 SOC; 3 SOI 2 SOI 2 SOI 1 SOC
Tree Features	3 Mammal Species 9 Bird Species	3 SOI 9 SOI
Rock Features	2 Mammal Species 2 Bird Species	2 SOI 1 SOC; 1 SOI

Associated Habitats (PNVT/4th Level HUC/ Special Feature)	Taxonomic Group	Status
Building and Bridges	5 Mammal Species	5 SOI
Assoc. with Archeology sites	3 Plant Species	3 SOC
Basalt-Lava Flows, Cinders	6 Plant Species	4 SOC; 2 SOI
Bedrock/Rock Crevices	2 Plant Species	1 SOC; 1 SOI
Calcareous Soil/Alkaline Clay	6 Plant Species	5 SOC; 1 SOI
Canyons/Cliffs and/or Ledges	8 Plant Species	6 SOC; 2 SOI
Limestone/Dolomitic Limestone	10 Plant Species	9 SOC; 1 SOI
Granitic Soils/Igneous Rocks	2 Plant Species	2 SOI
Sandstone Rocks/Soils	3 Plant Species	3 SOC
Verde Formation Soils	5 Plant Species	5 SOC

Chapter 4 – Risks to Ecosystem and Species Diversity

This chapter describes the results of the risk assessments we undertook for ecosystems and species associated with the PNF.

What is risk?
Risk is often defined as the chance of something going wrong or as the danger that injury, damage, or loss will occur.

For the ecosystem and species risk assessments, we recognized risk as having two parts:

- the *likelihood* of a negative outcome
- the potential *severity* of a negative outcome

Throughout this document we have used the term *departure* to refer to a negative outcome. We identified departure for individual ecosystem characteristics and summarized them in chapter 2 as the difference between reference conditions and current conditions. We also assessed the amount of departure (e.g. severity) and the trend or direction of change that is estimated to occur in the future (e.g. likelihood). With information about the severity and likelihood of negative outcomes, we assessed existing and potential risks to ecosystems and species, and our ability to control such risks.

The questions we are attempting to answer by assessing risk are:

1. What is the level of risk to individual ecosystem characteristics and species?
2. What are the sources of the risk, or what are the threats that contribute to the risk?
3. Which threats do we, as an agency, have the ability to control or mitigate?

Ecosystem Risk Assessment Approach

We assessed the risks to terrestrial and aquatic ecosystems on the PNF following these basic steps:

1. Determine the level of risk to ecosystem characteristics (severity and likelihood).
2. For ecosystems with substantial risk, identify the threats contributing to the risk.
3. Screen threats to determine which ones are under agency authority to control or mitigate.
4. Screen threats to resolve which ones are reversible and which ones are responsive to management actions.
5. Record the results of screening as the primary threats to carry forward for consideration in plan revision.

Determining Levels of Risk to PNVTs
To determine levels of risk, we first gathered information on departure, trends, and ecological niche for individual ecosystem characteristics. Then we considered the severity of departures and probable trends across all ecosystem characteristics that occupy the same area of the landscape, or are otherwise dependent on, or affected by a given departure. For PNVTs, we analyzed soils and vegetation together. We analyzed riparian information as both a vegetation type and as a watershed characteristic.

We assigned each PNVT to one of six risk categories reflecting the possible combinations of severity and likelihood as shown in figure 9.

Figure 9. Combinations of severity and likelihood result in different categories of risk to ecosystem sustainability for PNVTs.

		Likelihood		
		No Trend **STABLE/STATIC**	Trend **TOWARDS** Reference Condition	Trend **AWAY** from Reference Condition
Severity	Substantial Departure from Reference Conditions	**1.** Legacy of past management OR stable deviation from ongoing activities. Evaluate system reversibility, threats.	**2.** Risk addressed. Continue current management and identify restoration opportunities.	**3.** Potential for high risk. Evaluate threats and reversibility.
	No Substantial Departure from Reference Conditions	**4.** Low risk. Continue current management.	**5.** No Deviation. No Risk.	**6.** Potential risk. Evaluate magnitude of future deviations, threats and reversibility.

PNVT Risk Assessment Results

The results of the risk assessment for PNVTs are briefly stated below and shown in table 12a.

Category 1 - The departure and trends for *Semi-Desert Grassland, Ponderosa Pine-Evergreen Oak Woodland, Ponderosa Pine Forest,* and *Mixed Conifer Forest with Frequent Fire* exhibit the residuals of past management or a stable deviation from ongoing activities. Need to evaluate system reversibility and threats.

Category 2 - *Mixed Conifer with Aspen* shows measurable departure in vegetation structure but the trends are stable and towards HRV – therefore risks are addressed. Can continue with current management but need to identify restoration opportunities and ensure protection of listed species.

Category 3 – *PJ Grassland* and *Colorado Plateau Grassland* have substantial departure in fire frequency and soils and trends away from HRV that pose a high risk. Need to evaluate threats and reversibility.

Category 4 – *Interior Chaparral* has low to no departure and stable trends posing low risk to sustainability. *Desert Communities* have low to moderate departure with stable trends. Can continue with current management but need to evaluate system reversibility and threats to soils. *PJ Evergreen Shrub* and *PJ Woodland* have low departures and positive trends for vegetation but high departures and negative trends for soils, suggesting potential risk. Can continue current management but need to evaluate the magnitude of future deviations and threats.

Category 5 - No PNVTs fell into this category of no deviation and moving towards HRV.

Category 6 – Madrean Encinal Woodland and Riparian Forests have low to moderate departures and unknown and variable trends, posing potential risk, especially to listed species. Need to evaluate the magnitude of future deviations, threats and reversibility.

Table 12a. Summary of PNVT conditions and assigned risk category

Potential Natural Vegetation Type (PNVT)	Proportion of Eco-section[1]: Off-PNF vs. On-PNF (%)	Vegetation Departure: Off-PNF vs. On-PNF (%)	PNF contrib. to sustain-ability Rating	PNF veg. departure & trend	PNF soil departure & trend	Number of Associated Species			PNVT Risk Category	Risk Assessment Outcome
						T&E	SOC	SOI		
Interior Chaparral	73/27	44/3	High	Trace: Stable	Low: Stable	0	0	0	4	Conditions and trends near HRV, therefore risk is low.
Pinyon-Juniper Evergreen Shrub	81/19	47/27	High	Low: Stable	Moderate: Away	0	0	9	4	Potential loss of sustainability exists.
Pinyon-Juniper Woodland	71/29	65/14	High	Low: Toward	High: Away	0	4	11	4	Potential loss of sustainability exists.
Pinyon-Juniper Grassland	76/24	49/30	High	Low: Away	High: Away	0	2	7	3	Potential loss of sustainability exists.
Semi-Desert Grassland	81/19	91/79	Moderate	High: Stable	High: Stable	0	1	8	1	Potential loss of sustainability exists.
Colorado Plateau Grassland	95/5	25/14	Moderate	Low: Unknown	High: Away	0	2	7	3	Potential loss of sustainability exists.
Ponderosa Pine-Evergreen Oak	75/25	83/83	Low	High; Stable	Low: Stable	1	4	8	1	Potential loss of sustainability exists.
Ponderosa Pine Forest	80/20	94/100	Low	High: Stable	Low: Stable	1	2	8	1	Potential loss of sustainability exists.
Mixed-Conifer Forest w/ Frequent Fire	80/20	99/100	Low	High: Stable	Trace: Stable	1	3	7	1	Potential loss of sustainability exists.
Mixed Conifer with Aspen	99/1	24/58	Low	Moderate: Toward	Trace: Stable	1	0	7	2	Trends are stable or toward reference conditions, therefore risk is low.
Desert Communities	99/1	68/14	High	Low: Stable	Moderate: Stable	0	2	7	4	Conditions and trends toward HRV, therefore risk is low.
Madrean Encinal Woodland	83/17	17/32	Low	Low: Away	Moderate: Stable	0	0	0	6	Potential loss of sustainability exists.
Riparian Forest	84/16	32/25	High	Low: Unknown	Moderate: Unknown	3	10	13	6	Potential loss of sustainability exists.

[1] Only the Tonto Transition Section (313c) is reported because it accounts for 92% of the PNF area, typifying the ecological niche of the PNF.

Assessment of Vegetation Departure by Ecological Subsection

Several PNVTs found on the PNF have a potential loss of sustainability due to the combination of substantial departure in one or more ecological conditions (vegetation, soils, or fire regime), and projected trends for the current ecological conditions that are stable or in a direction away from reference conditions (i.e. HRV).

For those PNVTs showing a substantial departure (≥ 34%) in vegetation conditions compared to HRV, assessing how the existing departure is distributed within the bounds of the PNF is useful for knowing where ecological change is needed most.

Table 12b displays for each PNVT the ecological subsections where the substantial departures in vegetation conditions occur within the bounds of the PNF. Several PNVTs *(P-J Evergreen Shrub, P-J Woodland, and Semi-Desert Grassland)* show that conditions in some areas of the forest are more departed than others.

Table 12b. Summary of PNVT Vegetation Departure by Ecological Subsection

PNVT Name	Departure from Historic Range of Variability (HRV) Conditions		
	Low (1-33%)	Moderate (34-66%)	High (67-100%)
Interior Chaparral	313Cc, 313Cd, M313Al		
P-J Evergreen Shrub	313Cc, M313Al	313Ca, 313Cd, M313Ak	
P-J Woodland	313Cd, 322Ax	M313Ak	
P-J Grassland		313Cb, 313Cc, 313Cd, 322Ax, M313Ak	
Semi-Desert Grassland		313Ca, 313Cb	313Cc
Colorado Plateau Grassland	313Cb, 313Cc, 313Cd, 322Ax		
Ponderosa Pine Evergreen Oak Woodland			313Cc, 313Cd
Ponderosa Pine Forest			313Cc, 313Cd, 322Ax
Mixed-Conifer with Frequent Fire			313Cc
Mixed Conifer Forest with Aspen		313Cc	
Desert Communities	313Cc		
Madrean Encinal Woodland	313Cc		

313Ca = Verde Plains Desert Grass Shrubland; 313Cb = Chino High Plains Grassland; 313Cc = Mazatzal Mtns. Interior Chaparral; and 313Cd = Mazatzal Mtns. Woodland. These are subsections of the Tonto Transition ecological section.
322Ax = Aquarius Mtns. Woodland subsection of the Mohave Desert ecological section.
M313 = is a subsection of the White Mountains-SF Peaks-Mogollon Rim ecological section.
See Map B-1 in Appendix B for the locations of the ecological subsections within the PNF.

PNVT Risk Assessment Key Findings

Interior Chaparral - No substantial departure from reference conditions exists for vegetation, soils and fire. Future trends are stable. Because current and projected ecological conditions are near HRV, there is a low probability of loss to sustainability.

Pinyon-Juniper Evergreen Shrub - *S*ubstantial departure from reference conditions occurs for soils. Future trend for soil conditions is away from reference conditions. Potential loss of sustainability exists.

Pinyon-Juniper Woodland - *S*ubstantial departure from reference conditions occurs for soils. Future trend for soil conditions is away from reference conditions. Potential loss of sustainability exists.

Pinyon-Juniper Grassland - *S*ubstantial departure from reference conditions occurs for soils and fire. Future trend for vegetation and soil conditions is away from reference conditions. Potential loss of sustainability exists.

Semi-Desert Grassland - *S*ubstantial departure from reference conditions occurs for vegetation, soils, and fire. Future trends for vegetation and soil conditions are stable, but remain distant from reference conditions. Potential loss of sustainability exists.

Colorado Plateau Grassland - *S*ubstantial departure from reference conditions occurs for soils and fire. Future trend is unknown for vegetation conditions and away for soil conditions. Potential loss of sustainability exists.

Ponderosa Pine-Evergreen Oak - *S*ubstantial departure from reference conditions occurs for vegetation and fire. Future trends for vegetation are stable, but remain distant from reference conditions. Potential loss of sustainability exists.

Ponderosa Pine Forest - *S*ubstantial departure from reference conditions occurs for vegetation and fire. Future trends for vegetation are stable, but remain distant from reference conditions. Potential loss of sustainability exists.

Mixed-Conifer Forest w/ Frequent Fire - *S*ubstantial departure from reference conditions occurs for vegetation and fire. Future trends for vegetation are stable, but remain distant from reference conditions. Potential loss of sustainability exists.

Mixed Conifer with Aspen - *S*ubstantial departure from reference conditions occurs for vegetation. Future trends for vegetation are toward reference conditions, therefore risks to sustainability are addressed and probability of loss is low.

Desert Communities - *S*ubstantial departure from reference conditions occurs for soils. Future trends for vegetation and soil conditions are stable. With current and projected ecological conditions near HRV, there is a low probability of loss to sustainability.

Madrean Encinal Woodland - *S*ubstantial departure from reference conditions occurs for soils and fire. Future trend for soil conditions is stable and away from reference conditions for vegetation. Potential loss of sustainability exists.

Riparian Forest - *S*ubstantial departure from reference conditions occurs for soils. Future trend for vegetation and soil conditions is unknown. Potential loss of sustainability exists.

Determining Levels of Risk to Watersheds

For the 5th HUC watersheds, we assessed the risks to sustainability by evaluating the departure and trends for individual ecosystem characteristics as reported in the *Water Resources Report* (Jarnecke and others 2008).

Several ecosystem characteristics that co-occur across the landscape were considered together. **Upland soil** and **vegetation conditions** were analyzed together because they indirectly affect watershed function in a number of ways depending on how they influence the routing, timing, and duration of overland water flows and infiltration.

Riparian areas, wetlands, seeps and springs, and **perennial streams** are all groundwater dependent features. Risks to these features were based on water quantity information and upland watershed conditions (soils and vegetation).

Risks to **water quantity** were based on stream presence or absence within the Prescott Active Management Area (AMA)[7], other known/pending large groundwater withdrawals, diversion of streamflow, urban growth, and low recharge potential.

Risks to **water quality** were based on ADEQ categories 4 or 5 (Impaired, Not-Attaining, or has TMDL). Water quality pollutants and impairment (heavy metals, turbidity, dissolved oxygen, temperature, and nutrients) may or may not be directly attributable to upland watershed condition (soils and vegetation). Categories 2 and 3 were not included because they represent 'insufficient' or 'inconclusive' sampling data from ADEQ.

For **aquatic species** (fish, reptiles, amphibians, and invertebrates), the 5th HUC watersheds were considered at risk if one or more non-native aquatic species is present on or off-PNF. For native species, the 5th HUC watersheds were considered at risk if native species historically occurred, but are no longer present.

Watershed Risk Assessment Results

Table 13 displays the hydrologic characteristics for each 5th HUC watershed that were found to be at risk.

At a glance, two of the subbasins (*Aqua Fria River and Upper Verde River*) have more watersheds with many hydrologic characteristics at risk compared to the other six subbasins.

The *Hassayampa River* and *Santa Maria River* subbasins, involve fewer watersheds, but these watersheds are in better shape, having few hydrologic characteristics at risk.

[7] The Prescott AMA is one of several Active Management Areas established within the state of Arizona to provide long-term management and conservation of their limited groundwater supplies. Under the direction of the Arizona Department of Water Quality (ADWR), the AMAs administer state laws, explore ways of augmenting water supplies to meet future needs, and routinely work to develop public policy in order to promote efficient use and an equitable allocation of available water supplies. The ADWR has a statutory responsibility to reach safe-yield within the Prescott AMA by 2025. Safe-yield involves the promotion of conservation and the development and utilization of renewable water sources.

Table 13. Summary of Hydrologic Characteristics "At Risk" on PNF Portions of 5th HUC Watersheds

Subbasins (HUC4) Watersheds (HUC5)	**Uplands** Soils	**Uplands** Veg	**Riparian/ Wetland**	**Springs/ Seeps**	**Perennial Streams**	**Water Quantity**	**Water Quality**	**Aquatic Species** Non-Native Species Present***	**Aquatic Species** Native Species No Longer Present
Agua Fria River									
Agua Fria R/L. Pleasant				√		√		No data	
Ash Ck / Sycamore Ck	√**		√	√	√	√		√	√
Big Bug Ck/Agua Fria R.			√	√	√	√		No data	
Bishop Ck	√		√					√	
Black Canyon Ck			√	√	√	√	√	√	
Big Chino Wash									
Lower Big Chino Wash	√		√	√	√	√		No data	
Lower Partridge Ck	√							No data	No data
Middle Big Chino Wash	√	√	√			√		No data	No data
Williamson Valley Wash	√		√	√	√	√		√	
Big Sandy River									
Muddy Ck	√	√	√			√		No data	No data
Burro Creek									
Boulder Ck	√	√	√					√	
Upper Burro Ck	√	√	√					√	
Hassayampa River									
Middle Hassayampa R.								No data	
Upper Hassayampa R.			√		√		√	√	
Santa Maria River									
Kirkland Ck								√	
Sycamore Ck	√							√	
Verde River Upper									
Cherry Ck/Upper Verde	√		√	√	√	√	√	√	√
Granite Ck/Upper Verde	√	√	√	√	√	√		√	
Grindstone Wash/UV	√		√	√	√	√	√	√	√
Hell Canyon	√		√	√	√	√		√	No data
Sycamore Creek	√		√	√	√	√		√	
Verde River Lower									
Fossil Ck/Lower Verde			√	√	√	√	√	√	√

**Check mark indicates characteristic at risk within 5th code watershed.
***Potential Risk to native species could be caused by Non-Native species.
See Map B-2 in Appendix B for the locations of the 5th HUC watersheds.

Watershed Risk Assessment Key Findings

Subbasin: Agua Fria River
Within this subbasin, the PNF portions of three watersheds show considerable risk to sustainability (Ash Creek/Sycamore Creek, Big Bug Creek/Aqua Fria Creek and Black Canyon Creek). The Ash Creek/Sycamore Creek watershed is at risk for six of the seven characteristics that were assessed. It is at risk for all features except water quality. The Big Bug Creek/Aqua Fria Creek watershed shows risks to all groundwater dependent features with no data available to assess risks to aquatic species. The Black Canyon Creek watershed shows the same risks to all groundwater dependent features, with additional risks to water quality and aquatic species.

Subbasin: Big Chino Wash
Within this subbasin, the PNF portions of two watersheds show considerable risk to sustainability (Lower Big Chino Wash and Williamson Valley Wash). The Lower Big Chino Wash watershed shows risks to upland soils, all groundwater dependent features, with no data available to assess risks to aquatic species. The Williamson Valley Wash watershed shows risks to upland soils, all groundwater dependent features, and aquatic species. All four of the watersheds show a risk to upland soils.

Subbasins: Big Sandy River and Burro Creek
PNF portions of watersheds within these subbasins are at risk for upland soils and vegetation and riparian/wetland areas. There are risks to aquatic species in Boulder Creek and Upper Burro Creek watersheds.

Subbasin: Hassayampa River
Within this subbasin, the PNF portions of both watersheds (Middle and Upper Hassayampa Rivers) have relatively few risks to their sustainability compared to other watersheds on the PNF. The Middle Hassayampa River watershed shows no risks, but with no data available for assessing aquatic species. The Upper Hassayampa River watershed shows risks to riparian/wetland areas, perennial streams, water quality and aquatic species.

Subbasin: Santa Maria River
Within this subbasin, the PNF portions of both watersheds (Kirkland Creek and Sycamore Creek) have relatively few risks to their sustainability compared to other watersheds on the PNF. The Kirkland Creek watershed shows a risk to aquatic species. The Sycamore Creek watershed shows risks to upland soils and aquatic species.

Subbasin: Upper Verde River
Within this subbasin, the PNF portions of all five watersheds show considerable risk to sustainability (Cherry Creek, Granite Creek, Grindstone Wash, Hell Canyon, and Sycamore Creek). The Cherry Creek and Grindstone Wash watersheds are at risk for all seven characteristics that were assessed. The Granite Creek watershed is at risk for six of seven characteristics (risks to all but water quality). The Sycamore Creek watershed shows the least amount of risk in this subbasin with risks to upland soils, all groundwater dependent features, and aquatic species. All five of the watersheds show a risk to upland soils.

Subbasin: Lower Verde River
Within this subbasin, the PNF portions of the Fossil Creek/Lower Verde watershed show considerable risk to sustainability. It is at risk for all groundwater dependent features, water quality, and aquatic species.

Determining Levels of Risk to Subbasins

Risks to the 4th HUC subbasins were assessed because they exist at a scale large enough to help define the ecological niche of the PNF with respect to aquatic ecosystems and water resources. We recognize that the influence of PNF lands on subbasin conditions is somewhat limited because the PNF intersects only a small portion (1-22 percent of the area) of eight subbasins. Nonetheless, this scale of assessment provides additional context for understanding the previously identified risks occurring at the 5th HUC watershed scale.

We used alternatives to HRV (representativeness and redundancy) to assess risks to riparian/wetland areas, seeps & springs, and perennial streams within each subbasin according to the nine possible combinations shown in Figure 10. Features that fell into categories 1, 2, 3, 4, and 7 were considered to be at higher risk than categories 5, 6, 8, and 9. Features described by the former group of categories are shown as shaded below and in table 14, where the subbasins risks are summarized.

Figure 10. Combinations of representativeness and redundancy result in different categories of risk to ecosystem sustainability for watersheds.

		Representativeness Rating		
		Under-Represented (< 0.8)	Proportional (0.8 to 1.2)	Over-Represented (> 1.20)
Redundancy Rating	Low = hydrologic feature is not found to occur in each watershed within the subbasin	**1. Highest Risk**	**2. High Risk**	**3. Moderate Risk**
	Moderate = hydrologic feature is found in each watershed but is not evenly distributed between watersheds	**4. High Risk**	**5. Less Risk**	**6. Less Risk**
	High = hydrologic feature is found in each watershed and is evenly distributed between them	**7. Moderate Risk**	**8. Less Risk**	**9. Least Risk**

Risks to watershed condition integrity (upland soils and vegetation condition), water yield potential, and water quality conditions were also assessed, based on the conditions known to exist on the PNF portions of the subbasins.

Subbasin Risk Assessment Results

The results of the risk assessment for subbasins associated with the PNF are shown in table 14. The shaded blocks represent the features that were found to be at risk.

The table shows that every subbasin has at least one feature at risk. The *Big Chino Wash* subbasin has the highest number of features at risk (five of seven), with *Burro Creek, Hassayampa River,* and the *Santa Maria River* subbasins each showing four features at risk. The *Aqua Fria* and *Lower Verde River* show the fewest features at risk, while there is incomplete data available for the *Sandy River* subbasin.

The results at this scale are different than the risk assessment results captured at the 5th HUC watershed scale. The risks identified at the 5th HUC scale apply to the PNF portions of the individual watersheds. At the 4th HUC scale, we looked at conditions outside of the PNF for all of the groundwater dependent features (riparian/wetlands, seeps and springs, perennial streams, and water yield potential) and water quality. Aquatic species are associated with aquatic habitats (streams, rivers, etc.) with no regard for administrative boundaries. The watershed condition integrity assessment however, was limited to upland soils and vegetation conditions found on the PNF.

Subbasin Risk Assessment Key Findings

Subbasin: Agua Fria River
Water quality and associated species are at risk.

Subbasin: Big Chino Wash
Five of seven features within this subbasin show risks to sustainability (PNF upland soils, riparian/wetland areas, seeps & springs, perennial streams, and associated species). At the subbasin scale, the Big Chino Wash exhibits the most risk to sustainability.

Subbasin: Big Sandy River
A lack of data hindered the risk assessment for this subbasin. The PNF contributes only 1 percent to the subbasin area.

Subbasin: Burro Creek
Four of seven features within this subbasin show risks to sustainability (PNF upland soils and vegetation, riparian/wetland areas, seeps & springs, and associated species).

Subbasin: Hassayampa River
Four of seven features within this subbasin show risks to sustainability (riparian/wetland areas, perennial streams, water quality, and associated species).

Subbasin: Santa Maria River
Four of seven features within this subbasin show risks to sustainability (PNF upland soils, riparian/wetland areas, perennial streams, and associated species).

Subbasin: Upper Verde River
Three of seven features within this subbasin show risks to sustainability (PNF upland soils, water quality, and associated species).

Subbasin: Lower Verde River
Two of seven features within this subbasin show risks to sustainability (water quality, and associated species).

Table 14. Summary of watershed features at risk at the subbasin scale*

Subbasins (HUC 4) Watersheds (HUC 5)	PNF Watershed Condition Integrity[1] Reduced?	Riparian/ Wetland Areas (Acres)	Seeps & Springs (Occurrences)	Perennial Streams (Miles)	Water Yield Potential	Water Quality Miles of Impaired (Cat. 4&5) Streams	Number of Associated Species			Count of Subbasin Features at Risk
							T&E	SOC	SOI	
Agua Fria River Aqua Fria R/L. Pleasant Ash Ck/ Sycamore Ck Big Bug Ck/ Aqua Fria R. Bishop Ck Black Canyon Ck	Soils: No Veg: No	PNF Contribution: 18% Rep.: Proportional Redund.: Moderate	PNF Contribution: 44% Rep.: Over Redund.: High	PNF Contribution: 16% Rep.: Proportional Redund.: Moderate	High relative to subbasin area	Subbasin: 21.0 PNF: 19.7 3 of 5 streams assessed	2	1	6	2 of 7
Big Chino Wash Lower Big Chino Wash Lower Partridge Ck Middle Big Chino Wash Williamson Valley Wash	Soils: Yes Veg: No	PNF Contribution: 54% Rep.: Over Redund.: Low	PNF Contribution: 83% Rep.: Over Redund.: Low	PNF Contribution: 5% Rep.: Under Redund.: Low	Proportional to subbasin area	Subbasin: 0.0 PNF: 0.0 1 of 4 streams assessed	1	0	3	5 of 7
Big Sandy River Muddy Ck	Soils: Yes Veg: Yes	N/A	N/A	N/A	Proportional to subbasin area	No streams assessed	0	0	0	Incomplete data
Burro Creek Boulder Ck Upper Burro Ck	Soils: Yes Veg: Yes	PNF Contribution 0% Rep.: N/A Redund.: Low	PNF Contribution 6% Rep.: Over Redund.: Low	PNF Contribution 0% Rep.: N/A Redund.: N/A	Proportional to subbasin area	No streams assessed	0	1	4	4 of 7
Hassayampa River Middle Hassayampa R. Upper Hassayampa R.	Soils: No Veg: No	PNF Contribution 11% Rep.: Proportional Redund.: Low	PNF Contribution 59% Rep.: Over Redund.: High	PNF Contribution 42% Rep.: Over Redund.: Low	High relative to subbasin area	Subbasin: 24.3 PNF: 9.3 1 of 2 streams assessed	0	0	4	4 of 7
Santa Maria River Kirkland Ck Sycamore Ck	Soils: Yes Veg: No	PNF Contribution 7% Rep.: Under Redund.: Moderate	PNF Contribution 40% Rep.: Over Redund.: High	PNF Contribution 3% Rep.: Under Redund.: Moderate	High relative to subbasin area	Subbasin: 0.0 PNF: 0.0 1 of 2 streams assessed	0	1	4	4 of 7
Verde River – Upper Cherry Ck/ U Verde Granite Ck/ U Verde Grindstone Wash/ U Verde Hell Canyon Sycamore Ck	Soils: Yes Veg: No	PNF Contribution 22% Rep.: Proportional Redund.: Moderate	PNF Contribution 33% Rep.: Over Redund.: Moderate	PNF Contribution 20% Rep.: Proportional Redund.: Moderate	Proportional to subbasin area	Subbasin: 48.1 PNF: 18.4 4 of 5 streams assessed	4	3	5	3 of 7
Verde River – Lower Fossil Ck/ Lower Verde	Soils: No Veg: No	PNF Contribution 11% Rep.: Over Redund.: N/A	PNF Contribution 6% Rep.: Over Redund.: N/A	PNF Contribution 6% Rep.: Over Redund.: N/A	Proportional to subbasin area	Subbasin: 33.9 PNF: 15.5 1 of 1 streams assessed	6	3	7	2 of 7

*Areas shaded in gray, were found to be at risk.
N/A = no assessment conducted due to a lack of appropriate data.

Threats to Ecosystem Diversity

The first step in the risk assessment process was to determine the level of risk to terrestrial and aquatic ecosystems. The remaining steps (2-5) involve identifying the threats that contribute to the risk and then screening those threats to determine which ones the Forest Service has the ability to control, manage or mitigate.

1. Determine the level of risk to *ecosystem* characteristics.
2. For ecosystems with substantial risk, identify the threats contributing to the risk.
3. Screen threats to determine which ones are under agency authority to control or mitigate.
4. Screen threats to resolve which ones are reversible and which ones are responsive to management actions.
5. Record the results of the screening process (steps 3 and 4 above) as the primary threats to carry forward for consideration in plan revision.

Screening threats involved determining which threats could be effectively controlled, mitigated, or modified. Some threats are not under agency jurisdiction (e.g. development of private land); others may require changes outside the scope of a forest plan (e.g., activities specifically designated by legislation, such as locatable mineral claims). Additionally, sometimes portions or all of a given system or ecosystem characteristic may be altered so that recovery is not possible even if threats are controlled or reduced (e.g. loss of topsoil from historic juniper tree pushing and chaining). In addition, the response from reduction of the threat may be so slow that current departures will essentially be present for hundreds of years (e.g. extreme droughts or floods). All of these considerations represented screening factors which could remove threats from further consideration during plan revision.

We list in table 15 and 16, the primary threats to PNVTs and watersheds that can be mitigated, are potentially reversible, and are responsive to Forest Service management actions.

Threats to Species Diversity

All of the species listed in Chapter 3 are considered “at risk”. This is because the process for selecting which species to carry forward for consideration during plan revision, was built around screening factors to identify which species are in danger of probable damage or loss to existing populations or habitat. Therefore, a different process was used to assess threats to species, after threats to ecosystems were determined.

First we identified the species that were associated with PNVTs and watersheds (see Appendix A). We assumed that the threats to ecosystems applied to the associated species (see tables 15 and 16). Second, we determined additional direct threats to species that are linked to the ecosystem, e.g. competition between non-native and native species (see table 16)[8]. Third we recorded additional species threats not linked to ecosystems (see table 18).

For species not already associated with particular ecosystems (PNVTs and watersheds), we attempted to link them with a specific habitat feature critical to their survival (e.g. cavities and snags for bats). Then we determined direct threats to those habitat features (see table 17). Finally, we recorded additional species threats not linked to habitat features (see table 18).

[8] No additional direct threats to terrestrial species were identified.

Table 15. Primary Threats to PNVTs

PNVT	Primary Threats	Associated Species (common name)
Desert Communities	Current landscapes are experiencing more fire than historically from human caused ignitions. The intrusion of invasive grasses can alter the natural surface fuel continuity and facilitate an increase in the size, frequency, and intensity of fires.	▪ Bendire's thrasher ▪ Crissal thrasher ▪ Elf owl ▪ Gila woodpecker ▪ Gilded flicker ▪ Lucy's warbler ▪ Purple martin ▪ Nevada Mormon-tea ▪ White mountain bladderpod
Grasslands (P-J Grassland; Semi-Desert Grassland; Colorado Plateau Grassland)	Grasslands have been impacted by fire exclusion and introduced grazing animals over the last century. As a result, areas with high tree and shrub cover, and low herbaceous cover are now more abundant. These conditions can accelerate soil loss and decrease hydrologic function. The spread of non-native annual grasses increases fire extent potential and shifts the grass composition in favor of non-native annuals over native perennials.	All Grasslands ▪ Gunnison's prairie dog ▪ Plain's harvest mouse ▪ Pronghorn antelope ▪ Ferruginous hawk ▪ Swainson's hawk ▪ Western burrowing owl ▪ Western grasshopper sparrow PJ Grassland ▪ Dwarf sand verbena ▪ Creeping mild-vetch Semi-Desert Grassland ▪ Metcalfe's ticktrefoil ▪ Mountain pepperweed
Ponderosa Pine (Ponderosa Pine; Ponderosa Pine Evergreen Oak)	The lack of low-intensity frequent surface fires has created more even-aged stands with high tree density and less grass cover. Fire exclusion has also favored the regeneration of evergreen oak species over pine, with increases in oak cover and concurrent declines in grass cover. These current structure and composition conditions create the threat of intense wildfire resulting in vegetative type conversions (forest to shrubland). Dispersed and developed recreation activities, including authorized and unauthorized OHV use, also contribute to the departure from reference conditions, providing a vector for the spread of non-native plants.	All Ponderosa Pine ▪ Cordilleran flycatcher ▪ Flammulated owl ▪ Grace's warbler ▪ Hairy woodpecker ▪ Mexican spotted owl ▪ Northern goshawk ▪ Purple martin ▪ Pygmy nuthatch ▪ Red-faced warbler Ponderosa Pine Forest ▪ Yavapai wild buckwheat ▪ Arizona bladderpod Ponderosa Pine – Evergreen Oak ▪ Creeping milk-vetch ▪ Metcalfe's ticktrefoil ▪ White mountain bladderpod ▪ Black dropseed
Pinyon-Juniper (PJ Evergreen Shrub; PJ Woodland)	High proportions of evergreen shrubs and trees, relative to grasses and forbs in these systems, limit the rate at which organic matter is deposited on soil surfaces as ground cover and incorporated into the soil matrix. This condition favors increased erosion, loss of surface and soil organics, and a decrease in hydrologic function.	All Pinyon-Juniper ▪ Bendire's thrasher ▪ Crissal thrasher ▪ Grey vireo ▪ Juniper titmouse ▪ MacGillivray's warbler ▪ Pinyon jay ▪ Rufus-sided towhee ▪ Virginia's warbler Pinyon-Juniper Woodland

PNVT	Primary Threats	Associated Species (common name)
		▪ Creeping milk-vetch ▪ Arizona cypress – pygmy form ▪ Metcalfe's ticktrefoil ▪ Yavapai wild buckwheat ▪ Heermann's wooly wild buckwheat ▪ Arizona bladderpod ▪ White mountain bladderpod Pinyon-Juniper Evergreen Shrub ▪ California flannelbush
Mixed Conifer with Aspen	Current landscapes have experienced less fire than historically, shifting the vegetation composition to conifer-dominated stands with lesser amounts of aspen suckers and saplings, and an overall decline in aspen clone vigor. Dispersed recreation activities have also contributed to the departure by trampling and removing vegetative groundcover and providing a vector for the spread of non-native plants.	▪ Cordilleran flycatcher ▪ Hairy woodpecker ▪ McGillivray's warbler ▪ Mexican spotted owl ▪ Northern goshawk ▪ Orange-crowed warbler ▪ Purple martin ▪ Pygmy nuthatch
Mixed Conifer	Most areas have been impacted by fire exclusion over the last century. Today there is more vegetation having a closed-canopy, high tree density structure. There has been a shift from ponderosa pine to more shade tolerant species. These changes in structure and composition have reduced the fire frequency and facilitated an increase in the size and intensity of stand-replacing fires.	▪ Cordilleran flycatcher ▪ Hairy woodpecker ▪ McGillivray's warbler ▪ Mexican spotted owl ▪ Northern goshawk ▪ Orange-crowed warbler ▪ Purple martin ▪ Pygmy nuthatch ▪ White mountain bladderpod ▪ Macdougal's bluebells ▪ Black dropseed
Madrean Encinal Woodland	Current landscapes have experienced less fire than historically, favoring the regeneration of oak over pine, with increases in oak cover. Dispersed recreation, unauthorized OHV use, and unmanaged herbivory also contribute to the departure from reference conditions by reducing vegetative groundcover and accelerating soil loss.	No species carried forward for consideration in Plan revision are known to be associated with this PNVT.
Primary threats to Riparian Forest PNVT are discussed in Table 17 – Primary Threats to Habitat Features. Threats are applicable to all riparian and wetland system features.		

Table 16. Primary Threats to 5th HUC watersheds and Direct Threats to Species

5th Level HUC	Primary Threats to Watersheds	Associated Species (common name)	Direct Threats to Species
Aqua Fria River Subbasin			
Aqua Fria River – Lake Pleasant	Groundwater pumping and stream flow diversions (occurring off-PNF) for domestic, municipal, recreational, or agricultural use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow.	▪ Arizona toad	Nonnative species (bullfrog, crayfish) compete with native species for food and space and are predators.
Ash Creek & Sycamore Creek	Groundwater pumping and stream flow diversions (occurring off-PNF) for domestic, municipal, recreational, or agricultural use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Departed upland soil conditions occur in one or more PNVTs that are present within the Ash Creek and Sycamore Creek watersheds.	▪ Desert sucker ▪ Longfin dace ▪ Gila chub ▪ Speckled dace ▪ Spikedace ▪ Arizona toad ▪ Lowland leopard frog ▪ Mexican gartersnake ▪ Verde Rim springsnail	Nonnative species (western mosquitofish, fathead minnow, green sunfish, rainbow trout, bullfrog, crayfish) compete with native species for food and space and are predators.
Big Bug Creek	Groundwater pumping for domestic/municipal use (occurring off-PNF) results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow.	▪ Arizona toad ▪ Lowland leopard frog	No known nonnative species occur within this watershed.
Bishop Creek	Departed upland soil conditions occur in one or more PNVTs that are present within the Bishop Creek watershed.	▪ Desert sucker ▪ Longfin dace ▪ Gila chub ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (fathead minnow, green sunfish) compete with native species for food and space and are predators.
Black Canyon Creek	Groundwater pumping (occurring off-PNF) for domestic/municipal use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Metals contamination (copper & lead) from past/present mining activities occur on the PNF.	▪ Desert sucker ▪ Longfin dace ▪ Arizona toad	Nonnative species (fathead minnow, green sunfish) compete with native species for food and space and are predators.
Big Chino Wash Subbasin			
Lower Big Chino Wash	Groundwater pumping and stream flow diversions (occurring off-PNF) for domestic, municipal, or agricultural use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater	▪ Speckled dace ▪ Arizona toad ▪ Lowland leopard frog	No known nonnative species occur within this watershed.

5th Level HUC	Primary Threats to Watersheds	Associated Species (common name)	Direct Threats to Species
	dependent stream-flow. Departed upland soil conditions occur in one or more PNVTs that are present within the Lower Big Chino watershed.		
Lower Partridge Creek	Departed upland soil conditions occur in one or more PNVTs that are present within the Lower Partridge Creek watershed.	No species carried forward for consideration in Plan revision are known to be associated with this watershed.	No known nonnative species occur within this watershed.
Middle Big Chino Wash	Groundwater pumping (occurring off-PNF) for domestic use results in depletion and loss of groundwater-dependent ecosystems seeps, springs, and groundwater dependent stream-flow. Departed upland soil and vegetation conditions in one or more that are present within the Middle Big Chino Wash watershed.	▪ Arizona toad ▪ Lowland leopard frog	No known nonnative species occur within this watershed.
Williamson Valley Wash	Groundwater pumping (occurring off-PNF) for domestic use results in depletion and loss of groundwater-dependent ecosystems seeps, springs, and groundwater dependent stream-flow. Departed upland soil conditions occur in one or more PNVTs that are present within the Williamson Valley Wash watershed.	▪ Gila chub ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (western mosquitofish, fathead minnow) compete with native species for food and space and are predators.
Big Sandy Subbasin			
Muddy Creek	Departed upland soil and vegetation conditions occur in one or more PNVTs that are present within the Muddy Creek watershed.	No species carried forward for consideration in Plan revision are known to be associated with this watershed.	No known nonnative species occur within this watershed.
Burro Creek Subbasin			
Boulder Creek	Departed upland soil and vegetation conditions occur in one or more PNVTs that are present within the Boulder Creek watershed.	▪ Desert sucker ▪ Longfin dace ▪ Roundtail chub ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (fathead minnow, red shiner, green sunfish, yellow bullhead, common carp) compete with native species for food and space and are predators of native species.
Upper Burro Creek	Departed upland soil and vegetation conditions occur in one or more PNVTs that are present within the	▪ Desert sucker ▪ Longfin dace ▪ Roundtail chub	Nonnative species (fathead minnow, red shiner, green sunfish, yellow bullhead,

5th Level HUC	Primary Threats to Watersheds	Associated Species (common name)	Direct Threats to Species
	Upper Burro Creek watershed.	▪ Arizona toad ▪ Lowland leopard frog	common carp) compete with native species for food and space and are predators of native species.
Hassayampa River Subbasin			
Middle Hassayampa River	Groundwater pumping (occurring off-PNF) for domestic, municipal, mining, and agricultural use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow.	No species carried forward for consideration in Plan revision are known to be associated with this watershed.	No known nonnative species occur within this watershed.
Upper Hassayampa River	Groundwater pumping (occurring off-PNF) for domestic/agricultural use resulting in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Historic and present mining and dredging are directly impacting riparian resources and water quality.	▪ Desert sucker ▪ Longfin dace ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (green sunfish) compete with native species for food and space and are predators of native species.
Santa Maria River Subbasin			
Kirkland Creek	Heavy metal contamination form past/present mining activities.	▪ Desert sucker ▪ Longfin dace ▪ Roundtail chub ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (green sunfish, yellow bullhead) compete with native species for food and space and are predators of native species.
Sycamore Creek	Departed upland soil conditions occur in one or more PNVTs that are present within the Sycamore Creek watershed.	▪ Desert sucker ▪ Longfin dace ▪ Roundtail chub ▪ Arizona toad ▪ Lowland leopard frog	Nonnative species (green sunfish) compete with native species for food and space and are predators of native species.
Upper Verde River Subbasin			
Cherry Creek	Surface water diversions and groundwater pumping (occurring off-PNF) for domestic/municipal/mining and agricultural use results in depletion and loss of groundwater ecosystems, seeps, springs, and groundwater dependent stream-flow. Water quality is impaired (turbidity). Departed upland soil conditions occur in one or more PNVTs that are present within the Cherry Creek watershed.	▪ Colorado pikeminnow ▪ Desert sucker ▪ Loach minnow ▪ Longfin dace ▪ Razorback sucker ▪ Roundtail chub ▪ Sonora sucker ▪ Spikedace ▪ Speckled dace ▪ Arizona toad ▪ Mexican gartersnake ▪ Narrowheaded gartersnake	Nonnative species (western mosquitofish, fathead minnow, red shiner, bluegill, green sunfish, smallmouth bass, largemouth bass, channel catfish, flathead catfish, yellow bullhead, common carp, rainbow trout, bullfrog, crayfish) compete with native species for food and space and are predators of native species.
Granite Creek	Groundwater pumping (occurring off-PNF) for domestic, municipal, mining,	▪ Desert sucker ▪ Longfin dace	Nonnative species (western mosquitofish, fathead

5th Level HUC	Primary Threats to Watersheds	Associated Species (common name)	Direct Threats to Species
	or agricultural use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Water quality is impaired (DO, E. Coli, mercury). Departed upland soil and vegetation conditions occur in one or more PNVTs that are present within the Granite Creek watershed.	▪ Roundtail chub ▪ Sonora sucker ▪ Speckled dace ▪ Spikedace ▪ Arizona toad ▪ Mexican gartersnake	minnow, red shiner, green sunfish, smallmouth bass, channel catfish, flathead catfish, yellow bullhead, common carp, bullfrog, crayfish) compete with native species for food and space and are predators.
Grindstone Wash	Groundwater pumping (occurring off-PNF) for domestic/municipal use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, & groundwater dependent streamflow. Water quality is impaired (turbidity). Departed upland soil conditions occur in one or more PNVTs that are present within the Grindstone Wash watershed.	▪ Colorado pikeminnow ▪ Desert sucker ▪ Longfin dace ▪ Razorback sucker ▪ Roundtail chub ▪ Sonora sucker ▪ Spikedace ▪ Speckled dace ▪ Arizona toad ▪ Lowland leopard frog ▪ Mexican gartersnake ▪ Narrowheaded gartersnake	Nonnative species (western mosquitofish, fathead minnow, red shiner, green sunfish, smallmouth bass, channel catfish, flathead catfish, yellow bullhead, common carp, bullfrog, crayfish) compete with native species for food and space and are predators of native species.
Hell Canyon	Groundwater pumping (occurring off-PNF) for domestic/municipal use results in depletion and loss of groundwater-dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Departed upland soil conditions occur in one or more PNVTs that are present within the Hell Canyon watershed.	No species carried forward for consideration in Plan revision are known to be associated with this watershed.	No known nonnative species occur within this watershed.
Sycamore Creek	Departed upland soil conditions occur in one or more PNVTs that are present within the Cherry Creek watershed.	▪ Desert sucker ▪ Sonora sucker ▪ Arizona toad	Nonnative species (green sunfish, smallmouth bass, yellow bullhead, bullfrog, crayfish) compete with native species for food and space and are predators of native species.
Lower Verde River Subbasin			
Fossil Creek	Groundwater pumping and stream flow diversions (occurring off-PNF) for domestic or agricultural use results in depletion and loss of groundwater-	▪ Colorado pikeminnow ▪ Desert sucker ▪ Loach minnow	Nonnative species (western mosquitofish, fathead minnow, red shiner, bluegill, green sunfish, smallmouth

5th Level HUC	Primary Threats to Watersheds	Associated Species (common name)	Direct Threats to Species
	dependent ecosystems, seeps, springs, and groundwater dependent stream-flow. Water quality is impaired (turbidity).	▪ Longfin dace ▪ Gila trout ▪ Razorback sucker ▪ Roundtail chub ▪ Sonora sucker ▪ Spikedace ▪ Speckled dace ▪ Arizona toad ▪ Lowland leopard frog ▪ Mexican gartersnake ▪ Narrowheaded gartersnake ▪ Brown springsnail	bass, largemouth bass, channel catfish, flathead catfish, yellow bullhead, common carp, rainbow trout, brown trout, bullfrog, crayfish) compete with native species for food and space and are predators of native species.

Table 17. Primary Threats to Habitat Features

Habitat Features	Primary Threats	Associated Species (common name)
Riparian	Groundwater depletion and stream flow diversions (occurring off-PNF), roads, trails, facilities, non-native plant species and upland species encroachment, uncharacteristic fire in riparian and adjacent areas, mining and dredging, and unmanaged herbivory leads to loss or damage to riparian characteristics. Disturbance to soils in these areas due to unmanaged herbivory, dispersed camping, or construction activities can decrease plant numbers.	▪ Beaver ▪ Western red bat ▪ Bald eagle ▪ Bell's vireo ▪ Common black hawk ▪ Elf owl ▪ Gila woodpecker ▪ Lucy's warbler ▪ MacGillivray's warbler ▪ Mexican spotted owl ▪ Red-faced warbler ▪ Rufous-sided towhee ▪ Southwestern willow flycatcher ▪ Western yellow-billed cuckoo ▪ Maricopa tiger beetle ▪ Cordilleran flycatcher ▪ Orange-crowned warbler ▪ Abert's towhee ▪ Broadleaf lupine ▪ Cochise sedge ▪ Jones' spider-flower ▪ King's milkvetch ▪ Oak Creek triteleia ▪ Parish's alkali grass ▪ Rough whitlow-grass ▪ Showy maidenfern ▪ Thread-leaf giant-hyssop ▪ Utah bladder fern
Tree features (cavities, snags, leaves, bark, downed logs)	Fires can consume tree features directly resulting in the loss of nesting, breeding and roosting habitat. Smoke from fire can displace species and cause direct mortality. Trampling can cause mortality to individuals occupying leaf litter. Timber harvest activities may result in direct damage/loss of trees/snags.	▪ Arizona myotis ▪ Big free-tailed bat ▪ Western red bat ▪ Cordilleran flycatcher ▪ Flammulated owl ▪ Gila woodpecker ▪ Hairy woodpecker ▪ Juniper titmouse ▪ Lucy's warbler ▪ Mexican spotted owl ▪ Northern goshawk ▪ Purple martin ▪ Pygmy-nuthatch ▪ Red-faced warbler
Rock features (caves, cliffs, ledges canyons,)	Activities including recreational rock climbing, caving, mining, construction and vandalism can disturb or damage habitat. Removal of surface rock causes direct mortality and damages habitat. Alterations of the rock surfaces such as removal of rock through excavation or	▪ Allen's lappet-browed bat ▪ Spotted bat ▪ American peregrine falcon ▪ Purple martin ▪ Cliff fleabane ▪ Mogollon fleabane ▪ New Mexico alum-root ▪ Rock scorpionweed ▪ Senator Mine alum-root

Habitat Features	Primary Threats	Associated Species (common name)
	rock climbing can alter the habitat enough to prevent plant establishment.	▪ Showy maidenfern ▪ Utah bladder fern
Buildings and bridges	Chemical and pesticide use may poison species or prey. Activities including maintenance, construction, and demolition, or vandalism can damage or destroy features.	▪ Arizona myotis ▪ Big free-tailed bat ▪ Pale Townsend's big-eared bat ▪ Pocketed free-tailed bat ▪ Western red bat
Archeological sites	Trampling by unauthorized OHV use especially upon small, regenerating plants, can decrease plant numbers.	▪ Phillip's agave ▪ Tonto basin agave ▪ Verde Valley sage
Basalt-lava flows, cinders	Large scale excavation, such as mining can cause plant removal on basalt-lava flows and cinders.	▪ Apache beardtongue ▪ Basin bladder-pod ▪ Flagstaff beardtongue ▪ Netted globecherry ▪ Wild buckwheat ▪ Yavapai claret-cup
Bedrock/rock crevices	Trampling by unauthorized OHV use especially upon small, regenerating plants, can decrease plant numbers.	▪ Arizona wild-buckwheat ▪ Bigelow's onion
Calcareous soils, alkaline clays	Invasive species can out-compete slower growing sensitive plants by taking up growing space, moisture, and nutrients and choking out native species.	▪ King's milkvetch ▪ Long Valley tumblemustard ▪ Parish's alcali grass ▪ Showy maidenfern ▪ Skunk-top scurfpea ▪ Southwestern ringstem
Limestone/Dolomitic limestone	Dolomitic limestone often forms bluffs from which visitors view the landscape. Disturbance to soils in these areas due to dispersed camping or other management activities can destroy plants.	▪ Arizona wild-buckwheat ▪ Basin bladder-pod ▪ Compacted rock daisy ▪ Flagstaff pennyroyal ▪ King's milkvetch ▪ Matted prickly-phlox ▪ Mt. Dellenbaugh sandwort ▪ Ripley's wild-buckwheat ▪ Skunk-top scurfpea ▪ Western flame-flower
Granitic soils, igneous rocks	Rock climbing that takes place on granitic rock outcrops can trample or remove these plants or can alter the habitat enough to prevent plant establishment.	▪ Melon-loco ▪ Yavapai claret-cup
Sandstone rocks/soils	Disturbance to soils in these areas due to dispersed camping or other management activities can decrease plant numbers.	▪ Flagstaff pennyroyal ▪ Rothrock's hedge-nettle ▪ Wild buckwheat
Verde Formation	Disturbance to soils in these areas due to unmanaged herbivory, dispersed camping or construction activities can decrease plant numbers.	▪ Heathleaf wild buckwheat ▪ Mearns lotus ▪ Ripley's wild-buckwheat ▪ Rusby's milkwort ▪ Verde Valley sage
Undeveloped grassland-prairie	Fragmentation/degradation from development and/or fencing.	▪ Gunnison prairie dog ▪ Pronghorn antelope

Table 18. Additional Threats to Species

Species that occur or are likely to occur on the PNF (common name)	Additional Threats not Associated to Habitat or Feature
▪ Pale townsend's big-eared bat ▪ Spotted bat ▪ Allen's lappet-browed bat ▪ Arizona myotis ▪ American peregrine falcon ▪ Bald eagle ▪ Ferruginous hawk ▪ Swainson's hawk	Human presence can disrupt species during sensitive life stages (breeding season – birds and bats; hibernation - bats).
▪ Abert's towhee ▪ Grace's warbler ▪ Grey vireo ▪ Lucy's warbler ▪ Rufus-sided towhee ▪ Southwest willow flycatcher ▪ Virginia's warbler	Nest parasitism from brown-headed cowbirds, when present, reduces survival of the host species' young.
▪ Gunnison prairie dog (currently not known to occur on the PNF)	Mortality of species from indiscriminate shooting.
▪ Virginia's warbler	Prescribed fire during breeding season can cause direct mortality.

Primary Threats Key Findings

Summary of the primary threats to ecosystem and species sustainability on the PNF:

Terrestrial Ecosystems - The primary threats to sustainability include fire exclusion activities during the last century in fire-dependent vegetation types; the establishment and spread of invasive plant species; unmanaged herbivory; and dispersed and developed recreation activities, including authorized and unauthorized OHV use.

Aquatic Ecosystems - The primary threats to sustainability include ground and surface water withdrawals and diversions (occurring off-PNF); departed upland watershed conditions (soils, vegetation, and fire regime); degraded water quality including heavy metals contamination; and nonnative species competition and predation.

Species - The primary threats to sustainability include the threats listed above in addition to: direct damage to or loss of individual habitat features; human presence, disturbance, or harassment during species critical life stages (e.g. breeding, hibernation); nest parasitism from brown-headed cowbirds; and other direct mortality from indiscriminate poisoning or shooting.

The primary threats to ecosystems and species identified for the PNF will be carried forward for further consideration during plan revision. Elements of the existing land and resource management plan will be examined to identify where changes in policy are needed to mitigate or control these threats.

Chapter 5 – Ecological Sustainability Summary

Previously, in this document, we summarized conditions and trends of terrestrial and aquatic ecosystem components. We assessed the difference between reference and current conditions and called it departure. Additionally, we estimated future changes in conditions (trends) by projecting current conditions through time assuming current levels of management.

Using the departure and trend information we estimated the risks to ecosystem sustainability. Species at risk were identified and linked to the various ecosystems or habitat features found on the PNF. Finally, we identified the threats (or sources of risk) to these ecosystems and species.

The purpose of this chapter is to summarize the contributions that the PNF offers to ecosystem sustainability based on overall ecosystem conditions, estimated future trends, and associated risks.

The following paragraphs summarize the contributions to sustainability provided by ecosystems occurring on the PNF. Terrestrial ecosystems (PNVTs) are listed first, followed by aquatic ecosystems (subbasins). Each summary includes a description of the role of the PNF within the larger ecological unit, a portrayal of species diversity, and a summary of the estimated ecosystem departure, trends, and changes in ecological conditions necessary to improve ecosystem sustainability.

PNVT: Interior Chaparral
Interior Chaparral accounts for 25% of the planning unit and represents the second most abundant PNVT on the PNF. On-PNF vegetation conditions are considerably less departed than off-PNF (3% versus 44%). The PNF plays a major role in contributing to the sustainability of this PNVT in the central highlands of Arizona.

Species Diversity: This PNVT is not associated with any species that warrant consideration during the PNF Plan Revision.

Interior Chaparral on the PNF shows low levels of departure in vegetation, soils, and fire regime conditions. Future trends for vegetation and soils are projected to be stable allowing this PNVT to maintain its historic range of ecological conditions. This PNVT will likely continue to function in a way that contributes to ecosystem resiliency and diversity over time. No changes in ecological conditions are needed to improve the sustainability of this ecosystem.

PNVT: Pinyon-Juniper Evergreen Shrub
Pinyon-Juniper Evergreen Shrub accounts for 37% of the planning unit and represents the most abundant PNVT on the PNF. On-PNF vegetation conditions are less departed than off-PNF (27% versus 47%). The PNF plays a major role in contributing to the sustainability of this PNVT in the central highlands of Arizona.

Species Diversity: This PNVT provides habitat for 8 SOI bird species and 1 SOI plant species.

P-J Shrublands on the PNF show a low level of departure in vegetation, and a moderate level of departure in soil conditions. Future trends for vegetation are movement toward reference conditions and stabilization near HRV. Soil conditions are estimated to slowly trend away based on the high proportion of impaired and unsatisfactory soils present. To enhance the sustainability of this ecosystem, there is a need to improve soil conditions with respect to surface organic matter and soil loss.

PNVT: Pinyon-Juniper Woodland
Pinyon-Juniper Woodland accounts for 3% of the planning unit. On-PNF vegetation conditions are considerably less departed than off-PNF (14% versus 65%). The PNF plays a major role in contributing to the sustainability of this PNVT in the central highlands of Arizona.

Species Diversity: This PNVT provides habitat for 8 SOI bird species; 4 SOC and 3 SOI plant species.

P-J Woodlands on the PNF exhibit low levels of departure in vegetation conditions and fire regime, and high levels of departure in soil conditions. Vegetation characteristics are expected to trend toward HRV under current management, while soil characteristics are expected to slowly trend away. To enhance the sustainability of this ecosystem, there is a need to improve soil conditions with respect to surface and soil organic matter availability and soil loss.

PNVT: Pinyon-Juniper Grassland
Pinyon-Juniper Grassland accounts for 11% of the planning unit. On-PNF vegetation conditions are less departed than off-PNF (30% versus 49%). The PNF plays a major role in contributing to the sustainability of this PNVT in the central highlands of Arizona.

Species Diversity: This PNVT provides habitat for 3 SOI mammal species, 4 SOI bird species, and 2 SOC plant species.

P-J Grasslands on the PNF display low levels of departure in vegetation conditions, and high levels of departure in soil conditions and fire regime. Soil and vegetation conditions are expected to trend away from reference conditions. To enhance the sustainability of this ecosystem, there is a need to improve soil conditions with respect to surface and soil organic matter, and soil loss.

PNVT: Semi-Desert Grassland
Semi-Desert Grassland accounts for 10% of the planning unit. Vegetation conditions are highly departed both off- and on-PNF with on-PNF conditions slightly better (79% versus 91%). The PNF plays a moderate role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 3 SOI mammal species, 4 SOI bird species, 1 SOC and 1 SOI plant species.

Semi-Desert Grasslands on the PNF show high levels of departure in vegetation and soil conditions, and fire regime. Future vegetation and soil conditions are expected to remain at a stable distance from reference conditions. To enhance the sustainability of this ecosystem, there is a need to improve vegetation conditions (composition and structure attributes) and soil conditions with respect to surface and soil organic matter, and soil loss.

PNVT: Colorado Plateau Grassland
Colorado Plateau Grassland accounts for 3% of the planning unit. On-PNF vegetation conditions are less departed than off-PNF (14% versus 25%). The PNF plays a moderate role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 3 SOI mammal species, 4 SOI bird species, and 2 SOC plant species.

Colorado Plateau Grasslands on the PNF display low levels of departure in vegetation conditions, and high levels of departure in soil conditions and fire regime. Soil conditions are expected to remain at a

stable distance from reference conditions due to the high proportion of impaired and unsatisfactory soils. Future trends in the vegetation conditions are not modeled, but are more likely away from reference conditions rather than towards. This conclusion is based on a shift in fire occurrence from frequent (1 in 25 years) under reference conditions to zero under current conditions (1950-2006). To enhance the sustainability of this ecosystem, there is a need to improve soil conditions with respect to surface and soil organic matter, and to limit soil loss.

PNVT: Ponderosa Pine-Evergreen Oak
Ponderosa Pine-Evergreen Oak accounts for 5% of the planning unit. On- and off-PNF vegetation conditions are similarly departed (83% versus 83%). The PNF plays a minor role in contributing to the sustainability of this PNVT in the central highlands of Arizona.

Species Diversity: This PNVT provides habitat for 1 T&E and 8 SOI bird species, and 4 SOC plant species.

Ponderosa Pine-Evergreen Oak Woodlands on the PNF show high levels of departure in vegetation conditions and fire regime, and low levels of departure in soil conditions. Vegetation and fire regime conditions are expected to remain stable but distant from HRV well into the future. Soil condition trends are expected to remain stable. To enhance the sustainability of this ecosystem, there is a need to improve vegetation composition and structure attributes sufficient to transition the vegetative states in a manner consistent with the historic fire regime.

PNVT: Ponderosa Pine Forest
Ponderosa Pine Forest accounts for 3% of the planning unit. On- and off-PNF vegetation conditions are similarly departed (100% versus 94%). The PNF plays a minor role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 1 T&E and 8 SOI bird species, and 2 SOC plant species.

Ponderosa Pine Forests on the PNF show high levels of departure in vegetation conditions and fire regime, and low levels of departure in soil conditions. Vegetation and fire regime conditions are expected to remain stable but distant from HRV well into the future. Soil condition trends are expected to remain stable. To enhance the sustainability of this ecosystem, there is a need to improve vegetation composition and structure attributes sufficient to transition the vegetative states in a manner consistent with the historic fire regime.

PNVT: Mixed-Conifer Forest w/ Frequent Fire
Mixed-Conifer Forest accounts for <1% of the planning unit. On- and off-PNF vegetation conditions are similarly departed (100% versus 99%). The PNF plays a minor role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 1 T&E and 7 SOI bird species; and 3 SOC plant species.

Mixed-Conifer Forests on the PNF show high levels of departure in vegetation conditions and fire regime, and low levels of departure in soil conditions. Vegetation and fire regime conditions are expected to remain stable but distant from HRV well into the future. Soil condition trends are expected to remain stable. To enhance the sustainability of this ecosystem, there is a need to improve vegetation composition and structure attributes sufficient to transition the vegetative states in a manner consistent with the historic fire regime.

PNVT: Mixed-Conifer Forest with Aspen
Mixed Conifer with Aspen accounts for <1% of the planning unit. On-PNF vegetation conditions are considerably more departed than off-PNF (58% versus 24%). The PNF plays a minor role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 1 T&E and 7 SOI bird species.

Mixed-Conifer Forests with Aspen currently display moderate levels of departure in vegetation conditions. Vegetation trends are expected to move toward HRV under current management, allowing this PNVT to return to sustainable conditions over time.

PNVT: Desert Communities
Desert Communities account for <1% of the planning unit. On-PNF vegetation conditions are considerably less departed than off-PNF (14% versus 68%). The PNF plays a major role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 7 SOI bird species and 2 SOC plant species.

Desert Communities on the PNF show a low level of departure in vegetation, and a moderate level of departure in soil conditions. Future trends for vegetation and soils are projected to be stable allowing this PNVT to function near its historic range of variability. To enhance the sustainability of this ecosystem, there is a need to improve soil conditions with respect to surface organic matter and soil loss characteristics.

PNVT: Madrean Encinal Woodland
Madrean Encinal Woodland accounts for <1% of the planning unit. On-PNF vegetation conditions are more departed than off-PNF (32% versus 17%). The PNF plays a minor role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT is not associated with any species that warrant consideration during the PNF Plan Revision.

Madrean Encinal Woodlands on the PNF display low levels of departure in vegetation, and moderate levels of departure in soil and fire regime conditions. Soil conditions are expected to remain stable with vegetation conditions trending away from reference conditions. To enhance the sustainability of this ecosystem, there is a need to improve vegetation composition and structure attributes sufficient to transition the vegetative states in a manner consistent with the historic fire regime.

PNVT: Riparian Forests
Riparian Forests account for only 1% of the planning unit, but are proportional to the surrounding landscape. On-PNF vegetation conditions are less departed than off-PNF (25% versus 32%). The PNF plays a major role in contributing to the sustainability of this PNVT.

Species Diversity: This PNVT provides habitat for 2 SOI mammal species; 3 T&E, 1 SOC and 11 SOI bird species; 1 SOC invertebrate species; 8 SOC and 2 SOI plant species.

Riparian Forests on the PNF display low levels of departure in vegetation and moderate levels of departure in soil conditions. Future trends in the vegetation and soil conditions are unknown, but movement away from HRV poses a high risk to sustainability because this PNVT supports the greatest number of species at risk. To enhance the sustainability of this ecosystem, there is a need to

improve soil conditions with respect to surface organic matter and soil loss characteristics, and to limit the establishment and spread of invasive plants.

Subbasin: Agua Fria River
The PNF occupies 19% of the subbasin area. The Aqua Fria subbasin includes five watersheds that overlap portions of the PNF. The PNF contributes 18%, 44%, and 16% of riparian areas, seeps and springs, and perennial stream mileage, respectively. The water yield potential of PNF lands is higher than off-PNF lands within the subbasin. Upland soil and vegetation conditions on the PNF portion contribute to favorable hydrologic functioning of the subbasin.

Species Diversity: This subbasin provides habitat for 2 T&E and 3 SOI fish species; 2 SOI amphibian species; 1 SOI reptile species and 1 SOC invertebrate species.

Seeps and springs, riparian area, and perennial stream mileage on the PNF are either over-represented or proportional to the subbasin as a whole. Redundancy is moderate for riparian areas and perennial streams and high for seeps and springs. These ratings indicate a higher likelihood that all states are present and that they are distributed across watersheds such that one disturbance event is not expected to eliminate an entire condition or hydrologic characteristic state.

Water quality in the Black Canyon Creek watershed is currently assessed as impaired (19.7 stream miles on-PNF), but should improve through on-going remediation efforts.

The PNF plays a key role in contributing to the ecological sustainability of this subbasin. To enhance ecological sustainability, there is a need to improve water quality and to limit the occurrence of non-native aquatic species.

Subbasin: Big Chino Wash
The PNF occupies 16 percent of the subbasin area. The Big Chino Wash subbasin includes four watersheds that overlap portions of the PNF. The PNF contributes 54% of riparian areas, 83% of seeps and springs, but only 5% of perennial stream mileage found in the subbasin. The water yield potential of PNF lands is proportional to off-PNF lands within the subbasin. Upland soil conditions on the PNF portion are departed from HRV creating potential risk to hydrologic functions. In addition, this subbasin has more direct use and demand for water through both surface and groundwater withdrawals.

Species Diversity: This subbasin provides habitat for 1 T&E fish species; and 3 SOI amphibian species.

The PNF is over-represented for riparian acres and the amount of seeps and springs/sq. mile. However, it is under-represented for perennial stream mileage when compared to the subbasin as a whole. This indicates that there is a higher risk of not having all the variation in conditions for perennial streams on the PNF portion of the subbasin. Whether the lack of representation of perennial streams within the subbasin is due to PNF management activities, physical limitations of the PNF portion of the subbasin, or influences not under direct control of the PNF, such as groundwater withdrawals, is unknown. More information is needed to determine whether the low representativeness is a function of forest management or is caused by anthropogenic, biological, or environmental factors.

Redundancy is low for all three hydrological characteristics measured in the subbasin. The low rating was due to the presence of high contrast in contribution from one watershed to another and lack of representation in two of four watersheds found within the subbasin.

The PNF plays a key role in contributing to the ecological sustainability of this subbasin. To enhance ecological sustainability, there is a need to improve departed upland soil conditions and provide protection to existing surface water yield and ground water recharge potentials.

Subbasin: Big Sandy River
The PNF occupies only 1 percent of the subbasin area, within one watershed – Muddy Creek. No perennial streams, seeps and springs, or riparian acreage are reported within the PNF portion of the watershed. Only 10 riparian acres, 138 seeps and springs, and 86 miles of perennial stream are found within the entire subbasin. The water yield potential of PNF lands is proportional to off-PNF lands within the subbasin. Upland soil and vegetation conditions on the PNF portion are departed from HRV creating potential risk to hydrologic functions.

Species Diversity: This subbasin is not associated with any species that warrant consideration during the PNF Plan Revision.

No estimate of representativeness was made for riparian acreage, seeps and springs, or perennial streams since none exist in the PNF portion of the Muddy Creek watershed. Redundancy cannot be calculated since only one watershed is present on the PNF. No streams have been assessed for water quality.

The PNF plays a very limited role in contributing to the ecological sustainability of this subbasin.

Subbasin: Burro Creek
The PNF occupies only 4 percent of the subbasin area. The Burro Creek subbasin includes two watersheds that overlap portions of the PNF. The PNF contributes 0%, 6%, and 0% of riparian acres, seeps and springs, and perennial stream mileage, respectively. The water yield potential of PNF lands is proportional to off-PNF lands within the subbasin. Upland soil and vegetation conditions on the PNF portion are departed from HRV creating potential risk to hydrologic functions.

Species Diversity: This subbasin provides habitat for 1 SOC and 2 SOI fish species; and 2 SOI amphibian species.

The PNF is over-represented for the amount of seeps and springs/sq. mi compared to the subbasin as a whole. With no perennial streams or riparian acreage reported in PNF portions of the watersheds that intersect with the PNF, representativeness could not be estimated. Due to the lack of perennial stream miles present with the PNF portion of the subbasin, redundancy was not estimated. Seeps and springs and riparian acreage are both present within one of two watersheds that overlap the PNF leading to a redundancy indicator of low for both characteristics. Generally a low redundancy indicates uneven distribution of various conditions of each hydrologic characteristic. In this case, that may be due to the small portion of the subbasin that intersects with the PNF, and variation in geomorphology within the subbasin. No streams have been assessed for water quality.

The PNF plays a very limited role in contributing to the ecological sustainability of this subbasin.

Subbasin: Hassayampa River
The PNF occupies 13 percent of the subbasin area. The Hassayampa River subbasin includes two watersheds that overlap portions of the PNF. The PNF contributes 11%, 59%, and 42% of riparian acres, seeps and springs, and perennial stream mileage, respectively. The water yield potential of PNF lands is higher than off-PNF lands within the subbasin. Upland soil and vegetation conditions on the PNF portion contribute to favorable hydrologic functioning of the subbasin.

Species Diversity: This subbasin provides habitat for 2 SOI fish species; and 2 SOI amphibian species.

The PNF is proportional or over-represented for the three hydrologic characteristics considered indicating that there is high likelihood of the full array of conditions associated with those features present on the PNF.

Redundancy varies for the hydrologic characteristics. Both riparian and perennial stream density have low redundancy; in both cases one of the two watersheds that overlap the PNF (Middle Hassayampa River) has neither riparian acreage nor perennial stream mileage within the portion found on the PNF. This is likely due to the fact that only three square miles of this watershed are found on the PNF. In addition, this area is located at low elevation where precipitation is low. There is high redundancy for seeps and springs since the density of that characteristic is approximately equal over the two watersheds that intersect the PNF.

Water quality in the upper reach of the Hassayampa River watershed is currently assessed as impaired (9.3 stream miles on-PNF), but should improve through on-going remediation efforts. In addition, historic and present mining and dredging are directly impacting riparian resources.

The PNF plays a key role in contributing to the ecological sustainability of this subbasin. To enhance ecological sustainability, there is a need to improve water quality and to limit the occurrence of non-native aquatic species.

Subbasin: Santa Maria River
The PNF occupies 16 percent of the subbasin area. The Santa Maria subbasin includes two watersheds that overlap portions of the PNF. The PNF contributes 7% of riparian acreage, 40% of seeps and springs, and only 3% of perennial stream mileage to the subbasin. The water yield potential of PNF lands is higher than off-PNF lands within the subbasin. Upland soil conditions on the PNF portion are departed from HRV creating potential risk to hydrologic functions.

Species Diversity: This subbasin provides habitat for 1 SOC and 2 SOI fish species; and 2 SOI amphibian species.

Seeps and springs are over-represented on the PNF compared to the subbasin as a whole. Perennial stream mileage and riparian acreage are under-represented. Redundancy for perennial stream mileage is moderate with stream mileage found in the PNF portion of each watershed but not evenly distributed.

The PNF plays a key role in contributing to the ecological sustainability of this subbasin. To enhance ecological sustainability, there is a need to improve departed upland soil conditions and to limit the occurrence of non-native aquatic species.

Subbasin: Upper Verde River
The PNF occupies 22 percent of the land area in the Upper Verde River subbasin, the largest PNF contribution of all 8 subbasins that overlap with the PNF. The Upper Verde subbasin includes five watersheds that overlap portions of the PNF. The PNF contributes 22% of riparian acreage, 33% of seeps and springs, and 20% of perennial stream mileage within the subbasin. The water yield potential of PNF lands is proportional to off-PNF lands within the subbasin. Upland soil conditions on the PNF portion are departed from HRV creating potential risk to hydrologic functions.

Species Diversity: This subbasin provides habitat for 4 T&E, 3 SOC and 2 SOI fish species; 1 SOI amphibian species; and 2 SOI reptile species.

The PNF riparian habitat and perennial stream mileage is proportional to that found in the subbasin as a whole. Seeps and springs are over-represented on the PNF compared to the subbasin. Redundancy is moderate for all three hydrologic characteristics evaluated. A moderate rating indicates that riparian areas, seeps and springs, and perennial stream mileage are found in all watersheds that overlap with the PNF; however the density per watershed is not evenly distributed across those watersheds. For example, 76% of perennial stream miles, 15% of riparian acreage, and 1% of seeps and springs are found in the Grindstone Wash watershed within the PNF. On the other hand, 9% of perennial stream mileage, 40% of riparian acreage and 51% of seeps and springs are found in the PNF portion of Cherry Creek watershed. These variations are likely due to differences in geomorphology between watersheds rather than management activities. Overall, these ratings indicate a higher likelihood that all states are present and that they are distributed across watersheds such that one disturbance event is not expected to eliminate an entire condition or hydrologic characteristic state.

Water quality in the Cherry Creek and Grindstone Wash watersheds are currently assessed as impaired (18.4 stream miles on-PNF) due to exceedances of turbidity which affect warm water aquatic life.

The PNF plays a key role in contributing to the ecological sustainability of this subbasin. To improve ecological sustainability, there is a need to mitigate the threats to this subbasin stemming from departed upland soil conditions, degraded water quality, and non-native aquatic species occurrence.

Subbasin: Lower Verde River
The PNF occupies only 3% of the Lower Verde River subbasin. Only one watershed overlaps the PNF and provides 11% of riparian acreage, 6% of seeps and springs and 6% of perennial stream mileage. The water yield potential of PNF lands is proportional to off-PNF lands within the subbasin. Upland soil and vegetation conditions on the PNF portion contribute to favorable hydrologic functioning of the subbasin.

Species Diversity: This subbasin provides habitat for 6 T&E, 2 SOC and 3 SOI fish species; 2 SOI amphibian species; 2 SOI reptile species; and 1 SOC invertebrate species.

The PNF portion of the subbasin is over-represented for all three hydrologic characteristics considered. Redundancy cannot be measured since only one watershed overlaps with the PNF.

Water quality in the Fossil Creek watershed is currently assessed as impaired (15.5 stream miles on-PNF), due to exceedances of turbidity which affect warm water aquatic life.

The PNF plays a very limited role in contributing to the ecological sustainability of this subbasin. To enhance ecological sustainability, there is a need to improve departed upland soil conditions and water quality, and to limit the occurrence of non-native aquatic species.

Conclusion

This report summarizes the results of our ecosystem and species diversity evaluations, and associated risk assessments. In chapter 5, we have briefly identified the contributions to ecological sustainability provided by the PNF and identified which ecosystem components show an ecological need for change.

The findings from this report, along with information from the PNF Economic and Social Sustainability Assessment, need for change to existing plan component evaluations, and public input will be summarized in a Comprehensive Evaluation Report (CER). The CER will integrate the *social*, *economic* and *ecological* components of sustainability and will identify portions of the existing PNF Land and Resource Management Plan (1986, as amended) that need revision.

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References are available upon request at the Supervisor's Office of the Prescott National Forest. 500 US Highway 89 North, Building 79, Prescott, AZ 86313.

Appendix A. Taxa Associated with Plan Revision

The following tables display the species carried forward on the PNF and their habitat associations.

TABLE A -1. Mammals Associated with PNVTs or Special Features

	PNVTs			Habitat Features			
	PJ Grassland	Semi-Desert Grassland	Colorado Plateau Grassland	Riparian	Tree features	Rock features	Buildings & Bridges
Allen's lappet-browed bat						X	
Arizona myotis					X		X
Beaver				X			
Big free-tailed bat					X		X
Gunnison's prairie dog	X	X	X				
Pale townsend's big-eared bat							X
Plains harvest mouse	X	X	X				
Pocketed free-tailed bat					X		X
Pronghorn antelope	X	X	X				
Spotted bat						X	
Western red bat				X	X		X

TABLE A-2. Birds Associated with PNVTs or Special Features

	PNVTs									Habitat Features			
	Desert Communities	PJ Grassland	Semi-Desert Grassland	Colorado Plateau Grassland	Ponderosa Pine	P. Pine Evergreen Oak	PJ Evergreen Shrub	PJ Woodland	Mixed Conifer with Aspen	Riparian	Tree Features	Rock Features	Buildings & Bridges
Abert's towhee										X			
American peregrine falcon												X	
Bald eagle										X			
Bell's vireo										X			
Bendire's thrasher	X						X	X					
Common black hawk										X	X		
Cordilleran flycatcher					X	X			X	X			
Crissal thrasher	X						X	X					
Elf owl	X									X			
Ferruginous hawk		X	X	X									
Flammulated owl					X	X					X		
Gila woodpecker	X									X	X		
Gilded flicker	X												
Grace's warbler					X	X							
Gray vireo							X	X					
Hairy woodpecker					X	X			X		X		
Juniper titmouse							X	X			X		
Lucy's warbler	X									X	X		
MacGillivray's warbler							X	X	X	X			
Mexican spotted owl					X	X			X	X	X		
Northern goshawk					X	X			X				
Orange-crowned warbler									X	X			
Pinyon jay							X	X					
Purple martin	X				X	X			X		X	X	
Pygmy nuthatch					X	X			X		X		
Red-faced warbler					X	X				X			
Rufous-sided (spotted) towhee							X	X		X			
Southwestern willow flycatcher										X			
Swainson's hawk		X	X	X									
Virginia's warbler							X	X					
Western burrowing owl		X	X	X									
Western grasshopper sparrow		X	X	X									
Western yellow-billed cuckoo										X			

TABLE A-3. Fish/Reptiles/Amphibians/Invertebrates Associated with 5th HUC Watersheds or Riparian Habitat Special Feature

	Aqua Fria River – Lake Pleasant	Ash Creek & Sycamore Creek	Big Bug Creek – Aqua Fria River	Bishop Creek	Black Canyon Creek	Lower Big Chino Wash	Lower Partridge Creek	Middle Big Chino Wash	Williamson Valley Wash	Muddy Creek	Boulder Creek	Upper Burro Creek	Middle Hassayampa River	Upper Hassayampa River	Kirkland Creek	Sycamore Creek	Cherry Creek – Upper Verde River	Granite Creek-Upper Verde River	Grindstone Wash – Upper Verde	Hell Canyon	Sycamore Creek - Verde River	Fossil Creek – Lower Verde River	Riparian **Habitat Feature**
Colorado pikeminnow																	H		H			H/I	
Desert sucker		C		C	C						C	C		C	C	C	C	C	C		C	C	
Loach minnow [1]																	H					H/I	
Longfin dace		C		C	C						C	C		C	C	C	C	C	C			C	
Gila chub		C		C					C														
Gila topminnow [1]		H		C																		H/I	
Gila trout [1]																						H	
Razorback sucker																	H		H			H/I	
Roundtail chub											C	C			C	C	C	C	C			C	
Sonora sucker																	C	C	C		C	C	
Spikedace																	H	C	C			H/I	
Speckled dace		C				C											C	C	C			C	
Arizona toad	C	C	C	C	C	C		C	C		C	C		C	C	C	C	C	C		C	C	
Lowland leopard frog		C	C	C		C		C	C		C	C		C	C	C						C	
Mexican gartersnake		H															C	C	C			C	
Narrowheaded gartersnake																	C		C			C	
Verde Rim springsnail [2]		C																					
Brown springsnail [3]																						C	
Maricopa tiger beetle																							C

Source: Arizona Statewide Freshwater Assessment (TNC 2007 - www.azconservation.org)
Legend: C = Current (are present now); H = Historic; I = Introduced
Footnote 1: These species do not presently occur in the planning area (PNF).
Footnote 2: The Verde Rim springsnail is only known from one spring complex in the headwaters of Sycamore Creek (Ash Creek/Sycamore Creek watershed).
Footnote 3: The Brown springsnail is limited to Brown Springs (Fossil Creek – lower Verde River) on private lands, though the PNF has water rights on the spring.

TABLE A-4. Plants Associated with PNVTs or Special Features

	PNVTs								Habitat Features									
	Desert Communities	PJ Grassland	Semi-Desert Grassland	Dry Mixed Conifer	Ponderosa Pine	Ponderosa Pine Evergreen Oak	P J Evergreen Shrub	P J Woodland	Riparian	Assoc. with Archeology Sites	Basalt – Lava Flows, Cinders	Bedrock/Rock Crevices *	Calcareous Soil Alkaline Clay	Canyons/Cliffs and/or Ledges	Limestone/ Dolomitic	Granitic Soils/ Igneous Rocks	Sandstone Rocks/Soils	Verde Formation
Apache beardtongue											X							
Arizona bladderpod					X													
Arizona cypress pygmy form								X										
Arizona phlox																		
Arizona wild-buckwheat												X			X			
Basin bladder-pod								X			X				X			
Bigelow's onion												X						
Black dropseed				X		X												
Broadleaf lupine									X									
California flannelbush							X											
Cliff fleabane														X				
Cochise sedge									X									
Compacted rock daisy															X			
Creeping milk-vetch		X				X		X										
Dwarf sand verbena		X																
Flagstaff pennyroyal															X		X	
Flagstaff beardtongue											X							
Heathleaf wild buckwheat																		X
Heermann's woolly wild-buckwheat								X										
Jones' spider-flower									X									
King's milk-vetch									X				X		X			

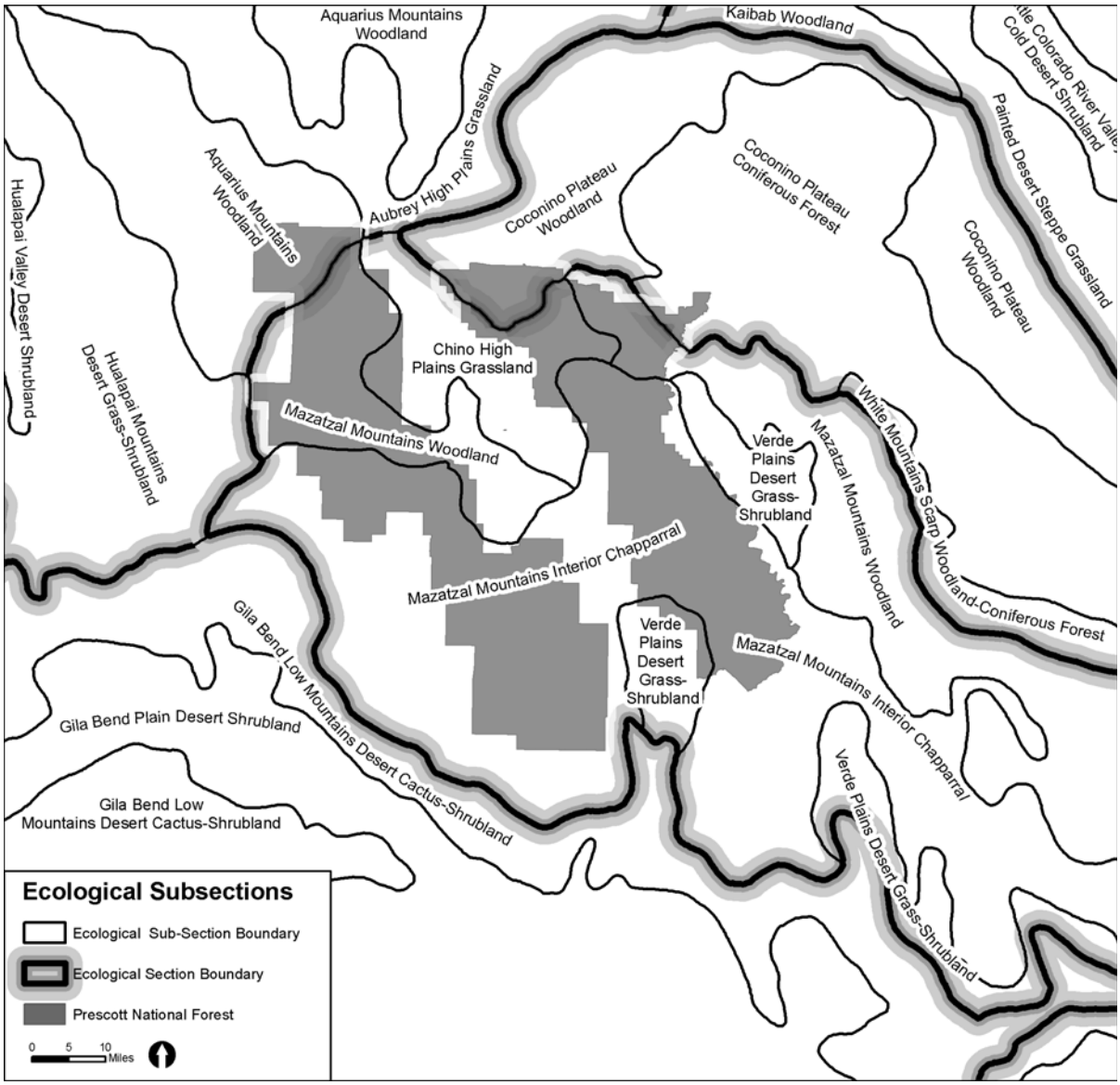
	PNVTs								Habitat Features									
	Desert Communities	PJ Grassland	Semi-Desert Grassland	Dry Mixed Conifer	Ponderosa Pine	Ponderosa Pine Evergreen Oak	PJ Evergreen Shrub	PJ Woodland	Riparian	Assoc. with Archeology Sites	Basalt – Lava Flows, Cinders	Bedrock/Rock Crevices *	Calcareous Soil Alkaline Clay	Canyons/Cliffs and/or Ledges	Limestone/ Dolomitic	Granitic Soils/ Igneous Rocks	Sandstone Rocks/Soils	Verde Formation
Long lalley tumblemustard													X					
Macdougal's bluebells				X		X												
Matted prickly-phlox															X			
Mearns lotus																		X
Melon-loco																X		
Metcalfe's ticktrefoil			X			X		X										
Mogollon fleabane														X				
Mountain pepperweed			X															
Mt. dellenbaugh sandwort															X			
Native tobacco						X	X											
Netted globecherry											X							
Nevada mormon-tea	X																	
New mexico alum-root														X				
Oak creek triteleia									X									
Parish's alkali grass									X				X					
Phillip’s agave										X								
Ripley's wild-buckwheat															X			X
Rock scorpionweed														X				
Rothrock's hedge-nettle																	X	
Rough whitlow-grass									X									
Rusby's milkwort																		X
Senator mine alum-root														X				
Showy maidenfern									X				X	X				
Skunk-top scurfpea													X	X	X			

	PNVTs								Habitat Features									
	Desert Communities	PJ Grassland	Semi-Desert Grassland	Dry Mixed Conifer	Ponderosa Pine	Ponderosa Pine Evergreen Oak	PJ Evergreen Shrub	PJ Woodland	Riparian	Assoc. with Archeology Sites	Basalt – Lava Flows, Cinders	Bedrock/Rock Crevices *	Calcareous Soil Alkaline Clay	Canyons/Cliffs and/or Ledges	Limestone/ Dolomitic	Granitic Soils/ Igneous Rocks	Sandstone Rocks/Soils	Verde Formation
Southwestern ringstem													X					
Thread-leaf giant-hyssop									X									
Tonto basin agave										X								
Utah bladder fern									X					X				
Verde valley sage										X								X
Western flame-flower															X			
White mountain bladderpod	X			X		X		X										
Wild buckwheat											X						X	
Yavapai claret-cup											X					X		
Yavapai wild buckwheat					X			X										

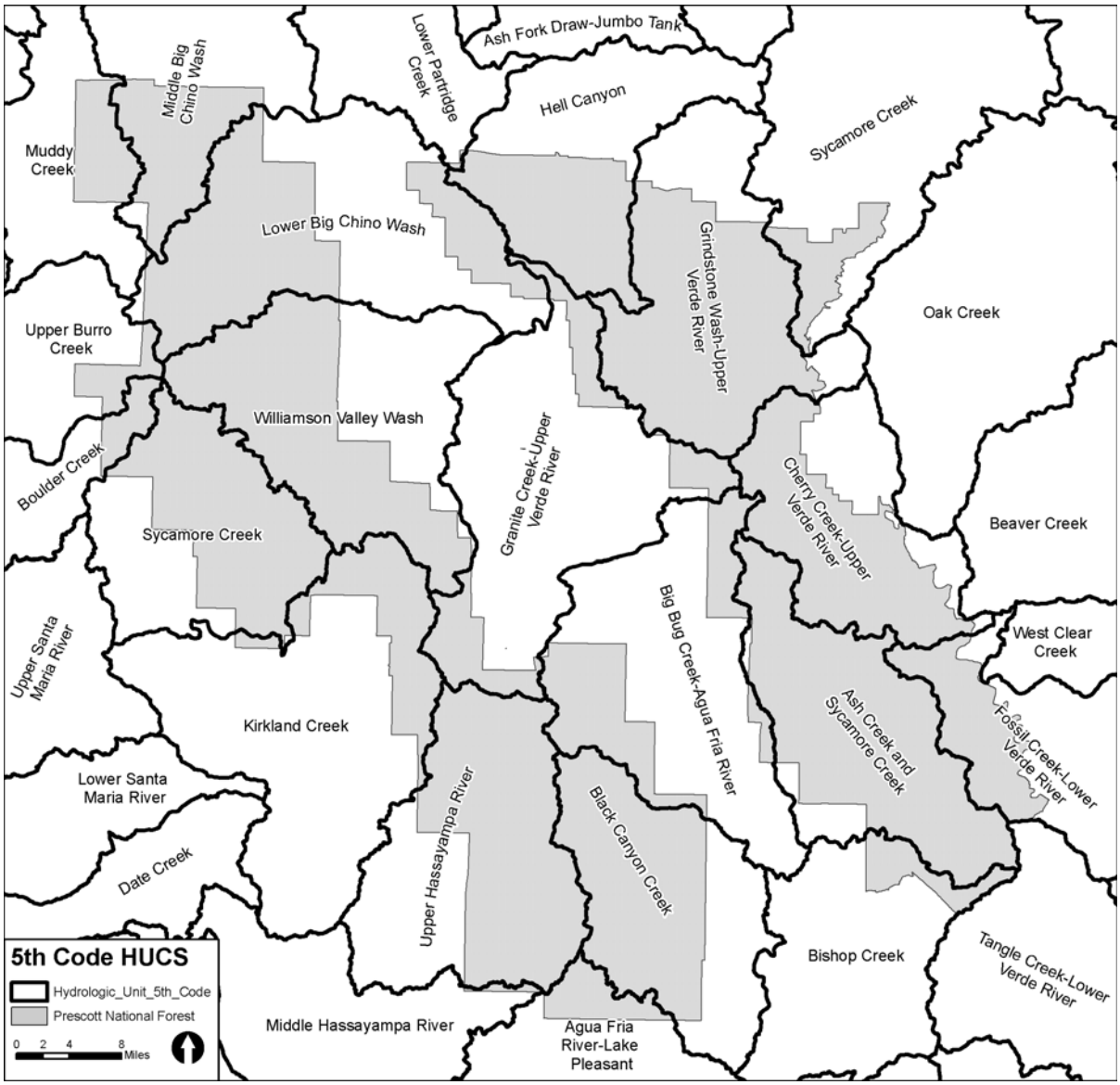
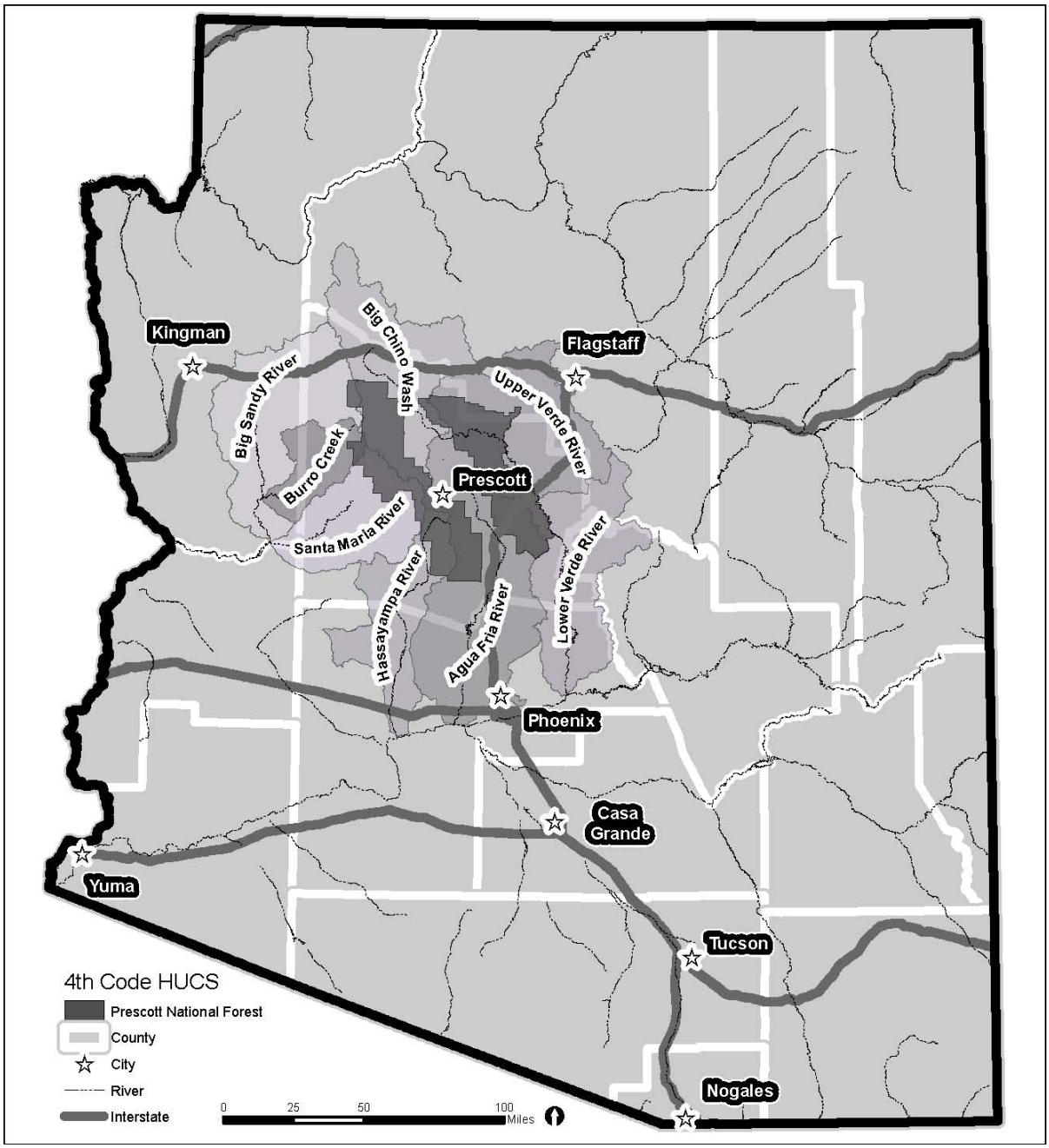
* Bedrock/rock crevices within Desert and PJ Evergreen Shrub PNVTs (especially in Verde Valley)

Appendix B. Maps

Map B-1. Ecological Subsections of the Prescott National Forest



Map B-2. 5th HUC Watersheds of the Prescott National Forest



Map B-3. Subbasins (4th HUC watersheds) associated with the PNF