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Ecological Sustainability Report

Apache-Sitgreaves National Forests

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Ecological Sustainability Report

Apache-Sitgreaves National Forests
Apache, Coconino, Greenlee and Navajo Counties, Arizona

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Introduction

The purpose of this report is to identify, analyze and evaluate the ecological environment of the Apache-Sitgreaves National Forests[1] (ASNFs) and the surrounding area. This report profiles the diversity of ecosystems and species, and identifies threats and associated risks within the ASNFs and across the broader landscape. It also provides information regarding needs for ecological change considered necessary to determine areas needing revision in the existing Land and Resource Management Plan (forest plan), as amended, for the ASNFs. It outlines and puts into context the relationship between the resources managed by the ASNFs and the broader ecological environment. This assessment is broad-based forestwide and does not address site specific situations that may occur on the forests within any one ranger district (RD). This evaluation and analysis only deals with that portion of the ASNFs that is in Arizona. The portion of the forests that is found within New Mexico will be analyzed by the Gila National Forest under its forest plan revision effort.

The U.S.D.A. Forest Service (Forest Service) is charged with developing management plans that create a framework for contributing to ecological sustainability on National Forests and Grasslands. Ecological sustainability is recognized as one of the three interdependent components of sustainability, social and economic being the other two components. The planning rule (36 CFR 219.10(b)) and directives (Forest Service FSH 1909.12 43) define ecological sustainability as providing for the diversity of plant and animal communities using a multi-scale approach that evaluates and provides guidance for ecosystem and species management. The primary focus for assessing ecological sustainability in the current planning rule is to provide for ecosystem diversity which contributes to a diversity of native plant and animal species.

The strategy for developing the forest plan framework for ecological sustainability involves consideration of both ecosystem and species diversity. A hierarchical approach is used to provide effective guidance for ecosystem diversity and supplement it with additional guidance as needed for species diversity. Evaluations of ecosystem and species diversity provide information on the need for ecological change in direction from the current forest plan. The evaluations focus on selected ecosystem characteristics and species. According to the current planning rule, the characteristics of ecosystem diversity are selected because they provide for meaningful evaluation of ecosystem composition, structure and process and are significant to the decisions that are to be made in the forest plan. Species are selected because they are of concern or interest, and are evaluated to ensure their needs are met either through ecosystem diversity plan components, or species specific plan components, if ecosystem components are not adequate.

This report, along with information from the ASNFs' Need for Change Evaluations, Economic and Social Sustainability Assessment and public input are summarized in the Comprehensive Evaluation Report (CER). The CER integrates the social, economic and ecological components of sustainability and identifies areas of the forest plan that need revision.

This report is organized into six chapters. Chapter 1, ecological niche, provides a description of the planning unit and the surrounding landscape. Chapter 2, ecosystem diversity, discusses conditions and trends in the vegetation communities, and physical resources. Chapter 3, species diversity, discusses the habitats for wildlife, fish and rare plants that exist within the ASNFs. Chapter 4, integration of ecosystem and species diversity risk assessment, provides an ecosystem and species status and risk assessment. Chapter 5, ecological need for change, presents the ecological needs for change based on the analysis. And Chapter 6, references cited, lists the references referred to.

[1] In 1974, the Apache National Forest was combined with the Sitgreaves National Forest & became the Apache-Sitgreaves National Forests (ASNFs).

Chapter 1 – Apache-Sitgreaves National Forests: Ecological Niche

Description of the Planning Unit

The ASNFs are located within Apache, Coconino, Greenlee, and Navajo Counties, on and adjacent to the Colorado Plateau in east-central Arizona (figure 1). The Arizona-New Mexico border bounds the ASNFs on the east and the Fort Apache and San Carlos Reservations on the west and south. State and private lands are to the north. The ASNFs encompass approximately two million acres, roughly 18 percent of all National Forest System lands in Arizona. Elevations on the forests range from approximately 3,400 feet northwest of Clifton, Arizona to nearly 11,400 feet west of Springerville, Arizona.

Mountains, hills, cinder cones, plains, plateaus, deep canyons and escarpments form the irregular topography of this lightly populated area of Arizona. This varied landscape supports ponderosa pine, mixed conifer and spruce-fir forests; Great Basin, semi-desert and montane/subalpine grasslands; madrean pine-oak and piñon-juniper woodlands; interior chaparral; wetland/cienega; and mixed broadleaf deciduous, montane willow and cottonwood-willow riparian areas. In fact, the ASNFs contain a portion of the largest ponderosa pine forest in the world and also include the most extensive montane/subalpine grasslands in Arizona.

According to McNab and Avers (1994), geology in the ASNFs is comprised of mid- to late-Cenozoic volcanism, including basalt lava flows, cinder cones and volcanic ash deposits; middle Tertiary to Cretaceous metamorphic rocks and Mesozoic sedimentary rocks (Merrill 1984).

Geologic processes have produced the second and third highest mountains in Arizona; with Mount Baldy at 11,420 feet and Escudilla Mountain at 10,912 feet, as well as the Mogollon Rim. The Mogollon Rim marks the southern edge of the Colorado Plateau as well as the Sitgreaves portion of the forests. This long escarpment, thousands of feet high in some areas, extends for nearly 200 miles across central Arizona. The average elevation of this undulating rim and plateau country is about 7,000 feet. The Clifton RD and a portion of the Alpine RD are located below the Mogollon Rim.

Figure 1. The ASNFs, shown in gray, are located in east central Arizona, along the Arizona-New Mexico border.

The general geographic region where the forests are located is known as the White Mountains. This region was glaciated at least four times during the late Quaternary, the earliest episode being between 100 thousand to 70 thousand years ago and the youngest being approximately 10,000 years ago (Merrill 1984). The ASNFs also contain the largest drainage area in Arizona for perennial streams (Merrill 1984). Many of the headwater streams of the Colorado River basin are found on the ASNFs. The Little Colorado, Black, Blue, and San Francisco Rivers all originate here, making it one of the richest sites for riparian communities in the state (TNC 1999).

One Class I airshed occurs within the forests associated with the 7,079 acre Mount Baldy Wilderness Area. Class I airsheds are one of three classes provided for in the Clean Air Act for the Prevention of Significant Deterioration program[2]. It is the "cleanest" area with respect to air quality and receives special visibility protection.

According to Sellers and Hill (1974), the climatic type for the ASNFs is that of the Highland Region. Because Arizona is located in a peripheral position between subtropical and temperate areas and between continental and oceanic influences, the ASNFs can be subject to rather dramatic and rapid changes in local weather conditions. Seasonal and daily weather can be highly variable due to the uneven topography and the wide range in elevations found on the ASNFs. The climate varies from hot steppe at the lower elevations to boreal at the higher elevations.

The ASNFs contain very diverse plant communities that occupy certain areas along an elevational gradient. In general, at low elevations (3,445 to 6,135 feet), the ASNFs support semi-desert grassland and madrean evergreen woodland biotic communities (biotic communities are from Brown 1994). As a general rule low to middle elevations (6,135 to 8,792 feet) support interior chaparral, Great Basin coniferous woodland, and Plains and Great Basin grassland biotic communities. Rocky Mountain (petran) and madrean montane coniferous forests, subalpine coniferous forests, alpine and subalpine grassland, and montane grassland biotic communities dominate the middle to high elevations (8,792 to 11,483 feet) and are found primarily in the northern two-thirds of the ASNFs. Rocky Mountain and madrean montane coniferous forests are the largest and most widespread plant communities on the ASNFs.

Surrounding Landscape Ecoregion - Province, Section and Subsections

An attempt has been made to identify the importance or “stewardship responsibility” of vegetation managed by the ASNFs by comparing the quantity and spatial extent of vegetation within and outside of the ASNFs’ administrative boundary. *Ecoregions* mapped are ecosystems of regional extent. As described by Bailey (1983) ecoregions distinguish areas that share common climatic and vegetation characteristics (Cleland et al. 1997). Ecoregions are subdivided into *provinces*, which are controlled primarily by continental weather patterns such as length of dry season and duration of cold temperatures. Provinces are also characterized by similar soil orders. *Sections* are a subdivision of provinces, described by broad areas of similar subregional climate, geomorphic process, geology, geologic origin, topography, and drainage networks. Such areas are often inferred by relating geologic maps to potential natural vegetation "series" groupings such as those mapped by Küchler (1964). Ecological *subsections* are a further division of sections, and described by areas with similar surface geology, geomorphic process, soil groups, subregional climate, and potential natural vegetation communities (McNab and Avers 1994). Because subsections are smaller in size they are more useful in planning at a smaller scale.

[2] The Clean Air Act (CAA), & the regulations promulgated to enforce its provisions have been modified several times over the years. These modifications have added several air pollution prevention & control provisions designed to protect & enhance the quality of the Nation's air resources. One of these provisions called for the application & enforcement of national ambient air quality standards (NAAQS) in certain geographic areas or "air quality control regions" throughout the U.S. The NAAQS establish health-based levels of certain "criteria air pollutants" considered healthy for all persons in all areas of the country. CAA regulations require that any owner/operator proposing a "new source" - i.e., proposing to: 1) build a new major stationary source of criteria air pollutants; or 2) perform major modifications to an existing stationary source of criteria air pollutants - must apply for a preconstruction air emissions permit & submit to certain preconstruction review requirements & mitigation. These preconstruction review regulations for new sources fall under two major programs: 1) Prevention of Significant Deterioration (PSD) provisions (for attainment areas); & 2) Non-attainment Area (NAA) provisions.

Using the National Hierarchical Framework of Ecological Units[3] (Cleland et al. 1997) an analysis of the landscapes surrounding the ASNFs was completed using the ecological section and subsection units. This broad-scale analysis was done to set the context for the contributions the ASNFs make to ecological sustainability. The ASNFs is located within the Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow ecoregion province (M313) (McNab and Avers 1994); and is located entirely within the province's White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section (M313A), comprising approximately 15 percent of the section's total acreage (figure 2 and table 1). In addition, the ASNFs are located within a portion of seven subsections in the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section.

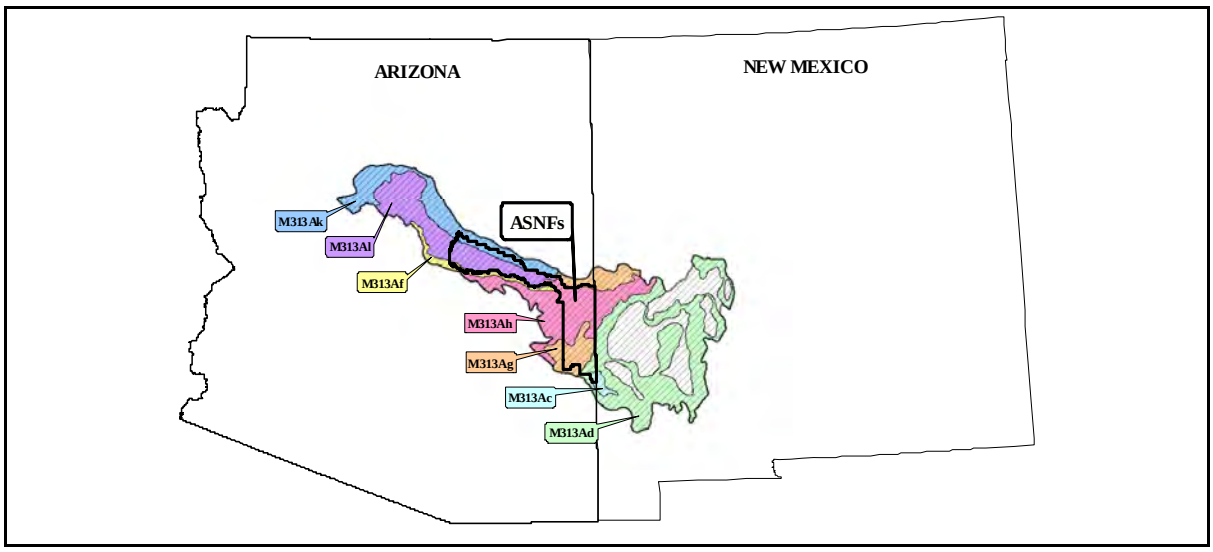

Figure 2. ASNFs in context to the land areas of the White Mountains-San Francisco Peaks-Mogollon Rim M313A ecoregion section (cross-hatched area) and the seven subsections in which it occurs, and the ecoregion section in context within Arizona and New Mexico. The seven subsections are: M313Ac is the Burro Mountains Oak-Juniper Woodland; M313Ad is the Mogollon Mountains Woodland; M313Af is the White Mountains Scarp Woodland-Coniferous Forest; M313Ag is the White Mountains Woodland; M313Ah is the White Mountains Coniferous Forest; M313Ak is the Coconino Plateau Woodland; and M313Al is the Coconino Plateau Coniferous Forest.

[3] In 1993, as part of the Forest Service's National Hierarchical Framework of Ecological Units (ECOMAP 1993), ecoregions were adopted for use in ecosystem management. The hierarchical interrelationships, or nesting, are as follows: 1) The United States is divided into three Domains (based on general climatic characteristics). The intermountain west (including Arizona & New Mexico) falls within the Dry Domain. The essential feature of the Dry Domain is that annual losses of water through evaporation at the earth's surface exceed annual water gains from precipitation; 2) Domains are further subdivided into Divisions, northeastern & eastern Arizona fall within the Tropical/ Subtropical Steppe Division. Tropical steppes border the tropical deserts on both the north & south & in places on the east as well. Locally because of altitude, plateaus & high plains within what would otherwise be desert have a semiarid steppe climate. The Tropical/ Subtropical Steppe Division is further subdivided into a Mountain segment exhibiting altitudinal zonation & the climatic regime of the adjacent lowlands & is distinguished according to the character of altitudinal zonation; 3) Divisions are further subdivided into Provinces & central & eastern Arizona falls within the Arizona-New Mexico Mountains Semi-desert--Open Woodland--Coniferous Forest--Alpine Meadow Province of the Mountain segmentation. This area consists mostly of steep foothills & mountains, but includes some deeply dissected high plateaus; 4) Provinces are further subdivided into Sections & the ASNFs fall entirely within the White Mountains-San Francisco Peaks-Mogollon Rim Section which extends from the south rim of the Grand Canyon to central New Mexico; & 5) Sections are further subdivided into Subsections. The ASNFs fall within a portion of seven subsections (as detailed in figure 2).

Table 1 presents the relationship or scale, in acres, of the ASNFs to the overall ecoregion section and its seven subsections (columns one and two). Overall, the section and the seven subsections total nearly 13.5 million acres. The ASNFs occupies 15 percent of these total acres. Column three displays the section and subsection percent contribution to the ASNFs' acreage, while column four displays the ASNFs' percent contribution to the section and seven subsections' acreages.

Table 1. Land area, in acres, of the ASNFs in relation to the land areas of the ecoregion section and seven subsections in which it occurs.

Ecoregion Section & Subsection Codes	Ecoregion Section & Subsection Name	Total Area of the Ecoregion Section & Subsection (acres)	Total ASNFs Area Within the Section & Subsection (acres)	Ecoregion Section & Subsection Contribution to ASNFs Acreage (%)	ASNFs Contribution to Ecoregion Section & Subsection Acreage (%)
Ecoregion Section					
M313A	White Mountains-San Francisco Peaks-Mogollon Rim	13,474,691	2,015,305	100	15.0
Subsection					
M313Ac	Burro Mountains Oak-Juniper Woodland	128,507	23,289	1.2	18.1
M313Ad	Mogollon Mountains Woodland	3,591,109	89,790	4.5	2.5
M313Af	White Mountains Scarp Woodland-Coniferous Forest	321,920	25,450	1.3	7.9
M313Ag	White Mountains Woodland	1,057,569	382,762	19.0	36.2
M313Ah	White Mountains Coniferous Forest	2,124,359	697,141	34.6	32.8
M313Ak	Coconino Plateau Woodland	1,610,862	180,845	9.0	11.2
M313Al	Coconino Plateau Coniferous Forest	1,974,415	616,027	30.6	31.2
Other†	Located entirely within New Mexico	2,665,951	0	0.0	0.0

† Other = Mangas High Plains Grassland Subsection M313Ab; Mogollon Mountains Coniferous Forest Subsection M313Ae & San Francisco Peaks Coniferous Forest Subsection M313Am

The remaining 85 percent of the lands within the ecoregion section are owned or managed by a diversity of entities; including the Coconino, Gila, Kaibab, Prescott and Tonto National Forests, the states of Arizona and New Mexico, Bureau of Land Management, National Park Service, White Mountain Apache and San Carlos Apache Nations, and numerous private organizations and citizens.

According to McNab and Avers (1994), precipitation within the M313A section ranges from 20 to over 32 inches annually, with more than half of the precipitation falling during the winter months. Temperatures average 40º to 57º F; however winter temperatures vary throughout this section. The growing season ranges from less than 50 to 110 days, and winters are cold. This section is the primary watershed for much of Arizona and western New Mexico. Several large streams within the section are perennial. Much of the water is stored in reservoirs, and small artificial lakes are common. Ground water is limited and usually occurs at great depths.

Contribution to Ecosystem Sustainability

Vegetation

The importance of the lands within the ASNFs to the sustainability of ecosystems within the greater ecological section depends on the amount and condition of these ecosystems within and outside of the forests' boundaries (table 2). The ecological section scale analysis (spatial niche) is intended to place the ASNFs into a broader ecological context; that is, to what degree the ASNFs are contributing to

maintaining a given ecosystem characteristic and the ecological processes associated with that ecosystem characteristic. When an ecosystem type or characteristic is found to occur across adjacent planning units spatial niche analysis occurs within the context of the ecoregion section and comes down to this: when the bulk of a ecosystem characteristic (major vegetation type in the case of table 2) within the ecoregion section is located on-forest (Riparian Area/Forest), sustainability analysis falls to a temporal niche analysis (focus is on conditions on-forest). When the bulk of major vegetation types within the ecological section is located off-forest (i.e. Forests, Woodlands, Grasslands, etc.), the sustainability analysis falls to a spatial and temporal niche analysis (focus on conditions off-forest). For other PNVTs, ecological sustainability analysis will reflect the sum conditions of the PNVT both on- and off-forest.

Table 2. The ASNFs' major vegetation types in the broader context, or "niche," within the White Mountains-San Francisco Peaks-Mogollon Rim M313A ecoregion section (Forest Service 2006).

Ecosystem Characteristic (Major Vegetation Types on the ASNFs)	White Mountains-San Francisco Peaks-Mogollon Rim Ecoregion Section M313A			
	Total area for each major vegetation type contained within the ecoregion		ASNFs' contribution to the total area of each major vegetation type contained within the ecoregion	
	Acres	Percent†	Acres	Percent‡
Forests	5,455,090	40.5	952,577	17.5
Woodlands	3,535,061	26.2	627,727	17.8
Grasslands	2,726,674	20.2	341,785	12.5
Chaparral	233,468	1.7	56,006	24.0
Riparian Areas/Riparian Forests	68,972	0.5	29,430	42.7

† Summation of this column does not equal 100% because there are other vegetation types within the ecoregion section that do not occur on the ASNFs, such as, Alpine & Tundra, Desert Communities, Gambel Oak Shrubland, & Sagebrush Shrubland which are not displayed

‡ The percent values displayed in this column are representative of the ASNFs' contribution to the specific vegetation type's total area within the ecoregion section. As examples: Nearly 43% of all the riparian area/forest vegetation type within the ecoregion section is located on the ASNFs, 57% is located elsewhere in the ecoregion section; & roughly 18% of all of the forest vegetation type within the ecoregion section is located on the ASNFs, 82% is located elsewhere in the ecoregion section

Watersheds

Watersheds are cataloged using a uniform hierarchical system developed by the United States Geological Survey (USGS). The United States is divided & sub-divided into successively smaller hydrologic units. The hydrologic units are arranged within each other, from the largest (regions) to the smallest (cataloging units or sub-basin). 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 sub-basin. The ASNFs fall within the Lower Colorado River region (15), one of 20 regions that makes up the entire United States. The ASNFs' watersheds are contained within three basins. See table 3 and figure 3 for a list and proportional extent of the forests' basins and sub-basins. Table 3 displays that the ASNFs' greatest contribution to sustainability to water resources is in the following watersheds: Little Colorado River Headwaters, Black River, San Francisco River, Middle Little Colorado River, Chevelon Canyon, and Silver Creek. To provide additional detail, fifth level HUCs (watersheds) were delineated inside the fourth fields by the Natural Resource Conservation Service in Arizona and are shown in figure 4.

Table 3. Third (basin) and fourth (sub-basin) hydrologic unit code (HUC) watersheds, area and proportional extent of ASNFs' area compared to entire watersheds.

Basin Name (Third Hydrologic Unit Code (HUC) Watershed)	Sub-basin Name (Fourth Hydrologic Unit Code (HUC) Watershed†)	ASNFs' Area within Sub-basins (acres)	Non-ASNFs Area within Sub-basins (acres)	Entire Sub-basin Area (acres)	ASNFs' Area as Percent of all Sub-basins	Percent Miles on ASNFs (NHD Original)Δ
Little Colorado Riv (150200)	Little Colorado Riv Headwaters	212,355	302,891	515,246	41	65
	Upper Little Colorado Riv	48,245	989,019	1,037,264	5	0
	Silver Ck	282,451	324,263	606,714	47	0
	Middle Little Colorado Riv	168,163	1,446,514	1,614,677	10	21
	Chevelon Canyon	332,923	191,435	524,358	64	0
Gila Riv (150400)	Mangus Ck-Upper Gila Riv	20,084	1,291,220	1,311,304	2	0
	San Francisco Riv	535,326	1,258,243	1,793,569	30	38
	Upper Gila Riv-San Carlos Reservoir	158,168	1,613,061	1,771,229	9	18
Salt Riv (150601)	Black Riv	228,358	572,225	800,583	29	52
	White Riv	3,104	405,163	408,267	1	0
	Upper Salt Riv	16,147	1,361,434	1,377,581	1	0
	Carrizo Ck	4,180	449,897	454,077	1	0
	Tonto Ck	5,373	665,199	670,572	1	0
Totals of all Watersheds		2,014877	10,870,562	12,885,439	16‡	

† See figures 3 & 4 for the spatial location of the ASNFs within the fourth & fifth hydrologic unit code (HUC) watersheds, respectively

‡ Total percentage of ASNFs' areas as compared to total of all watersheds

Δ Data is from the National Hydrologic Data (NHD) layer which has less detail than forest data. Therefore, there are differences in miles of stream displayed within fifth level HUCs due to differences in scale as discussed later in the document

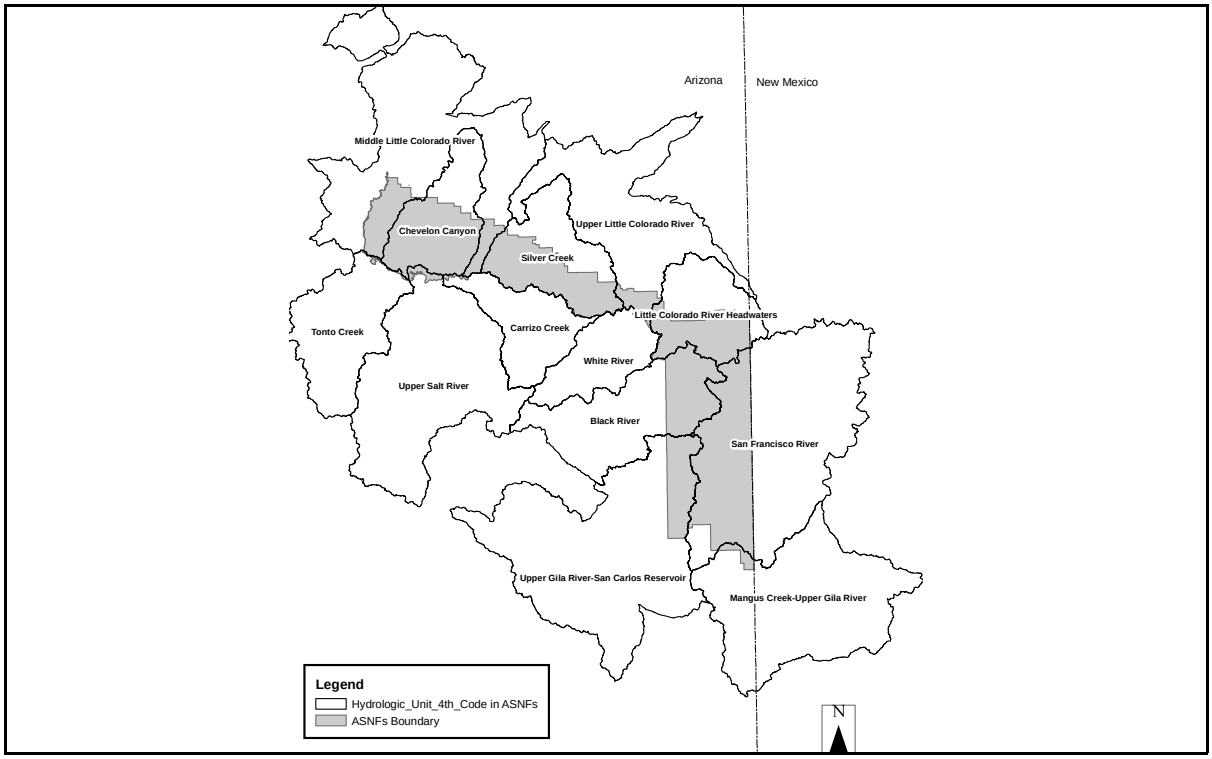

Figure 3. Location of the fourth hydrologic unit code (HUC) watersheds associated with the ASNFs.

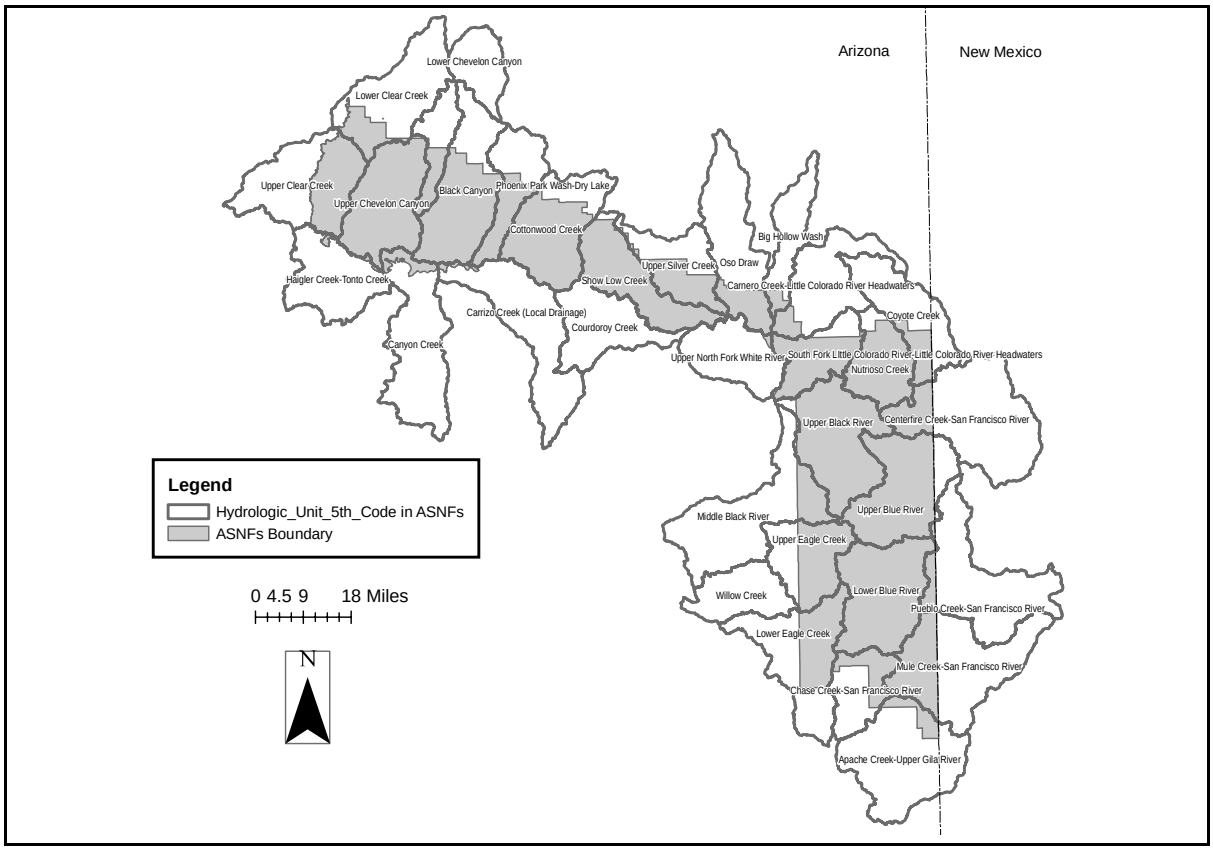

Figure 4. Location of the fifth hydrologic unit code (HUC) watersheds associated with the ASNFs.

Airsheds

Airsheds are represented locally by watershed boundaries. This is because daily airflow patterns generally move down stream drainages when land cools at night and up stream drainages as land warms during the day. Regional (multi-state) airsheds have been delineated based on the work of groups of governmental entities, such as the nine-state Grand Canyon Visibility Transport Commission (GCVTC), which may target specific air quality values at risk, such as visibility within Class I wilderness areas. Mount Baldy is the only Class I airshed designated within the ASNFs (figure 5). This airshed is represented only by the air directly above the wilderness area. Although this is a political boundary, air quality is affected by pollutants that are generated from within the wilderness area, such as smoke from fires, from pollutants that flow into the airshed from local sources, such as wood smoke from homes or prescribed fire and dust from roads, or from long range transport of pollutants from metropolitan areas and large industry many miles away.

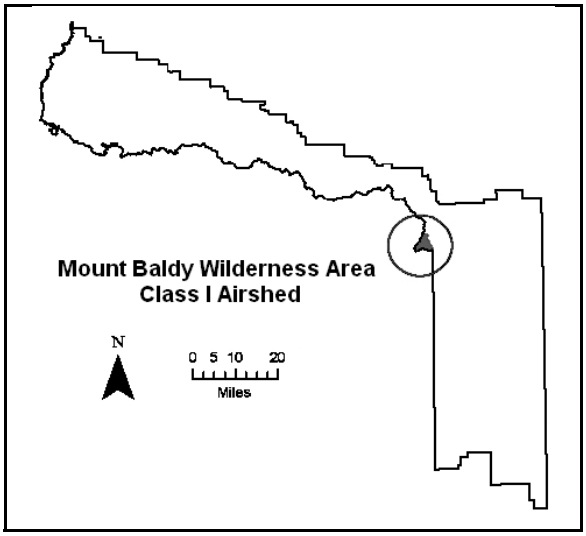

Figure 5. Location of the Mount Baldy Wilderness Area Class I Airshed on the ASNFs; denoted by the circled shaded area.

Chapter 2 – Ecosystem Diversity

Terrestrial Systems

This section summarizes the current and historic ecological conditions, along with projected trends based on current management for the ASNFs. Analyses were conducted on vegetation using potential natural vegetation types (PNVT), existing mid-scale vegetation types found on the ASNFs[4], and soil types from Terrestrial Ecological Unit Inventory data for the ASNFs[5]. A comparison between PNVTs and existing vegetation was used to show the departure from reference conditions. Comparisons of the forests' current soil conditions to soil reference conditions were also analyzed to derive departure, estimate trends and future conditions.

Vegetation

Vegetation Communities

The Region 3 Ecological Sustainability Report (Forest Service 2006) provides guidance on evaluating ecological sustainability by using PNVTs as the framework for vegetation analysis. Vegetation is the primary terrestrial ecosystem characteristic chosen for analysis for two reasons. First, it is the primary terrestrial and biological ecosystem component that is manipulated through management and affected by natural processes. Second, it represents habitat for wildlife and provides the required link to species diversity. For more complete details regarding the analysis and findings of vegetation discussed in this document see the Vegetation Specialist's report.

The distribution of PNVTs on the Forest Service's Southwest Region (Region 3) National Forest System lands and across land ownership throughout Arizona and New Mexico was analyzed by the Nature Conservancy (TNC) (Vander-Lee et al. 2006). PNVTs are coarse-scale groupings of ecosystem types that share similar vegetation composition, and historic ecosystem disturbances such as fire, drought, and grazing by native species. The PNVTs used for this analysis were summarized from the Terrestrial Ecosystem Survey of the ASNFs (Laing et al. 1987) and cross-walked with the Southwest Regional Gap Analysis Project[6] (USGS 2004) landcover vegetation data. The ASNFs' Terrestrial Ecosystem Survey (ASTES) data (Laing et al. 1987) were used for PNVT mapping because of their relevance to site potential, vegetation composition, and historic disturbance patterns for each PNVT. Characterizations of PNVTs, their historic range of natural variability (HRV) and vegetation state and transition modeling[7] are included in the Vegetation Specialist's report.

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[4] Mid-scale vegetation types were determined using satellite data & are mapped at the scale of 1:100,000. The mid-scale vegetation inventory for all ASNFs' vegetation types analyzed in this report was conducted in 2005 & 2006.

[5] The Terrestrial Ecological Unit Inventory referenced in this document is specific to the ASNFs & is a classification of ecological types. It maps terrestrial ecological units based on soil types & existing vegetation (Laing et al. 1987).

[6] The Southwest Regional Gap Analysis Project (SWReGAP) was initiated in 1999 as a multi-institutional cooperative effort to map & assess biodiversity for a five-state region (AZ, CO, NV, NM, UT) comprising approximately 560,000 square miles in the southwestern U.S. A key task was the development of a seamless landcover map for the region & the collection of other pertinent bio-physical spatial data.

[7] Modeling projected trends in state & transitions were derived through the use of the Vegetation Dynamics Development Tool (VDDT) (ESSA Technologies 2006). VDDT software is a non-spatial model that allows the user to model vegetation change over time as a series of vegetation states that differ in structure, composition, & cover & to specify the amount of time it takes to move from one vegetation state to another in the absence of disturbance. Various disturbance agents affecting the movement of vegetation between states

Table 4 displays the major PNVTs (Vander-Lee et al. 2006) found within the ASNFs and ecoregion section and what percent of each PNVT within the ecoregion section is contributed by the forests. In addition, the proportional representativeness within the forests and ecoregion section is presented.

The majority of PNVTs (nine) have a greater proportional representation on the ASNFs than in the ecoregion section; this includes all of the riparian PNVTs. The ASNFs' top five biggest contributing PNVTs to the ecoregion section are: Cottonwood-Willow, Madrean Pine-Oak, Wetland/Cienega, Spruce-Fir with Wet Mixed Conifer and Mixed Conifer with Frequent Fire, from greatest to least, respectively.

Spatial and Temporal Niche Analysis

As mentioned earlier, spatial niche analysis occurs within the context of the ecoregion section(s) and comes down to this: when the bulk of the PNVT within the ecoregion section is located on-forest, sustainability analysis falls to a temporal niche analysis (focus is on conditions on-forest). When the bulk of the PNVT within the ecological section is located off-forest, the sustainability analysis falls to a spatial and temporal niche analysis (focus on conditions off-forest). For other PNVTs, ecological sustainability analysis will reflect the sum conditions of the PNVT both on- and off-forest. See figure 6 for a graphic representation used to determine if the management of lands within the ASNFs is influential to the sustainability within the ecoregion section.

Spatial Niche Analysis: As can be seen from table 4, the importance of the PNVTs within the ASNFs to the sustainability of ecosystems represented by these vegetation communities varies with amount and distribution within and outside of the ASNFs' boundaries. On one hand, the Ponderosa Pine Forest PNVT comprises 30 percent of the ASNFs, and represents only about 13 percent of the overall ecoregion section acreage. A similar situation exists with the Piñon-Juniper Woodland, and Great Basin and Semi-desert Grassland PNVTs in that these PNVTs represent a relatively small percentage of the forests and an even smaller percent of what the ecoregion section contains overall; 22 percent and eight percent, 13 percent and ten percent, and six percent and 14 percent, respectively. Because these PNVTs are such a relatively small percentage of what the ecoregion section contains, overall, the ability of the ASNFs to make a significant contribution to the ecological sustainability of these vegetation communities within the ecoregion section specifically and the Southwest in general is limited, but may be very important.

(or transitions) are incorporated (e.g., surface fires, stand-replacing fires, grazing, insect outbreaks, & drought events, etc.). By varying the types & rates of disturbance across the landscape, the effects of different disturbance regimes, such as historic & current fire regimes, or different management treatments, such as wildland fire use, fire suppression, prescribed burning, grazing practices, & mechanical fuel treatments, on vegetation can be investigated (Schussman & Smith 2006a). Input data used in modeling came directly from ASNFs' forest management activities & fire data over the last 50 years.

Table 4. Land area, in acres, of the ASNFs' major potential natural vegetation types (PNVTs) in relation to the overall land area of the forests and their context, or "niche", and proportional representativeness within the White Mountains-San Francisco Peaks-Mogollon Rim M313A ecoregion section.

Potential Natural Vegetation Types (PNVTs)	White Mountains-San Francisco Peaks-Mogollon Rim Ecoregion Section M313A						ASNFs' Proportional Representativeness Relative to the Ecoregion SectionΔ
	Total PNVT area contained within the ASNFs (column 2)		Total PNVT area contained within ecoregion section (column 3)		ASNFs' contribution to the PNVT total area within ecoregion section		
	Acres (a)	Percent (b)	Acres (a)	Percent† (b)	Acres	Percent‡	
Forests							
Ponderosa Pine	604,577	30.0	4,573,316	33.9	604,577	13.2	nearly equal (0.9:1)
Mixed Conifer with Frequent Fire	288,840	14.3	753,072	5.6	288,840	38.4	greater (2.6:1)
Spruce-Fir with Wet Mixed Conifer	59,160	2.9	128,702	1.0	59,160	46.0	greater (2.9:1)
Woodlands							
Madrean Pine-Oak	396,678	19.7	615,111	4.6	396,678	64.5	greater (4.3:1)
Piñon-Juniper	231,049	11.5	2,919,950	21.7	231,049	7.9	lesser (0.5:1)
Grasslands							
Great Basin	177,681	8.8	1,789,899	13.3	177,681	9.9	lesser (0.7:1)
Semi-desert	107,599	5.3	761,965	5.7	107,599	14.1	nearly equal (0.9:1)
Montane/Subalpine	56,505	2.8	174,810	1.3	56,505	32.3	greater (2.2:1)
Chaparral							
Interior	56,006	2.8	233,468	1.7	56,006	24.0	greater (1.6:1)
Riparian Areas/Riparian Forests							
Wetland/Cienega	11,825	0.6	18,468	0.1	11,825	64.0	greater (6:1)
Mixed Broadleaf Deciduous	6,865	0.3	19,747	0.1	6,865	34.8	greater (3:1)
Montane Willow	5,542	0.3	24,302	0.2	5,542	22.8	greater (1.5:1)
Cottonwood-Willow	5,198	0.3	6,455	< 0.1	5,198	80.5	greater (3.3:1)

† Summation of this column does not equal 100% because there are other PNVTs within the ecoregion section that do not occur on the ASNFs, such as, Alpine & Tundra, Desert Communities, Gambel Oak Shrubland, Madrean Encinal Woodland, & Sagebrush Shrubland which are not displayed

‡ The percent values displayed in this column are representative of the ASNFs' contribution to the specific PNVT's total area within the ecoregion section. As examples: Nearly 65% of all the Madrean Pine-Oak Woodland PNVT within the ecoregion section is located on the ASNFs, 35% is located elsewhere in the ecoregion section; & roughly 13% of all of the Ponderosa Pine Forest PNVT within the ecoregion section is located on the ASNFs, 87% is located elsewhere in the ecoregion section

Δ Ratios are based on comparison of percentages displayed in column 2b & column 3b

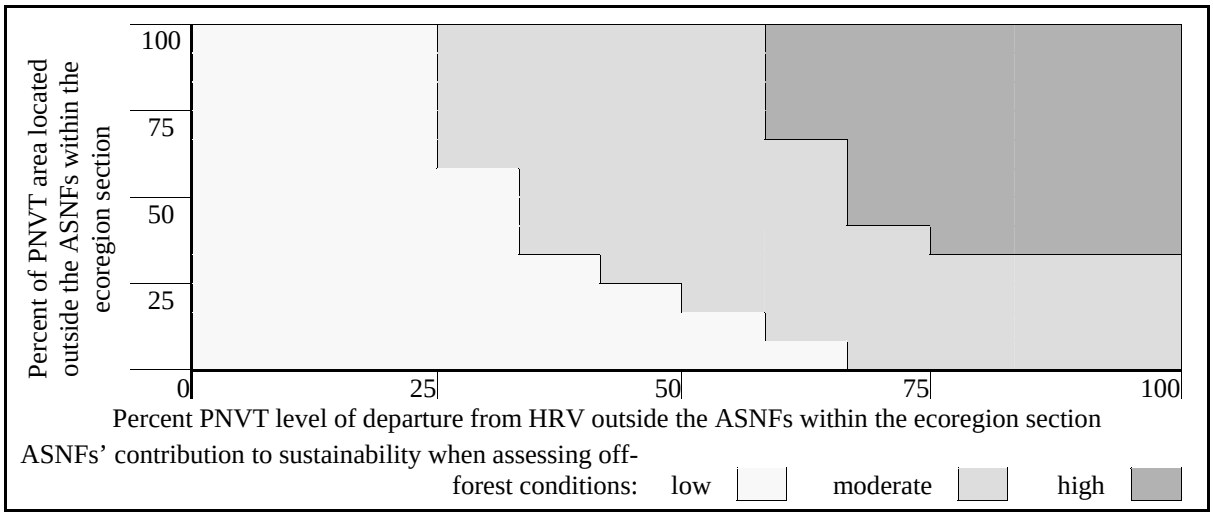

Figure 6. Spatial niche analysis. Potential ASNFs contribution to sustainability of PNVT off-forests within the White Mountains-San Francisco Peaks-Mogollon Rim Ecoregion Section.

Conversely, all of the Riparian Forests and Wetland/Cienega Riparian Area PNVTs, individually, each make up less than one percent of the ASNFs, however, they represent a significant portion of the total acreage of these vegetation types within the ecoregion section. A similar situation exists with the Madrean Pine-Oak Woodland, Spruce-Fir with Wet Mixed Conifer, and Mixed Conifer with Frequent Fire Forest PNVTs in that these PNVTs contribute a relatively large percentage of the ecoregion sections acreage; overall, for these vegetation communities. The management of these vegetation communities within the ASNFs is very influential and makes a significant contribution to the ecological sustainability of these PNVTs within the ecoregion section.

Temporal Niche Analysis: HRV is a description of the change over time and space in the ecological condition of PNVTs and the ecological processes that shape those types. PNVTs represent the vegetation type and characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006). According to Fletcher (1998), the term "natural variability" is synonymous with other terms used in referencing inherent variability in baseline conditions, such as "historic", "pristine", "prehistoric",' "prewestern technological man", "primeval", and "pre-European", Euro-American, etc. Natural variability can be characterized by: 1) the range of ecosystem conditions, such as the extent of particular seral (or intermediate) classes of vegetation and 2) the disturbance regimes (defined in terms of frequency, spatial arrangement, and severity of disturbances) that produce such conditions. Descriptions of HRV also focus on quantifying the rate of change in PNVT characteristics and the influence of humans on changes in PNVT characteristics (Schussman and Smith 2006).

In the forest plan revision process, HRV is used as an ecological baseline or reference point. Knowledge of this HRV of forest ecosystem conditions is essential for understanding how current forest 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, "disturbance regimes" of fire, drought and insects, wind, flooding, etc. are also evaluated within the framework of HRV. The comparison of current conditions with HRV provides the forest planning process with a scientifically based assessment tool.

Potential Natural Vegetation Types (PNVTs)

A summary of information regarding each of the PNVTs found on the ASNFs follows. Detailed PNVT assessments can be found in the Vegetation Specialist report.

Forest PNVTs

Ponderosa Pine: This PNVT generally occurs at elevations ranging from 6,000 to 9,000 ft on loose, well-drained soils derived from igneous, metamorphic, and sedimentary parent material. The dominant species in this system is ponderosa pine. Other trees, such as Gambel oak, Rocky Mountain Douglas-fir, piñon pine, and junipers may be present. There is typically a shrubby understory; such as currants/gooseberries, and buckbrush, mixed with a variety of grasses and forbs, such as Arizona fescue, mountain muhly, pine dropseed, blue grama, fleabanes, pussytoes, and others. This type sometimes occurs as savannah with extensive grasslands interspersed between widely spaced clumps or individual trees. This system is adapted to drought during the growing season, and has evolved several mechanisms to tolerate frequent, low intensity surface fires.

The Ponderosa Pine Forest is widespread and at 604,577 acres, or 30 percent of the forests, represents the largest PNVT on the ASNFs. The ASNFs' niche for this PNVT is approximately 13 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the Coconino Plateau Coniferous Forest and the White Mountains Woodland subsections, the ASNFs contribute 30 and 25 percent of this PNVT, respectively.

Current conditions within the Ponderosa Pine Forest are severely departed from HRV (table 5). With a Departure Index[8] (DI) of 94 percent, this PNVT is the second most departed. There is a sizeable over representation of young to middle-age and mature old forest with regeneration, both with closed canopies (States G,H and I) and a significant under representation of mature old forest with regeneration with open canopy (State D,E).

[8] One of the simplest means of analyzing vegetative data is to look at the degree of association between sample sets & the level of similarity or dissimilarity between them (comparing current conditions to HRV). Departure Indices (DI) were developed to measure the degree to which the defined historic (HRV) set of conditions, such as, amount & arrangement of vegetation successional structure, composition & cover classes, compare with the amount & arrangement of these same variables as they exist today. See the Vegetation Specialist's report for a more complete description of DIs & an explanation & example on how the DI was calculated for each PNVT.

Table 5. Vegetative states, successional structure and respective composition, cover, and departure index from historic range of variability (HRV) for the Ponderosa Pine Forest PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Percent Composition		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A,F	Grass-forb, seedling & sapling	15	0	0	
B	Young forest; < 30% canopy cover	1	0	0	
C	Mid-age forest; < 30% canopy cover	6	0	0	
D,E	Mature old forest with regeneration; < 30% canopy cover	6	100	6	
G,H	Young to mid-age forest; > 30% canopy cover	49	0	0	
I	Mature old forest with regeneration; > 30% canopy cover	23	0	0	
J	Uncharacteristic grassland (perpetual)	0	0	0	
		100	100	6	94%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x6) = 12]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (12/(100+100) = 0.06]; then subtracting that value from 1 [in this case (1-0.06) = 0.94]; & multiplying that value by 100 [in this case (0.94x100) = 94%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Mixed Conifer with Frequent Fire: This PNVT contains a mix of dominant and co-dominant species in both dry and moister environments in the Rocky Mountain (petran), madrean montane and subalpine coniferous forest biotic communities at elevations between 7,500 and 10,000 feet. Dominant and co-dominant species vary in relation to elevation and moisture availability. This PNVT is situated between the lower, drier ponderosa pine, and pine-oak forests, and higher, moister spruce-fir or subalpine conifer forests. In the lower and drier elevation portions within this PNVT, Gambel oak, ponderosa pine, piñon and alligator juniper may co-dominate. In higher and moister areas ponderosa pine may co-dominate with Rocky Mountain Douglas fir, quaking aspen, white fir, southwestern white pine, and Rocky Mountain juniper. Other vegetation that may be present but does not co-dominate in these higher, moister areas includes Engelmann and blue spruce. The understory vegetation is comprised of a wide variety of shrubs, grasses, sedges, rushes, and forbs; the composition depends on soil type, aspect, elevation, disturbance history, and other factors.

This PNVT is the third largest on the forests and covers approximately 288,840 acres, or nearly 14 percent. The ASNFs' niche for this PNVT is approximately 38 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and Coconino Plateau Coniferous Forest subsections, the ASNFs contribute 67 and 59 percent of this PNVT, respectively.

Current conditions within the Mixed Conifer with Frequent Fire Forest are severely departed from HRV (table 6). With a DI of 99 percent, this PNVT is the most departed on the ASNFs. There is a significant over representation of young to middle-age forest with closed canopy (State G,H) and a significant under representation of mature old forest with regeneration with open canopy (State D,E).

Table 6. Vegetative states, successional structure and respective composition, cover, and departure index from historic range of variability (HRV) for the Mixed Conifer with Frequent Fire Forest PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Percent Composition		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A,F	Grass-forb, seedling & sapling	9	0	0	
B	Young forest; < 30% canopy cover	1	0	0	
C	Mid-age forest; < 30% canopy cover	3	0	0	
D,E	Mature old forest with regeneration; < 30% canopy cover	1	100	1	
G,H	Young to mid-age forest; > 30% canopy cover	76	0	0	
I	Mature old forest with regeneration; > 30% canopy cover	10	0	0	
J	Uncharacteristic grassland (perpetual)	0	0	0	
		100	100	1	99%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x1) = 2]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (2/(100+100) = 0.01]; then subtracting that value from 1 [in this case (1-0.01) = 0.99]; & multiplying that value by 100 [in this case (0.99x100) = 99%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Spruce-Fir with Wet Mixed Conifer: Also known as subalpine conifer forests, this PNVT ranges in elevation from approximately 9,000 to 11,400 feet on gentle to very steep mountain slopes. Englemann spruce, blue spruce and subalpine fir or corkbark fir dominate this PNVT either mixed or alone. Douglas-fir along with mixed conifer and quaking aspen stands may also be present in this system for long periods without regeneration. Herbaceous species may include but are not limited to red baneberry, starry false Solomon's seal, spruce-fir fleabane, blackberry, and subalpine lupine.

This PNVT, at approximately 59,160 acres or nearly three percent is the smallest forest type on the ASNFs. The ASNFs' niche for this PNVT is approximately 46 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and White Mountains Scarp Woodland-Coniferous Forest subsections, the ASNFs contribute 93 and 74 percent of this PNVT, respectively.

Current conditions within the Spruce-Fir with Wet Mixed Conifer Forest are moderately departed from HRV (table 7) with a DI of 42 percent. There is a significant over representation of mid development; young to mid-aged forest with regeneration (State B) and a significant under representation of late development; mature old forest with regeneration (State C).

Table 7. Vegetative states, successional structure and respective composition, and departure index from historic range of variability (HRV) for the Spruce-Fir with Wet Mixed Conifer Forest PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Percent Composition		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Early development; grass-forb, seedling & sapling with aspen ramets	13	25	13	
B	Mid development; young to mid-aged forest with regeneration	77	35	35	
C	Late development; mature old forest with regeneration	10	40	10	
		100	100	58	42%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x58) = 116]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (116/(100+100) = 0.58]; then subtracting that value from 1 [in this case (1-0.58) = 0.42]; & multiplying that value by 100 [in this case (0.42x100) = 42%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Woodland PNVTs

Madrean Pine-Oak: This PNVT is dominated by an open to closed canopy of evergreen oaks, such as Arizona white oak, Emory oak, gray oak and wavy leaf oak, and various conifers, such as alligator juniper. In addition, annual and perennial grasses, forbs, half-shrubs and shrubs can be found beneath the woodland overstory. Madrean Pine-Oak woodlands usually occupy foothills and mountains at elevations ranging from approximately 4,000 to 7,000 feet. Climate generally consists of mild winters and wet summers with mean annual precipitation ranging from about ten to 25 inches.

At roughly 396,678 acres or nearly 20 percent of the ASNFs, this PNVT is the second largest on the forests. The ASNFs' niche for this PNVT is approximately 65 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and the Burro Mountains Oak-Juniper Woodland subsections, the ASNFs contribute 96 and 78 percent of this PNVT, respectively.

Current conditions within the Madrean Pine-Oak Woodland are highly departed from HRV (table 8) with a DI of 74 percent. There is a significant over representation of young woody species with grass understory; closed canopy (State B) and medium to old (very large) woody species with grass understory; closed canopy (State E) and a significant under representation of medium to old (very large) woody species with grass understory; open canopy (State D).

Table 8. Vegetative states, successional structure and respective composition, cover, and similarity index from historic range of variability (HRV) for the Madrean Pine-Oak Woodland PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Percent Composition		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Grass-forb, seedling & sapling	1	4	1	
B	Young woody species with grass understory; closed canopy	45	3	3	
C	Young woody species with grass understory; open canopy	9	24	9	
D	Medium to old (very large) woody species with grass understory; open canopy	7	60	7	
E	Medium to old (very large) woody species with grass understory; closed canopy	36	4	4	
F	Resprouter dominated	2	5	2	
		100	100	26	74%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x26) = 52]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (52/(100+100) = 0.26]; then subtracting that value from 1 [in this case (1-0.26) = 0.74]; & multiplying that value by 100 [in this case (0.74x100) = 74%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Piñon-Juniper: This PNVT is mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation. On the ASNFs the most common pine is the piñon. The juniper component is a variable mix of oneseed juniper, Utah juniper, alligator juniper, and Rocky Mountain juniper. In addition, annual and perennial grasses, sedges and rushes, forbs, half-shrubs, and shrubs can be found beneath the woodland overstory.

At roughly 231,049 acres, this PNVT composes nearly 12 percent of the ASNFs. The ASNFs' niche for this PNVT is approximately eight percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the Coconino Plateau Coniferous Forest and White Mountains Coniferous Forest subsections, the ASNFs contribute 58 and 24 percent of this PNVT, respectively.

Current conditions within the Piñon-Juniper Woodland are lowly departed from HRV (table 9) with a DI of 33 percent. There is a significant over representation of medium to very large size trees with open canopy (State D) and a significant under representation of early successional, grass-forb; post tree reproduction and seedling, sapling; small to medium size trees with open canopy (States A and C).

Table 9. Vegetative states, successional structure and respective composition, cover and similarity index from historic range of variability (HRV) for the Piñon-Juniper Woodland PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Percent Composition		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Early successional, grass-forb; post tree reproduction	7	20	7	
B	Small to medium size trees with closed canopy	15	10	10	
C	Seedling, sapling; small to medium size trees with open canopy	3	20	3	
D	Medium to very large size trees with open canopy	68	40	40	
E	Very large size trees with closed canopy	7	10	7	
		100	100	67	33%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x67) = 134]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (134/(100+100) = 0.67]; then subtracting that value from 1 [in this case (1-0.67) = 0.33]; & multiplying that value by 100 [in this case (0.33x100) = 33%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Grassland PNVTs

Great Basin: Rain, temperature and soils limit this PNVT to lower elevations with vegetation coverage consisting of mostly grasses and forbs with interspersed shrubs. Grass species may include but are not limited to: Indian ricegrass, threeawns, blue grama, needle and thread, New Mexico feathergrass, green needlegrass, muhlys, James' galleta, big bluestem, little bluestem, western wheatgrass, and sand dropseed. Shrub species may include but are not limited to: saltbush, jointfir, rabbitbrush, snakeweed, winterfat, juniper, and wax currant. In general, this PNVT is found on moderate to gentle slopes.

This PNVT encompasses roughly 177,681 acres or nearly nine percent of the ASNFs. The ASNFs' niche for this PNVT is approximately ten percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the Coconino Plateau Coniferous Forest and White Mountains Coniferous Forest subsections, the ASNFs contribute 59 and 38 percent of this PNVT, respectively.

Current conditions within the Great Basin Grassland are highly departed from HRV (table 10) with a DI of 68 percent. There is a significant over representation of late development - open; some shrubs, seedlings/saplings and some mid-size trees (State C) and a significant under representation of mid development - grass-forbs, open canopy (State B).

Table 10. Vegetative states, successional structure and respective composition, cover and departure index from historic range of variability (HRV) for the Great Basin Grassland PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Early development - recently burned/sparsely vegetated, open canopy	0	5	0	
B	Mid development – grass-forbs, open canopy	10	73	10	
C	Late development - open; some shrubs, seedlings/ saplings & some mid-size trees	76	20	20	
D	Mid development - some very large shrubs, closed canopy & some very large trees, open canopy	14	2	2	
		100	100	32	68 %

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x32) = 64]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (64/(100+100) = 0.32]; then subtracting that value from 1 [in this case (1-0.32) = 0.68]; & multiplying that value by 100 [in this case (0.68x100) = 68%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Semi-desert: This PNVT occurs below the Mogollon Rim at elevations ranging from 3,200 to 4,500 feet. These grasslands are bounded by the Chihuahuan Desert at the lowest elevations and Madrean Pine-Oak Woodlands or Interior Chaparral at the higher elevations. Species composition and dominance varies across the broad range of soils and topography. Dominant grassland associations/types are black grama grassland, blue grama/hairy grama grassland, tobossa grassland, giant sacaton grassland, and mixed native perennial grassland. Shrubs also inhabit these grasslands and their abundance and species composition also varies; however, juniper and mesquite are most common.

This PNVT encompasses roughly 107,599 acres or roughly five percent of the ASNFs. The ASNFs' niche for this PNVT is approximately 14 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and Burro Mountains Oak-Juniper Woodland subsections, the ASNFs contribute 58 and 24 percent of this PNVT, respectively.

Current conditions within the Semi-desert Grassland are highly departed from HRV (table 11) with a DI of 80 percent. There is a significant over representation of perennial bunchgrass with shrubs and trees, open canopy and shrubs and trees with perennial bunchgrasses, closed canopy (States C and D) and a significant under representation of grass-forb regeneration and open perennial bunchgrass (States A and B).

Table 11. Vegetative states, successional structure and respective composition, cover, and similarity index from historic range of variability (HRV) for the Semi-desert Grassland PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Grass-forb regeneration	1	24	1	
B	Open perennial bunchgrass	19	76	19	
C	Perennial bunchgrass with shrubs & trees, open canopy	23	0	0	
D	Shrubs & trees with perennial bunchgrasses, closed canopy	57	0	0	
		100	100	20	80%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x20) = 40]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (20/(100+100) = 0.20]; then subtracting that value from 1 [in this case (1-0.20) = 0.80]; & multiplying that value by 100 [in this case (0.80x100) = 80%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Montane/Subalpine: This PNVT contains a mix of dominant and co-dominant species in both dry and moister environments. This PNVT typically occurs at elevations ranging from approximately 7,500 to 11,000 feet on gentle to steep slopes. Soils in swales and on riparian benches are usually moist throughout the year, and often harbor several plant associations with varying dominant grasses and herbaceous species. Uplands and swales are dominated by different species. Common species at higher elevations in more moist sites include tufted hairgrass, sheep fescue, Nebraska sedge, yarrow, dryspike sedge, Baltic rush, and non-native Canada bluegrass and Kentucky bluegrass. The more dry upland sites are dominated by mutton bluegrass, Arizona fescue, pine dropseed, mountain muhly, White Mountain sedge, sheep fescue, woolly cinquefoil, and small-leaf pussytoes. Common species at lower elevations in more moist sites include Canada and Kentucky bluegrass (both non-native species), spike muhly, spreading fleabane, annual muhly, white clover, yarrow, and dandelion. The more dry upland sites at lower elevations are dominated by pine dropseed, blue grama, spreading fleabane, prairie junegrass, White Mountain sedge, Canada bluegrass, annual muhly, and Fendler's sandwort. Tree stands may occur along the periphery of these grasslands; primarily ponderosa pine, southwestern white pine, Engelmann spruce, and subalpine fir, depending on elevation and presence of moisture. Some shrubs may also be present.

This PNVT, at roughly 56,505 acres or nearly three percent of the ASNFs is the smallest of the grassland types. The ASNFs' niche for this PNVT is approximately 32 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and White Mountains Coniferous Forest subsections, the ASNFs contribute 96 and 74 percent of this PNVT, respectively.

Current conditions within the Montane/Subalpine Grassland are moderately departed from HRV (table 12) with a DI of 55 percent. There is a significant over representation of mid development, open canopy (herbaceous vegetation) (State B) and a significant under representation of early development, open canopy (herbaceous vegetation) and late development, closed canopy (trees, shrubs and herbaceous vegetation) (States A and C).

Table 12. Vegetative states, successional structure and respective composition, cover, and departure index from historic range of variability (HRV) for the Montane/Subalpine Grassland PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Early development, open canopy (herbaceous vegetation)	0	20	0	
B	Mid development, open canopy (herbaceous vegetation)	90	35	35	
C	Late development, closed canopy (trees, shrubs & herbaceous vegetation)	10	45	10	
		100	100	45	55%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x45) = 90]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (90/(100+100) = 0.45]; then subtracting that value from 1 [in this case (1-0.45) = 0.55]; & multiplying that value by 100 [in this case (0.55x100) = 55%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Chaparral PNVT

Interior: This PNVT is typically found on mountain foothills and lower slopes where low-elevation desert landscapes transition into Madrean Pine-Oak Woodlands. Interior chaparral consists of mixed shrub associations including but not limited to: manzanita, desert ceanothus, mountain mahogany, silktassles, Stansbury cliffrose, yerba de pasmo, evergreen oaks, and various cacti such as prickly pear, hedgehog, and globe cactus, Arizona cypress, and sumacs. Grasses typically include bullgrass and longtongue muhly.

This PNVT is roughly 56,006 acres or nearly three percent of the ASNFs. The ASNFs' niche for this PNVT is approximately 24 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and White Mountains Coniferous Forest subsections, the ASNFs contribute 78 and 61 percent of this PNVT, respectively.

Current conditions within the Interior Chaparral are not departed from HRV (table 13) with a DI of 4 percent.

Table 13. Vegetative states, successional structure and respective composition, cover, and similarity index from historic range of variability (HRV) for the Interior Chaparral PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Grass-forb regeneration, open canopy	0	2	0	
B	Grass, shrub, open canopy	9	5	5	
C	Dense shrub; no understory, closed canopy	91	93	91	
		100	100	96	4%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x96) = 192]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (192/(100+100) = 0.96]; then subtracting that value from 1 [in this case (1-0.96) = 0.04]; & multiplying that value by 100 [in this case (0.04x100) = 4%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Riparian Area/Riparian Forest PNVTs

Wetland/Cienega: This PNVT is associated with perennial springs or headwater streams, bogs and fens (very unique habitats in Arizona) where groundwater intersects the surface and creates pools of standing water, sometime with channels flowing between pools. This PNVT occurs between 3,500 and 11,000 feet elevation. Often soils in these areas may be saline. Distribution and types of vegetation vary due to a gradient in saturated soils and salinity, and elevation. Some vegetation types found in wetland/cienegas include saltgrass, yerba mansa, sacaton, giant sacaton, and bog alkaligrass in more saline areas at lower elevations. At medium and higher elevations tufted hairgrass, mannagrasses, non-natives Canada and Kentucky bluegrass, rushes, sedges, flat sedges, and spikerushes can be found, and deep pools support a variety of other aquatic vegetation. This PNVT also includes high elevation meadows with subsurface flows dominated by herbaceous cover provided by a variety of sedges, grasses and rushes. Willows may also be present.

This PNVT is roughly 11,825 acres (less than one percent of the forests' total acres). The ASNFs' niche for this PNVT is approximately 64 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Coniferous Forest and White Mountains Scarp Woodland-Coniferous Forest subsections, the ASNFs contribute 95 and 79 percent of this PNVT, respectively.

Reference conditions have not been defined for this PNVT. As with the other riparian types, these areas are often subjected to water withdrawal (from private water rights), unauthorized grazing/browsing and recreation pressure and can be profoundly impaired and water quality can be severely degraded. Domestic livestock and wild ungulate grazing and motor vehicle activity have been major management disturbances in this PNVT; however, there is no record of HRV available.

Mixed Broadleaf Deciduous: This PNVT is found along approximately 860 miles of rivers and streams starting at low elevations (approximately 3,200 feet) and climbing up to approximately 7,000 feet at the upper elevations. The vegetation is a mix of riparian woodlands and shrublands with a variety of vegetation associations. The dominant vegetation is likely to depend upon a suite of site-specific characteristics including elevation, soil type, stream gradient, and depth to groundwater. For example, one vegetation association is dominated by bigtooth maple with mixed stands of Emory oak and scattered conifers (pines and junipers). Other sites can be dominated by a mixture of the following woody species: boxelder, Fremont cottonwood, Arizona sycamore, velvet ash, Arizona walnut, desert willow, and other willow species, as well as numerous shrub, grass and forb species. This PNVT often contains several species of oak and conifers from upstream and adjacent uplands. Vegetation can be dependent upon annual or periodic flooding for growth and reproduction, especially at lower elevations.

This PNVT is roughly 6,865 acres in size (less than one percent of the ASNFs' total acres). The ASNFs' niche for this PNVT is approximately 35 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Woodland and White Mountains Coniferous Forest subsections, the ASNFs contribute 86 and 83 percent of this PNVT, respectively.

Current conditions within the Mixed Broadleaf Deciduous Riparian Forest are lowly departed from HRV (table 14) with a DI of 28 percent. There is a significant over representation of small to medium diameter trees with closed canopy (State B) and a significant under representation of seedling, sapling; small diameter trees with open canopy (State C).

Table 14. Vegetative states, successional structure and respective composition, cover, and similarity index from historic range of variability (HRV) for the Mixed Broadleaf Deciduous Riparian Forest PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Grass-forb & shrub; post reproduction	15	10	10	
B	Small to medium diameter trees, closed canopy	53	30	30	
C	Seedling, sapling; small diameter trees, open canopy	7	25	7	
D	Medium to very large diameter trees, open canopy	7	15	7	
E	Very large diameter trees, closed canopy	18	20	18	
		100	100	72	28%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x72) = 144]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (144/(100+100) = 0.72]; then subtracting that value from 1 [in this case (1-0.72) = 0.28]; & multiplying that value by 100 [in this case (0.28x100) = 28%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Montane Willow: This PNVT is found along approximately 1,130 miles of rivers and streams starting at low elevations (approximately 3,500 feet) and climbing up to approximately 11,000 feet at the upper elevations. At lower elevations this PNVT can be found along perennial streams and seasonal or intermittent drainages. Here, the dominant woody vegetation includes Fremont cottonwood, Arizona sycamore, Arizona walnut, velvet ash, and soapberry. Shrubs include a variety of willows, chokecherry and Arizona alder. A variety of herbaceous species are usually present. At higher elevations, this PNVT is found along streambanks, seeps, fens, and isolated springs. Narrowleaf cottonwood may be present in these areas. In addition, this PNVT can be shrub and herb dominated. Dominant shrubs may include thinleaf alder, birch, redosier dogwood, and a variety of willows. In many high elevation situations within this PNVT the herbaceous species component is dominated by non-native Kentucky and Canada bluegrass.

This PNVT is roughly 5,542 acres (less than one percent of the forests' total acres). The ASNFs' niche for this PNVT is approximately 23 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the White Mountains Coniferous Forest and Coconino Plateau Coniferous Forest subsections, the ASNFs contribute 63 and 53 percent of this PNVT, respectively.

Reference conditions have not been defined for this PNVT. As with the other riparian types, these areas are often subjected to water withdrawal (from private water rights), unauthorized grazing/browsing and recreation pressure and can be profoundly impaired and water quality can be severely degraded. Domestic livestock and wild ungulate grazing and motor vehicle activity have been major management disturbances in this PNVT; however, there is no record of HRV available.

Cottonwood-Willow: This PNVT is typically found at lower elevations along approximately 800 miles of rivers and streams in wider valley bottoms. Dominant woody species include narrowleaf cottonwood and a variety of willow; such as, Bebb's, greenleaf, and dewystem. Various grasses and forbs are usually present. These areas are often subjected to water withdrawal, severely depleted groundwater, heavy grazing and recreational pressure and can be profoundly degraded. Vegetation can be dependent upon annual or periodic flooding for growth and reproduction, especially at lower elevations.

This PNVT is roughly 5,198 acres (less than one percent of the forests' acres). The ASNFs' niche for this PNVT is approximately 81 percent of the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section. Within the Coconino Plateau Woodland and Coconino Plateau Coniferous Forest subsections, the ASNFs contribute 92 and 82 percent of this PNVT, respectively.

Current conditions within the Cottonwood-Willow Riparian Forest are moderately departed from HRV (table 15) with a DI of 42 percent. There is a significant over representation of medium and very large diameter trees with open canopy (State D) and a significant under representation of shrubs and small, medium and very large diameter trees with closed canopy (States B and C).

Table 15. Vegetative states, successional structure and respective composition, cover, and similarity index from historic range of variability (HRV) for the Cottonwood-Willow Riparian Forest PNVT on the ASNFs.

State	Successional Structure, Composition & Cover Class	Composition (%)		Lesser Values (c)	Departure Index (DI)†‡
		Current (a)	HRV (b)		
A	Seedlings, saplings, shrubs; post reproduction, open canopy	27	20	20	
B	Shrubs, small & medium diameter trees, closed canopy	4	25	4	
C	Medium & very large diameter trees, closed canopy	14	35	14	
D	Medium & very large diameter trees, open canopy	55	20	20	
		100	100	58	42%

† Percent Departure Index (DI) is calculated by the following method using the Czekanowski Coefficient (Czekanowski 1913): Double the sum of the lesser values between states (column c) for Current (a) & HRV (b) composition (in this case [(2x58) = 116]); dividing that value by the sum of the Current (a) composition plus the sum of the HRV (b) composition [in this case (116/(100+100) = 0.58]; then subtracting that value from 1 [in this case (1-0.58) = 0.42]; & multiplying that value by 100 [in this case (0.42x100) = 42%]

‡ DI categories are defined as: Within HRV (0-20%); Low departure (21-40%); Moderate departure (41-60%); High departure (61-80%); & Severe departure (81-100%)

Vegetation Condition and Trend

The current conditions in many of the ASNFs' vegetation communities vary, sometimes to a large extent, from historic conditions (table 16). All of the PNVTs on the ASNFs have departed to varying degrees from their HRV successional structure, composition and cover classes, and processes. These changes have brought about corresponding shifts in fire regime condition class (FRCC)[9] as well. Departures from HRV have also occurred within the overall ecoregion section and subsections, to varying degrees. In many cases, departure from HRV mirrors the situation found on the forests, but also occurs to a greater or lesser degree, than the forests, within individual ecoregion subsections.

[9] FRCC reflects the degree of departure of the PNVT's current fire regime & vegetation conditions from its reference condition (HRV) fire regime & vegetation (Hann & Bunnell 2001, Hann et al. 2005). For a more complete description of FRCC see the Vegetation Specialist's report.

Table 16. Departure of current PNVTs from their reference condition on the ASNFs [bolded] and within the White Mountains-San Francisco Peaks-Mogollon Rim ecoregion section (M313A) [bolded] and seven subsections†. Italicized subsections are primarily located above the Mogollon Rim within the ASNFs, while the non-italicized subsections are primarily located below the Mogollon Rim within the ASNFs. In addition, current Fire Regime Condition Class (FRCC‡) is displayed in parentheses. For more information concerning how this information was derived see the Vegetation Specialist's report.

Potential Natural Vegetation Type (PNVT)	Departure From Historic Range of Variability (HRV) Conditions				No Departure-Within HRV (0-20%)
	Severe (81-100%)	High (61-80%)	Moderate (41-60%)	Low (21-40%)	
Forests					
Ponderosa Pine	**ASNFs**(3), **M313A**(3), Ac(3), Ad(3), Af(3), Ag(3), *Ah*(3), *Ak*(3) & *Al*(3)				
Mixed Conifer with Frequent Fire	**ASNFs**(3), **M313A**(3), Ad(3), Af(3), *Ah*(3) & *Al(3)*	Ag(3) & *Ak*(3)			
Spruce-Fir with Wet Mixed Conifer		Ag(2)	**ASNFs**(2), **M313A**(2), Af(2), *Ah*(2) & *Al*(2)	Ad(1)	
Woodlands					
Madrean Pine-Oak	Ac(3) & *Ak(3)*	**ASNFs**(3), **M313A**(3), Ad(3), Ag(3) & *Ah*(3)	Af(2) & *Al*(2)		
Piñon-Juniper				**ASNFs**(1), **M313A**(1), Ad(2), Ag(1), *Ah*(2), *Ak*(1) & *Al*(1)	Af(1)
Grasslands					
Great Basin		**ASNFs**(3) & Ac(3)	Af(2), *Ak*(2) & *Al*(2)	**M313A**(1), Ag(1) & *Ah*(2)	Ad(1)
Semi-desert		**ASNFs**(3), Ac(3) & *Al*(3)	Af(2) & Ag(2)	**M313A**(2), Ad(1), *Ah*(1) & *Ak*(1)	
Montane/Subalpine		Ad(2), Af(2) & *Ah*(2)	**ASNFs**(2), **M313A**(2) & *Al*(2)	Ag(2) & *Ak*(1)	
Chaparral					
Interior			Ac(2)	**M313A**(1), Ad(2), Af(2) & *Ak*(1)	**ASNFs**(1), Ag(1), *Ah*(1) & *Al*(1)

Table 16. Continued.

Potential Natural Vegetation Type (PNVT)	Departure From Historic Range of Variability (HRV) Conditions				No Departure Within HRV (0-20%)
	Severe (81-100%)	High (61-80%)	Moderate (41-60%)	Low (21-40%)	
Riparian Areas/Riparian Forests					
Wetland/CienegaΔ			**ASNFs**(2) & **M313A**(2)		
Mixed Broadleaf Deciduous		Af(3), *Ak*(3) & *Al*(3)	*Ah*(2)	**ASNFs**(1), **M313A**(1), Ad(2) & Ag(1)	
Montane WillowΔ		**ASNFs**(3), **M313A**(3)			
Cottonwood-Willow			**ASNFs**(2), **M313A**(2), Ag(2) & *Ak*(2)	Ad(1) & *Al*(1)	

† Ac = M313Ac = Burro Mountains Oak-Juniper Woodland Subsection; Ad = M313Ad = Mogollon Mountains Woodland Subsection; Af = M313Af = White Mountains Scarp Woodland-Coniferous Forest Subsection; Ag = M313Ag = White Mountains Woodland Subsection; *Ah = M313Ah = White Mountains Coniferous Forest Subsection*; *Ak = M313Ak = Coconino Plateau Woodland Subsection*; & *Al = M313Al = Coconino Plateau Coniferous Forest Subsection*

‡ The HRV for all PNVTs pertaining to fire regime condition class (FRCC) was class 1

Δ Departure assessments for Wetland/Cienega Riparian Area & Montane Willow Riparian Forest PNVTs are based on information other than a departure index. White (2002) sampled several montane willow & wetland/cienega communities & found they had low similarity with ASTES (Laing et al. 1987) data. In addition, 100% of the soils within the Montane Willow Riparian Forest PNVT have been classified as "impaired"

Forest PNVTs

The three forest PNVTs all show some departure from HRV in successional structure and composition. Ponderosa Pine and Mixed Conifer with Frequent Fire are the most severely departed PNVTs on the ASNFs with a DI of 94 and 99 percent, respectively. These forest types currently have an over abundance of young- and medium-aged trees in a crowded, closed canopy condition that limits herbaceous growth. These conditions provide continuous ladder fuels for the development of uncharacteristic fire behavior. Spruce-Fir with Wet Mixed Conifer is rated moderately departed at 42 percent. The FRCC for both Ponderosa Pine and Mixed Conifer with Frequent Fire have changed from class 1 to 3. Historically, fire in these forest types burned relatively frequently and at low intensities that kept the forest open and maintained abundant herbaceous cover.

Between 2002 and 2003 more than 20 million ponderosa pines died in Arizona and New Mexico following bug attacks, primarily bark beetles (Lenart 2007a). Another quarter million acres of spruce and aspen were defoliated in Arizona in 2003. Within the last few years, insects and disease have weakened or killed approximately 28, 47, and 75 percent of forested communities since 2000 (Ponderosa Pine, Mixed Conifer with Frequent Fire and Spruce-Fir with Wet Mixed Conifer, respectively) on the ASNFs. Anhold et al. (2007) reported more incidences of bark beetle, spruce aphids, and aspen damage on the ASNFs than any other forest in Arizona. Insect, disease, and pathogen outbreaks can increase fuel loads and influence fire behavior.

Increased insect outbreaks have been associated with changes in forest structure (over crowding) coupled with the current drought. According to Lynch (2007), insect and pathogen populations have responded to changing forest character (especially to changing structure and species composition) and variability in climate. Contemporary outbreaks differ from pre-1950s regimes in that *Ips* bark beetle species are now of more significance than *Dendroctonus* species in ponderosa pine when the reverse was once the case; damage to white fir has increased; dwarf mistletoe incidence and infection severity have increased in ponderosa pine, Douglas-fir, and spruce; and the cumulative effects of several biotic and abiotic agents, which individually are seldom fatal, is causing significant, widespread mortality and decline in aspen. According to Lynch (2007), damage in the spruce-fir vegetation type is unprecedented, in terms of the identity and variety of insects causing the damage and the severity of the damage. Extensive areas of aspen die-off and decline are being converted to coniferous forests. The potential for catastrophic insect outbreaks and pathogen-related mortality continues, especially during drought periods. The current insect outbreak among ponderosa pine is an order of magnitude larger and more severe than the outbreak that occurred during the drought of the 1950s (Lynch 2007.) High temperatures, coupled with drought, and high tree densities were also identified as one of the likely causes for death loss of ponderosa pines in recent years (Swetnam 2007). Contemporary trends have enough differences from historic trends to anticipate altered ecosystem process in the future.

Non-native invasive species are another indicator of departure from HRV. Non-native invasive species[10] (see Vegetation Specialist's report for a list of the ASNFs' non-native invasive plant

[10] Native plants developed to fill unique ecological niches within their natural habitats. What we know as weeds today (non-native invasive species) did not exist in any of the PNVTs on the ASNFs prior to Euro-American settlement. Non-native invasive species developed in & are native to other countries. Like our native plants, they are kept in check in their native environment by insects, pathogens or diseases & by competition with other species. In order to survive in their native ecosystems, many plants develop characteristics that make them especially hardy. Early European settlers in North America inadvertently brought weed seeds with them, perhaps in the hay they brought for their animals or in the dirt they used as ballast for their ships, or even in their clothes or bedding. Some activities, such as clearing the land, opened up niches that created places for weeds to grow. Euro-American settlers also purposely brought plants from their "home country" to reseed areas, make dye for clothing, & use as ornamental plants. Without their natural controls, some non-native

species) infest between 8,950 and 13,450 acres within Ponderosa Pine, 2,650 and 4,000 acres within Mixed Conifer with Frequent Fire, and 500 and 750 acres within Spruce-Fir with Wet Mixed Conifer.

Roads are an additional indicator of departure from HRV. Roads occupy roughly 5,600 miles within Ponderosa Pine, 3,300 miles within Mixed Conifer with Frequent Fire, and 800 miles within Spruce-Fir with Wet Mixed Conifer. Road densities are in the order of seven linear miles per one square mile. Roads are one of the primary vectors for the spread and establishment of non-native invasive weeds.

These departures have shifted the fire regimes for all three forested types, further from HRV. These same conditions are present throughout the ecoregion section and subsection where these PNVTs occur. In their current condition, these vegetation communities are at risk from uncharacteristically large insect outbreaks and destruction by unnaturally large and intense wildfires. Under current management, the modeled trend for successional structure and composition from HRV for the Ponderosa Pine and Mixed Conifer with Frequent Fire PNVTs does not change from present conditions (even out to 1,000 years) and will still be severely departed from reference conditions. However, the projected trends for Spruce-Fir with Wet Mixed Conifer indicate it will move to within HRVs within 40 to 50 years accompanied by a decline in FRCC to class 1 (within HRV).

Aspen, as a forest type and an integral part of the and Spruce-Fir with Wet Mixed Conifer Forest, (aspen does occur incidentally as an inclusion of dissimilar site potential within the Mixed Conifer with Frequent Fire Forest PNVT) is in decline as a consequence of a combination of lack of fire, increased insects and disease, increased competition from associated conifers, and high levels of grazing/browsing. Between 1998 and 2006, aspen injury or death has been detected on over 94,000 acres on the ASNFs (Anhold et al. 2007, Lynch 2007). Aspen sites in decline on the ASNFs have been surveyed over the past several years. Aspen sites surveyed on the ASNFs were all above 7,500 ft and mortality has reached 40 percent in both mid- and high- elevation sites. Low-elevation sites are located on northerly aspects while mid- and high-elevation sites are located on various aspects. Various biotic agents have been affecting aspen, including western tent caterpillar and leaf rust (*Melampsora* sp.), which was observed throughout portions of the White Mountains in 2007. Overall, diameter distributions showed mortality was not skewed to any particular size class; however, trees with diameters greater than 9 inches generally took longer to die than smaller size classes. Several insects and pathogens were associated with aspen mortality but appeared to be acting as secondary agents on stressed trees. Although aspen ramet[11] production occurred to some degree on all sites with the death of mature trees, aspen sprouts were nearly non-existent by the summer of 2007 due to ungulate browsing.

Concerning their spatial niche, all of the above mentioned levels of departure in conditions within the forested communities on the ASNFs are generally reflective of conditions across the ecoregion section and subsections where these PNVTs occur (principally above the Mogollon Rim) (table 16).

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plants became invasive species, reducing the diversity & quantity of native plants. Non-native invasive species are continuing to spread rapidly in many areas across the ASNFs. There are many negative ecological impacts associated with non-native invasive species. They 1) displace native plants, 2) reduce biodiversity, 3) affect threatened & endangered species, 4) alter normal ecological processes (e.g., nutrient cycling, water cycling), 5) alter the natural fire regime, 6) decrease wildlife habitat, 6) reduce recreational value, & 7) increase soil erosion & stream sedimentation. Weeds know no boundaries; they also are spreading on lands within the ecoregion section & subsections as well. In fact, no one really knows how fast or how far they are spreading.

[11] A ramet is an individual plant that has grown vegetatively from another individual as a clone of that plant, but a separate plant ~ specifically the separate "offspring" plant. For instance, in a clump of aspens, one single tree that is not the original tree is a ramet.

Because of the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs have a high contribution to the sustainability of both Ponderosa Pine and Mixed Conifer with Frequent Fire PNVTs and a moderate contribution to the sustainability of Spruce-Fir with Wet Mixed Conifer. For more information see Vegetation Specialist's report.

Woodland PNVTs

The two woodland PNVTs both show departure from their HRV in successional structure, and composition. The Madrean Pine-Oak has a high departure (74 percent), which is fourth highest on the ASNFs, while the Piñon-Juniper has a low departure rating (33 percent). The Madrean Pine-Oak currently has an over abundance of young- and medium-aged trees in a crowded closed canopy condition. This departure has caused an increased change in FRCC to level 3 (highly departed). Piñon-Juniper has shifted to an abundance of medium to large trees in an open canopy condition. As yet, the departure has not caused a shift in FRCC away from level 1.

Aside from the overstory structural characteristics that have changed, understory species composition within these woodlands has changed as well. Cool season perennial grasses historically were much more prominent in the herbaceous community under HRV. Currently the understories are dominated by warm season perennial grasses. Change to these species' dominance in the understory, loss of herbaceous cover, mortality of plant species, and increased erosion within these woodlands have been attributed to past improper livestock grazing.

According to Lenart (2007a), piñon ips beetles attacked over 1 million acres of piñon-juniper woodland in Arizona in 2003. Since 2000, insects and disease have impacted from 16 to 38 percent of these woodland communities on the ASNFs. According to Swetnam (2007), high temperatures during the current drought seem to have been a critical factor in the recent die-off of piñon pine. According to Anhold et al. (2007), relatively little mortality was observed in the piñon-juniper type in 2007, on the ASNFs, as opposed to previous years. No reason was given for this.

Non-native species and roads are additional indicators of departure from HRV. Non-native invasive species are infesting between 850 to 1,300 acres within the Madrean Pine-Oak and between 2,450 and 3,700 acres within the Piñon-Juniper. There are approximately 500 and 1,900 miles of roads within these same woodland types, respectively. Road densities are in the order of three linear miles per one square mile. Roads are one of the primary vectors for the spread and establishment of non-native invasive weeds.

In their current condition, these vegetation communities are at risk from uncharacteristically large insect outbreaks and destruction by unnaturally large and intense wildfires. Under current management, projected trend for successional structure and composition from HRV is continued movement away from their respective HRVs. Madrean Pine-Oak will remain in FRCC 3 and Piñon-Juniper will move into FRCC 2 within 50 years.

Concerning their spatial niche, all of the above mentioned levels of departure in conditions within the woodland communities on the ASNFs are generally reflective of conditions across the ecoregion section and subsections where these PNVTs occur (table 16). These woodland communities have also significantly expanded their range into neighboring grasslands. More discussion about this can be found in the write-up concerning the grassland PNVTs below. Because of the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs have a moderate contribution to the sustainability of both woodland PNVTs. For more information see Vegetation Specialist's report.

Grassland PNVTs

Grasslands of the ASNFs have undergone dramatic vegetation changes over the last 130 years, including encroachment by trees and shrubs, loss of perennial grass cover, and spread of non-native species. Changes in grassland composition and structure have not occurred uniformly across the forests and their extent and distribution are poorly understood at an ecoregional scale. Moreover, these changes are dynamic and ongoing. The three grassland PNVTs all show departure from HRV in successional structure and composition. The Semi-desert is rated highly departed and has the third highest departure of any PNVT on the ASNFs. The Great Basin is also rated highly departed, while Montane/Subalpine is rated as moderately departed. Some areas of these grasslands have undergone "type conversion" from grassland to woodland. Approximately 68 percent or nearly 120,800 acres of Great Basin has been invaded by woody species, primarily piñon and juniper, due to fire suppression and the expansion of the Piñon-Juniper Woodland. Approximately 80 percent or nearly 86,080 acres of the Semi-desert has been invaded by woody species, primarily juniper and mesquite, due to fire suppression and the expansion of the Madrean Pine-Oak Woodland. Finally, approximately ten percent or nearly 5,900 acres of the Montane/Subalpine has been invaded by woody species, primarily mixed conifer, ponderosa pine, or piñon-juniper, depending on elevation and aspect. According to Lenart (2007b), climate change may also be one of the major contributors to woody species encroachment into grasslands; because grasslands rank among the most sensitive ecosystems to climatic fluctuations, whether from natural variability or climate change (Lenart 2007c).

According to the Gori and Enquist (2003) and Marshall et al. (2006), amongst national forests in Arizona, the ASNFs have experienced a larger proportion of its grasslands converted to shrublands. Woody species establishment and expansion into these grasslands has caused a shift in site productivity and potential due to loss of herbaceous vegetation and concurrent increases in soil erosion, with resulting loss of soil fertility and productivity. These departures have also shifted the fire regimes for all three grasslands further from HRV. Insects and disease have impacted from seven to 15 percent of these grassland communities since 2000. Non-native invasive species and roads are additional indicators of departure from HRV. Across these grasslands non-native invasive species are infesting between 3,500 and 5,200 acres and more than 3,500 miles of roads are present within these communities; from greatest to least - Great Basin, Montane/Subalpine and Semi-desert for both non-native invasive weeds and roads, respectively. Road densities are in the order of seven linear miles per one square mile. Roads are one of the primary vectors for the spread and establishment of non-native invasive weeds.

There are no trend (state and transition) models for Great Basin or Montane/Subalpine Grasslands at this time; however, modeling for the Semi-desert Grassland can help explain future trends for all three. Projected trends of current management continue to move the Semi-desert Grassland even further from its HRV. Under current management, the ASNFs will continue to lose all three of these grassland communities.

Concerning their spatial niche, within the ecoregion section and subsections the Great Basin and Semi-desert grasslands are, in general, less departed from their respective HRVs where these PNVTs occur than on the ASNFs (table 16). Because of the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs have a moderate contribution to the sustainability of all three grassland communities. For more information see Vegetation Specialist's report.

Chaparral PNVT

The Interior Chaparral PNVT successional overstory structure and composition and FRCC (class 1) are within their HRV. Insects and disease have impacted about 19 percent of this community since

2000. Non-native invasive species and roads are indicators that there is some departure from HRV. Non-native invasive species are infesting between 100 to 150 acres and there are more than 160 miles of roads within this community. Road densities are in the order of two linear miles per one square mile. Roads are one of the primary vectors for the spread and establishment of non-native invasive weeds.

Concerning the spatial niche, all of the above mentioned levels of departure in conditions within the Interior Chaparral are generally reflective of conditions across the ecoregion section and subsections where this PNVT occur (table 16). Because of the degree of departure and proportion of this PNVT off-forests; the ASNFs have a low contribution to the sustainability of Interior Chaparral. For more information see Vegetation Specialist's report.

Riparian Areas/Riparian Forests PNVTs

Riparian areas are important because of the rarity of water in the region. The spatial extent of these riparian PNVTs is less than two percent of the ASNFs; however, they make up major portions of these PNVTs within the ecoregion. The small areal extent, coupled with the generally shallow saturated zone beneath them, make them vulnerable to changes in climate and management. The lingering effects of historic overgrazing and poorly located roads continue to be ecological concerns. Quantitative information regarding changes within the Wetland/Cienega and Montane Willow communities is unavailable at this time due to a lack of defined HRV. However, all of the riparian communities are considered low to highly departed, depending on the PNVT; Montane Willow highly[12], Mixed Broadleaf Deciduous low, and both Wetland/Cienega and Cottonwood-Willow moderately departed. Periodic floods and low-intensity fires were the primary disturbance factors shaping vegetation patterns in riparian areas. Changes in climate, including drought and summer floods, have resulted in a loss of mature and sapling trees, and therefore a reduced canopy cover. In addition, riparian tree species are not successfully reproducing. During drought conditions, riparian areas are more susceptible to damage from wildfire than under normal conditions. Montane Willow is in FRCC 3, Wetland/Cienega and Cottonwood-Willow are in FRCC 2, and Mixed Broadleaf Deciduous has a FRCC of 1.

Insects and disease have impacted from 11 to 23 percent of these riparian communities since 2000. Non-native invasive species and roads are additional indicators of departure from HRV. Non-native invasive species are infesting between 1,000 and 1,500 acres and there are more than 2,050 miles of roads within these communities. Road densities are in the order of 45 linear miles per one square mile. Roads are one of the primary vectors for the spread and establishment of non-native invasive weeds.

Vegetation models do not exist at this time to predict vegetation trend in relation to HRV for these riparian PNVTs. When models become available there will be a need to revisit this analysis to reassess trends within these riparian communities. That said; other data, including Proper Functioning Condition (see the Riparian Condition and Trend section for more information on Proper Functioning Condition) assessments as well as sampled sites (White 2002) show low similarity with ASTES data

[12] Departure assessments for Montane Willow Riparian Forest & Wetland/Cienega Riparian Area PNVTs are based on information other than a departure index. White (2002) sampled several montane willow & wetland/cienega communities & found they had low similarity with ASTES (Laing et al. 1987) data. In addition, 100% of the soils within the Montane Willow Riparian Forest PNVT have been classified as "impaired." What's more, some Proper Functioning Condition assessment data shows some sampled Wetland/Cienegas as Non Functioning or Functioning at Risk (see the Riparian Condition & Trend section for more information on Proper Functioning Condition).

in many locations. These data indicate that trend in these PNVTs are moving away from HRV for soil condition; bare ground has increased while vegetation and litter cover have declined. Since 1995, livestock grazing has been removed or limited from a substantial portion of these PNVTs across the ASNFs; however, as yet there is no data to indicate affect on trends across these riparian communities.

Concerning their spatial niche; there is no off-forest data to indicate levels of departure from HRV for Wetland/Cienegas and Montane Willow communities (however, they are believed to be at least as departed as conditions found on the forests). Where Cottonwood-Willow occurs, off-forests, within the ecoregion, departure from HRV is generally low to moderate (table 16). Where Mixed Broadleaf Deciduous occurs, off-forests, within the ecoregion, HRV departure ratings range across the spectrum from low to high (table 16). Because of the uncertainty in the degree of departure, and the proportion of each of these PNVTs off-forests; the ASNFs have a high contribution to the sustainability of both Montane Willow and Cottonwood-Willow PNVTs and a moderate contribution to sustainability of both Wetland/Cienega and Mixed Broadleaf Deciduous PNVTs. For more information see Vegetation Specialist's report.

Description of the riparian vegetation in the above section relates primarily to vegetative overstory structure and composition. Riparian (aquatic) area conditions are also described below in the Aquatic Resources section and considers hydrology, ground cover vegetation, and erosion/deposition (soils) attributes and processes of the land that meet the definitions of a riparian area. The riparian conditions found in the Aquatic Resources section are described in miles, and include many of the riparian areas that only can be represented cartographically as a line symbol.

Soil Resources

Overview

The Region 3 ecological sustainability report (Forest Service 2006) provides guidance for the forests to evaluate terrestrial ecosystems (ecological units) and soil resource characteristics most important in assessing ecosystem diversity. The objective is to identify specific ecological needs for change from current conditions. The analysis includes an evaluation of ecological units; soil resource current and estimated historic conditions, disturbances, and processes; trends and projected future conditions; and an evaluation of ecosystem risks (see chapter 4).

The following sections summarize findings found within and referred to within this documents, as the Soil Specialist's report, titled "An evaluation of Terrestrial Ecosystems (Ecological Units, Soil Composition, Structure and Processes) that affect ecosystem diversity and contribute to ecological sustainability". The ASTES (Laing et al. 1987) was used extensively in the analysis. There are no comparable data for areas outside the forests; therefore detailed analysis was not completed for scales larger than the forests' boundary.

Current and Reference Conditions

Forestwide, soil conditions were evaluated following Forest Service Handbook (Forest Service FSH 2509.18 R-3 Supplement) guidance, the ASTES report and other project level analyses. The soil resource characteristics that were evaluated included, soil condition (refined), soil loss soil condition using the Universal Soil Loss Equation USLE[13], soil productivity, and organic matter. Microbiotic

[13] The Universal Soil Loss Equation (Dissmeyer & Foster 1980) is an index based, empirically derived model modified for use in forestry & range management scenarios. The erosion estimates are judged against a

crusts were analyzed qualitatively and are discussed separately. Detailed analysis of these five factors is found within the Soil Specialist's report. Soil condition (refined) is considered a synthesis rating of soil resources, and is described in more detail within this report.

Maintaining satisfactory soil condition is important in maintaining long-term soil productivity; which is fundamental to sustaining ecosystem diversity. Unsatisfactory and impaired soil conditions result in reduced ability of the soil to grow plants and sustain productive, diverse vegetation and to provide favorable conditions for ecosystem diversity.

Vegetative ground cover is essential to maintain and improve soil organic matter levels, water infiltration rates, and productivity of all soils. Surface vegetative ground cover biodegrades into organic matter which is an important process of soil nutrient cycling and improves water infiltration into the soil. Groundcover increases the resistance to water flow which decelerates runoff, and reduces soil erosion due to overland flow and raindrop impacts.

Soil Condition (Refined)

Soil condition (refined)[14] is a qualitative rating developed within the Southwestern Region of the Forest Service that provides an overall picture of soil condition vital in sustaining ecosystems. It is based on three soil functions; the ability of soil to resist erosion, the ability of soil to infiltrate water, and the ability of soil to recycle nutrients.

From the Forest Service supplement referenced above, 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.
- *Inherently Unstable* - These soils have natural erosion rates exceeding tolerable limits. Based on soil loss models, these soils are eroding faster than they are renewing themselves.

Satisfactory soil condition also signifies that a low level of erosion is occurring, i.e. at a rate less than the estimate of the annual rate that soil is formed. This represents maintenance of soil productivity. Impaired or unsatisfactory soil conditions signify that a higher level of erosion than soil formation is occurring and represents continued loss of soil productivity. Some soils in unsatisfactory soil condition, such as those of the Great Basin Grassland PNVT, may be long-term or near-irreversibly disturbed and may not be able to revert back to the historic soil productivity levels or PNVTs due to loss of topsoil (Vander-Lee et al. 2006).

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criterion (tolerance) & those practices that meet the criterion to provide satisfactory erosion control for the site.

[14] The term "soil condition (refined)" will be referred to as "soil condition" within this document.

Table 17 presents the acreage and proportional extent of soil condition by PNVT for the ASNFs. The areas with the highest percentage of satisfactory conditions are found in the Wetland/Cienega, Spruce-Fir with Wet Mixed Conifer, Ponderosa Pine, Montane/Subalpine, and Mixed Conifer with Frequent Fire PNVTs (figure 7). Eighty-three percent or more of each of these PNVTs are generally in satisfactory soil condition. Indicators signify that soil function is being sustained and soil is functioning properly and normally. Satisfactory condition implies that the ability of the soil to maintain resource values and sustain outputs is high.

ASNFs' PNVTs with the greatest areas of impaired soil conditions are Great Basin Grassland, Piñon-Juniper Woodland, Montane Willow, Mixed Broadleaf Deciduous, and Cottonwood-Willow Riparian Forests. Fifty-seven percent or more of each of these PNVTs are generally in impaired soil condition. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. Predominant riparian condition is functional at risk (FAR), which loosely corresponds to an impaired soil condition. Riparian habitats in general are improving in condition across the forests. Improvement in riparian condition can be rapid in headwater areas with implementation of improved road and grazing management.

Table 17. Acreage and proportional (percent) extent of soil condition by potential natural vegetation types (PNVT) for the ASNFs.

Potential Natural Vegetation Type (PNVT)	Satisfactory		Impaired		Unsatisfactory		Unsuited/Unstable		ASNFs Sum of Acreage Totals
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
Forests									
Ponderosa Pine	568,302	94	0	0	36,275	6	0	0	604,577
Mixed Conifer with Frequent Fire	251,291	87	0	0	37,549	13	0	0	288,840
Spruce Fir with Wet Mixed Conifer	59,160	100	0	0	0	0	0	0	59,160
Woodlands									
Madrean Pine-Oak	15,867	4	35,701	9	115,037	29	230,073	58	396,678
Piñon-Juniper	41,589	18	166,355	72	0	0	23,105	10	231,049
Grasslands									
Great Basin	10,661	6	161,690	91	5,330	3	0	0	177,681
Semi-Desert	6,456	6	27,976	26	16,140	15	55,951	52	107,599
Montane/Subalpine	50,855	90	5,651	10	0	0	0	0	56,505
Chaparral									
Interior	0	0	0	0	10,641	19	45,365	81	56,006
Riparian Areas/Riparian Forests									
Wetland/Cienega	11,825	100	0	0	0	0	0	0	11,825
Mixed Broadleaf Deciduous	0	0	6,865	100	0	0	0	0	6,865
Montane Willow	0	0	5,542	100	0	0	0	0	5,542
Cottonwood-Willow	0	0	2,599	50	2,599	50	0	0	5,198
Grand Total	1,023,838	51	421,580	21	220,828	11	341,279	17	2,007,525†

† Total as forest acreage and percent does not include Water/Urban/Agriculture or Disturbed/Altered or other private land area acres and percentages

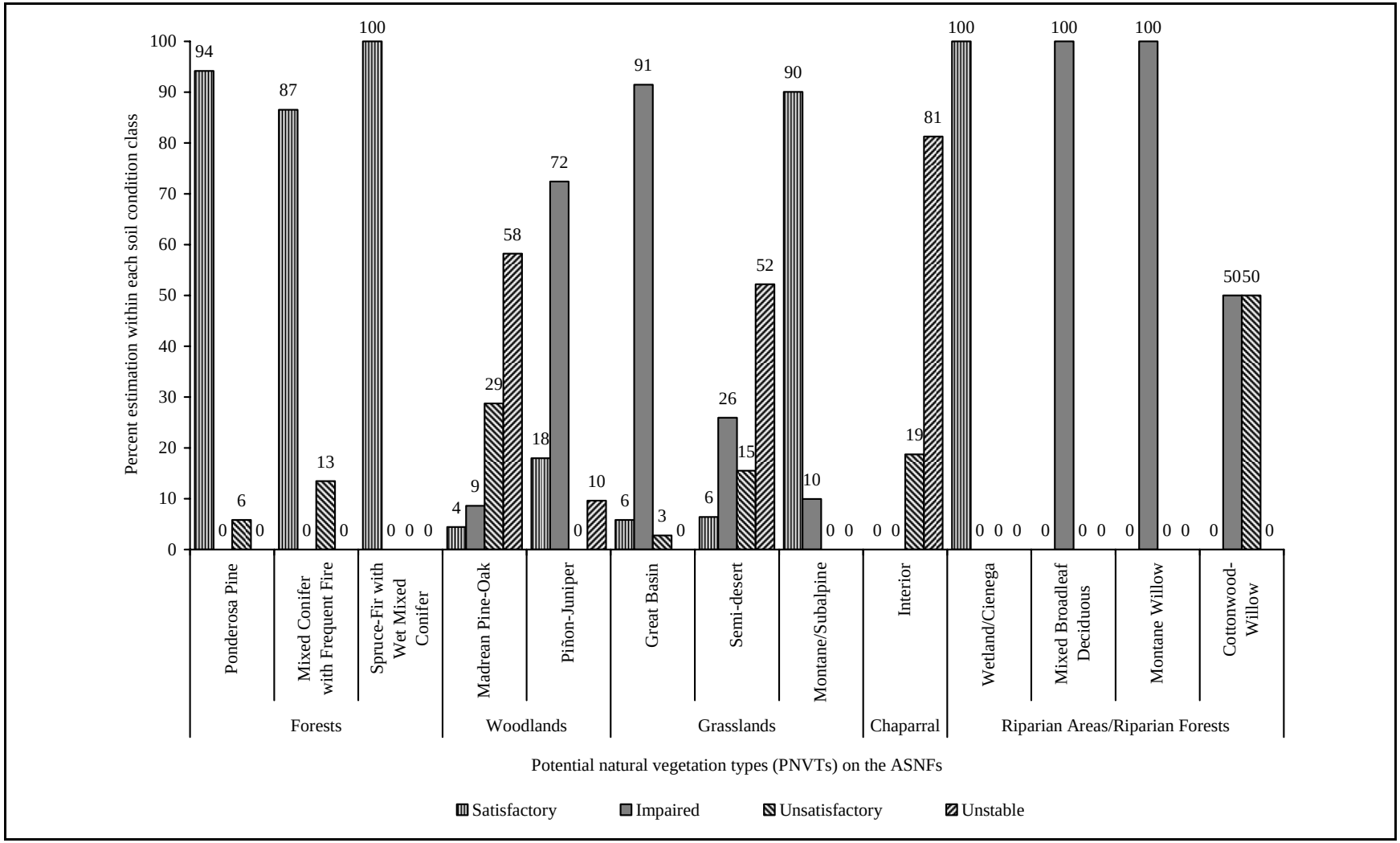

Figure 7. Percentage of soil condition classes; satisfactory, impaired, unsatisfactory, and unstable by the potential natural vegetation types (PNVTs) on the ASNFs.

The PNVTs with the greatest areas of unsatisfactory soil conditions are found in the Madrean Pine-Oak Woodland, Interior Chaparral, Cottonwood-Willow Riparian Forest, and Semi-desert Grassland. Fifteen percent or more of each of these PNVTs are generally in unsatisfactory soil condition. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs, or recover from impacts. Unsatisfactory soil conditions signify that a high level of erosion is occurring and that there is reduced infiltration. Litter and plant basal area levels, plant diversity, and adequate distribution across the soil surface are also lacking. This condition causes continued loss of soil and productivity beyond the capability to rebuild topsoil.

ASNFs' PNVTs with the greatest areas of unsuited and/or inherently unstable soil conditions are Interior Chaparral, Madrean Pine-Oak Woodland, and Semi-desert Grassland. Fifty-three percent or more of each of these PNVTs are generally in unsuited and/or inherently unstable soil condition. Unsuited soil conditions are those soil types that are inherently unstable, generally due to unstable geologic formations or very steep slopes.

Forestwide, approximately 50 percent of the soils (somewhat more than 1 million acres) are in satisfactory condition while approximately 21 percent, or slightly more than 400,000 acres, are impaired. About 11 percent, or roughly 221,000 acres, are in unsatisfactory condition and about 17 percent, or approximately 341,000 acres, are unsuited or inherently unstable. Most areas that are currently in impaired and unsatisfactory soil condition would probably have historically (HRV) been in satisfactory soil condition for a combined total of about 82 percent of the ASNFs (1,023,838acres) in satisfactory soil condition. About 17 percent of the ASNFs (341,279 acres) would have been unsuited or inherently unstable historically. Table 18 displays this information (Forest Service 2007b). Historic conditions were those present prior to the appearance of Euro-American settlement, generally considered to have been in the early 1800s (Forest Service 1991). Since then, large areas of public lands were denuded and otherwise altered through grazing, timbering, and related road construction, resulting in loss of soil cover and productivity (Forest Service 1991). For example, off highway vehicle use currently adds to loss of soil function in localized areas.

Table 18. Estimated historic (HRV) versus current soil condition percentages by soil condition class on ASNFs.

Soil Condition Class	Historic (HRV) Percent	Current Percent	Departure from HRV
Satisfactory	82	as low as 51	as much as 31
Unsatisfactory	unknown, but thought to be < 5	11	11
Impaired	unknown, but thought to be < 5	as much as 21	as much as 21
Inherently unstable	17	17	0

Soil Loss Soil Condition

The ASTES identified current, tolerance, potential, and natural soil loss by ecological map unit. On-site soil loss is modeled forestwide based on the Universal Soil Loss Equation (USLE).

Soil condition classes used for soil loss soil condition are satisfactory, unsatisfactory and unsuited. Satisfactory soil conditions signify that current erosion is less than the soil tolerable (*T*) threshold. Threshold values vary by soil type and roughly equate to the point where annual soil renewability is greater than soil loss and soil productivity is sustained. Erosion rates higher than *T* levels cause a loss of soil surface horizons and soil productivity. Conversely, erosion rates less than *T* levels allow for the soil to naturally regenerate enough and do not cause a loss of soil productivity. Satisfactory soil conditions signify that low levels of erosion are occurring less than *T* and therefore represent

maintenance of soil productivity. Unsatisfactory soil conditions signify a high level of erosion is occurring more than *T* levels and therefore represents continued loss of soil and productivity. Unsuited soil conditions are those soils that are inherently unstable due to unstable geology or very steep slopes.

Table 19 summarizes current soil loss soil condition forestwide as compared to HRV. Most unsatisfactory conditions are assumed to be satisfactory under HRV due to general lack of anthropogenic disturbance.

Table 19. Estimated historic range of variability (HRV) versus current soil loss soil condition percentages by soil condition class on ASNFs.

Soil Condition Class	Historic (HRV) Percent	Current Percent	Departure from HRV
Satisfactory	82	as low as 71	as much as 11
Unsatisfactory	low (< 5)	as much as 12	as much as 12
Unsuited/Inherently Unstable	18	18	0

Table 20 shows estimated soil loss soil condition classes for each PNVT on the ASNFs. See table 23 for a summary of soil loss soil condition by PNVTs as compared to HRV and estimated trend based on past, current and projected future activities and conditions.

Table 20. Forest soil condition (soil loss) by potential natural vegetation type (PNVT) for the ASNFs.

Potential Natural Vegetation Type (PNVT)	Satisfactory		Unsatisfactory		Unsuited/Unstable		Forest Total		Percent Contribution of ASNFs to Ecoregion Section
	Acres	Percent in PNVT	Acres	Percent in PNVT	Acres	Percent in PNVT	Acres	Percent in PNVT	
Forests									
Ponderosa Pine	568,302	94	36,275	6	0	0	604,577	30.0	13.2
Mixed Conifer with Frequent Fire	251,291	87	40,438	14	0	0	288,840	14.3	38.4
Spruce-Fir with Wet Mixed Conifer	59,160	100	0	0	0	0	59,160	2.9	46.0
Woodlands									
Madrean Pine-Oak	35,701	9	122,970	31	241,974	61	396,678	19.7	64.5
Piñon-Juniper	207,944	90	0	0	23,105	10	231,049	11.5	7.9
Grasslands									
Great Basin	172,351	97	5,330	3	0	0	177,681	8.8	9.9
Semi-desert	107,599	100	0	0	0	0	107,599	5.3	14.1
Montane/Subalpine	12,996	23	14,126	25	29,383	52	56,505	2.8	32.3
Chaparral									
Interior	0	0	10,641	19	45,365	81	56,006	2.8	24.0
Riparian Areas/Riparian Forests									
Wetland/Cienega	11,825	100	0	0	0	0	11,825	0.6	64.0
Mixed Broadleaf Deciduous	6,865	100	0	0	0	0	6,865	0.3	34.8
Montane Willow	5,542	100	0	0	0	0	5,542	0.3	22.8
Cottonwood-Willow	5,198	100	0	0	0	0	5,198	0.3	80.5
Forests†	1,425,343	71	240,903	12	361,355	18	2,007,525	100	38.0
Forest Percentage of Ecoregion Section†									17.0

† Total as forest acreage and percent does not include Water/Urban/Agriculture or Disturbed/Altered or other private land area acres and percentages

Soil Productivity and Soil Organic Matter

Current soil productivity is estimated by analyzing and combining current soil organic matter and current forage production, and incorporates current disturbances believed to decrease soil productivity. Potential soil productivity is an estimate of organic matter and forage production potential[15] without sustained periodic or episodic disturbances and may be useful in estimating historic soil productivity. Production potentials are based on soil-climate relationships and are found in the ASTES (Laing et al. 1987) report by mapping unit component. Some soils in unsatisfactory soil condition (some Great-Basin and Semi-desert Grasslands, and Piñon-Juniper Woodland PNVTs) may be long-term or nearly irreversibly disturbed and may not be able to return to their historic soil productivity levels (displayed in table 21).

Very little data exists to measure historical soil productivity and organic matter. However, some qualitative and quantitative inferences can be made and estimated providing insight into historic conditions primarily using knowledge about present disturbances and their effect on organic matter and productivity. Historic conditions analyzed here generally estimate conditions prior to Euro-American settlement conditions unless otherwise noted. Historic soil productivity can be estimated from an understanding of soil taxonomy, disturbances, and erosional processes and from productivity potential referenced in the ASTES (Laing et al. 1987) The published ASTES (Laing et al. 1987) identifies the herbaceous productivity potentials under each mapping unit component and is based on documented reference sites, both forestwide and regionwide. In part, soils are classified based on their current levels of soil organic matter. The most productive soils listed above are believed to have had equal to or more organic matter and productivity historically because they were not subject to equal amounts of disturbances seen over the last century.

Coarse woody material (greater than three inch diameter) amounts are variable across ponderosa pine and mixed conifer forests, but have been observed to be low in some areas following timber sales, thinning, or debris pile burning (Nelson personal observations: 1978-2007, ASNFs' Best Management Practices monitoring 2006, 2007). Reference conditions of coarse woody material levels are largely unknown. Hazardous fuel treatments (including debris pile burning) can leave too little coarse woody material, decreasing nutrient cycling function and long-term soil productivity (Graham 1994, Forest Service FSH 2518.22). Both internal soil organic matter and surface litter (including coarse woody material) contribute to maintenance of soil productivity. This, in turn, contributes to sustaining ecosystem diversity and those species that depend on the habitat for their survival. Little research is available for minimum coarse woody material levels needed to sustain soil organic matter for PNVTs in Arizona other than ponderosa pine and mixed conifer forests. Tables 21 and 22 compare historic, current, and predicted future estimates of soil organic matter and productivity.

Table 21. Current and estimated historic range of variability (HRV) for forage production and soil productivity by potential natural vegetation type (PNVT) for the ASNFs.

Potential Natural Vegetation Type (PNVT)	Current Forage Production	Potential (HRV) Forage Production	Current Soil Productivity	Potential (HRV) Soil Productivity	Departure from HRV
Forests					
Ponderosa Pine	low (L)	moderate (M)	M	M - high (H)	notable (N)
Mixed Conifer with Frequent Fire	L	L - M	M - H	M - H	
Spruce-Fir with Wet Mixed Conifer	L	L	M - H	M - H	

[15] Forage production potential is an estimate in pounds per acre of the annual-yield (air-dry/normal year) of herbaceous/woody plants that may provide food for grazing animals (Laing et al. 1987).

Table 21. Continued

Potential Natural Vegetation Type (PNVT)	Current Forage Production	Potential (HRV) Forage Production	Current Soil Productivity	Potential (HRV) Soil Productivity	Departure from HRV
Woodlands					
Madrean Pine-Oak	L - M	M	L - M	M	
Piñon-Juniper	L	M	L - M	M	N
Grasslands					
Great Basin	L - M	M	L - M	M	N
Semi-desert	L - M	M - H	L - M	M	N
Montane/Subalpine	M	H	M - H	H	N
Chaparral					
Interior	L - M	L - M	L - M	L - M	
Riparian Areas/Riparian Forests					
Wetland /Cienega	M - H	H	H	H	
Mixed Broadleaf Deciduous	L	L	L - M	L - M	
Montane Willow	M - H	M - H	M - H	M - H	
Cottonwood-Willow	L	L	L	L	

Notable departures between current and historic potential productivity are listed above. These PNVTs with associated departures have the greatest need for change to restore or improve soil and herbaceous vegetation productivity. PNVTs rated as high have soils that are capable of producing the greatest amount of herbaceous vegetation within the capabilities of the individual PNVT. The categories used are based on an analysis of the thickness of the surface organic matter (in the topsoil or A horizon), soil texture, depth to bedrock, and known disturbances. Categories used are qualitative descriptions based on the Forest Soil Scientist's expertise.

Table 22. Current and potential (historic range of variability [HRV]) surface organic matter (litter) by potential natural vegetation type (PNVT) on the ASNFs.

Potential Natural Vegetation Type (PNVT)	Current Surface Organic Matter (Litter)	Potential (HRV) Surface Organic Matter (Litter)	Departure from HRV
Forests			
Ponderosa Pine	high (H)	H	
Mixed Conifer with Frequent Fire	H	H	
Spruce-Fir with Wet Mixed Conifer	H	H	
Woodlands			
Madrean Pine-Oak	moderate (M)	M - H	notable (N)
Piñon-Juniper	low (L) - M	M	N
Grasslands			
Great Basin	L - M	M	N
Semi-Desert	L	M	N
Montane/Subalpine	L - M	M	N
Chaparral			
Interior	L	L-M	N
Riparian Areas/Riparian Forests			
Wetland/Cienega	M - H	H	N
Mixed Broadleaf Deciduous	L	M	N
Montane Willow	M	M	
Cottonwood-Willow	L	M	N

Microbiotic Crusts

Microbiotic (biological) crusts have not been quantified in any detail. However, a qualitative summary may be useful in describing existing conditions, the ecological role of microbiotic crusts[16], disturbance effects, risks, and ecological need for change.

Microbiotic crusts are communities of organisms living at the soil surface. Major components are cyanobacteria, green algae, microfungi, mosses, liverworts and lichens (Belnap et al. 2001, 2006). Biological soil crusts are commonly found in all of the forests' vegetation communities, but are most important in semiarid and arid environments. They have been observed in coarse textured soils predominantly in Piñon-Juniper Woodland and Semi-desert Grasslands on the forests and to a limited extent in other PNVTs dryer than Piñon-Juniper Woodlands, such as the Madrean Pine-Oak Woodland. Most areas where crusts have been observed, the crusts currently cover less than five percent of the soil surface. However, there are areas within the Ponderosa Pine and Piñon-Juniper PNVTs that were burned by the Rodeo-Chediski Fire[17] where microbiotic crusts cover up to ten percent of the soil surface.

Microbiotic crusts play an important ecological role in the environment (Belnap et al. 2001, 2006). Because they are concentrated in the top one to four millimeters of soil, they primarily affect processes that occur at the soil surface or soil-air interface. Microbiotic crusts increase soil stability and resistance to erosion, atmospheric nitrogen-fixation, nutrient contributions to plants, soil-plant-water relations, surface water infiltration, seedling germination, and plant growth. Fungi, both free-living and as a part of lichens, contribute to soil stability and water infiltration by binding soil particles with hyphae. Lichens and mosses assist in soil stability by binding particles with rhizines/rhizoids, increasing resistance to wind and water erosion. The increased surface topography of some crusts, along with increased aggregate stability, further improves resistance to wind and water erosion.

Crusts are well adapted to severe growing conditions, but poorly adapted to compressional disturbances. Livestock and elk grazing, and more recently, recreational activities (hiking, biking, and driving off roads and trails) place a heavy toll on the integrity of the crusts. Disruption of the crusts brings decreased organism diversity, soil nutrients, stability (and increased soil loss), and decreased organic matter and soil productivity. According to Belnap et al. (2001, 2006), studies of trampling disturbance have noted that moss and lichen cover, and cyanobacteria can be severely damaged or lost; leading to significant levels of water runoff and soil erosion; even before apparent injury to associated vegetation is evident.

Historical information regarding microbiotic crusts is limited and not quantified on the forests. However, reference sites in piñon-juniper woodlands located in Grand Canyon National Park that have not been subjected to livestock grazing impacts have been studied. These sites are typically in tree interspaces, have coarse-textured sandy loam soils, and high amounts of microbiotic crusts with

[16] Microbiotic soil crusts are a complex mosaic of living organisms - algae, cyanobacteria (blue-green algae), bacteria, lichens, mosses, liverworts, & fungi - that grow on or just below the soil surface. Biological soil crusts are common worldwide in arid & semi-arid chaparral, grasslands, & woodlands. Biological soil crusts are, literally, a carpet of photosynthetic life, they stabilize the soil, they make the soil more fertile, they may help the soil to retain more moisture, & the nature of the crust itself can keep unwanted plants, such as noxious & invasive weeds, out. Because of their functions in rangeland systems, biological soil crusts have been adopted by scientists & land management professionals as a visible indicator of rangeland health.

[17] The Rodeo-Chediski fire burned approximately 175,000 acres on the ASNFs in 2002. A little more than 50% of the fire burned at moderate or high soil burn severity, where soil cover was effectively removed exposing large areas of bare soil.

structure similar to those found in the forests. Coverage by microbiotic crusts can range from about five to 40 percent of the total soil surface. Off-highway vehicles (OHVs) and equipment used in logging and fuelwood harvest can also disturb crusts, especially when soils are moist (Belnap et al. 2001, 2006). It is not known what the microbiotic crust composition or coverage was historically on forests' PNVTs so no detailed inferences can be made.

Comparison of Current, Reference and Projected Future Conditions

No models currently exist to project trends and predict future conditions for soil resources, in particular, soil loss soil condition, soil condition, soil productivity, or soil organic matter. However, qualitative inferences can be made and estimated providing insight into future soil conditions primarily using knowledge about present disturbances and their effect on erosion processes, soil compaction, and nutrient cycling. Analysis (see Soil Specialist's report) that generally estimate trends and conditions using existing data and current conditions, combined with projected future vegetation conditions derived from the forests' VDDT models (see footnote seven for further explanation of modeling). The VDDT models predict overall dominant vegetation condition and trends and describe relative amounts in each of the defined ecological states for each PNVT[18] in the future (from 20 to 1,000 years).

Table 23 presents the estimated current departure from HRV and projected trend for vegetation and soil resources by PNVT that key on combinations of current departure (low, moderate, and high) from the HRV for soil condition, organic matter, ground vegetation, and PNVT. Inferences of future conditions and trend are made based on current knowledge of how canopy cover (and ecological state) presently affects these key soil components.

Recently implemented grazing allotment and forest health projects are expected to effectively improve some soil conditions; however, there is still a large gap between historic and current plant community and soil conditions. Trends in soil condition vary by PNVT. Soil condition in the Madrean Pine-Oak and Piñon-Juniper Woodland, and Semi-desert and Great Basin Grassland PNVTs are generally considered to be in a static to downward or degrading trend. Areas in woodland and grassland PNVTs with heavy canopy cover require thinning to improve soil conditions. Current levels of overstory treatment within these PNVTs, while effective in improving vegetation and soil conditions, are not of adequate scale to reverse current trends.

Trends in soil productivity and surface organic matter are variable by PNVT. Generally conditions are projected to be static at some level below those estimated for potential conditions. A combination of improved grazing strategies, mechanical thinning of invading woodland species and introduction of fire within fire dependent ecosystems should slowly improve litter cover, soil organics and forage production on treated areas. At current management levels, however, the amount of area improved is insufficient to affect conditions forestwide. As stated in soil condition discussions, estimates of future condition at the forest scale are based on the vegetative states, structure, composition, and cover estimates of historic, current, and future conditions through modeling tools described in the vegetation section of this report. These indicate that Madrean Pine-Oak and Piñon-Juniper PNVTs and grassland types are and will continue to be highly divergent from historical conditions, with a corresponding departure in soil productivity and surface litter.

[18] PNVTs are coarse-scale groupings of ecosystem types that share similar geography, vegetation, & historic ecosystem disturbances such as fire, drought, & grazing by native species. They represent the "climax" vegetation that will occupy a site.

Macrobiotic Crusts: Since current composition and density of macrobiotic crusts have not been inventoried, we can only infer trends based on current and projected management impacts that have been shown in research to alter populations of macrobiotic crusts. Of most importance is the role macrobiotic crusts play in maintaining productivity of the Semi-desert and Great Basin grasslands and woodland ecosystems. Mosses and other macrobiotic crust forming organisms are found in wetter environments, but are less important to overall soil productivity.

It is estimated that improved livestock management that is currently being implemented on the forests will benefit macrobiotic crusts. More emphasis on biomass harvesting may result in more macrobiotic crust disturbance through harvesting activities within woodlands, as well as grasslands with encroaching woody species.

Table 23. Estimated current departure from historic range of variability (HRV) and projected trend for soil resources and vegetation by potential natural vegetation type (PNVT) on the ASNFs.

Potential Natural Vegetation Type (PNVT)	Soil Condition (refined) in Relation to HRV		Soil Loss Soil Condition in Relation to HRV		Soil Organic Matter & Productivity in Relation to HRV		Vegetation in Relation to HRV	
	Departure	Trend	Departure	Trend	Departure	Trend	Departure	Trend
Forests								
Ponderosa Pine	low (L)	slightly away	L	static	L	slightly away	severe (S)	static
Mixed Conifer with Frequent Fire	L	slightly away	L	static	L	slightly away	S	static
Spruce-Fir with Wet Mixed Conifer	L	static	L	static	L	static	M	toward
Woodlands								
Madrean Pine-Oak	high (H)	away	H	away	H	away	H	away
Piñon-Juniper	H	away	L	away	H	away	L	static
Grasslands								
Great Basin	moderate (M)	away	L	away	M	away	H	away
Semi-desert	M	away	L	away	M	away	H	away
Montane/Subalpine	M	away	L	away	M	away	M	away
Chaparral								
Interior	M	away	H	away	M	away	within HRV	static
Riparian Areas/Riparian Forests								
Wetland/Cienega	M	slightly away	L	away	M	slightly away	M	ATBA†
Mixed Broadleaf Deciduous	M	away	L	static	M	away	L	ATBA
Montane Willow	L	away	L	away	L	away	H	ATBA
Cottonwood-Willow	M	away	L	away	M	away	M	ATBA

† ATBA = Departure in trend is assumed to be away

Aquatic Resources

Overview

This section describes the water resource characteristics identified as those most important in assessing water resource ecosystem diversity. They were analyzed at the broad planning unit (forest) - scale, at the medium-scale fourth level HUC watersheds to the finer-scale fifth level HUC watersheds as shown on figures 3 and 4. This analysis focuses on the "need for change" evaluation of water resource ecosystem diversity. It describes the ecological niche of the forests at multiple scales to evaluate the contributions to ecological sustainability that may occur at those scales. Key findings are highlighted where appropriate. Information used in this analysis is contained in the "Ecological Sustainability Analysis of the ASNFs: An evaluation of aquatic ecosystems (surface and groundwater quantity and quality, riparian and wetland conditions) that affect ecosystem diversity and contribute to ecological sustainability" (see Aquatic Ecosystem Specialist's report).

As mentioned previously in table 3, the ASNFs' greatest contribution to sustainability to water resources is in the following fourth level HUC watersheds: Little Colorado River Headwaters, Black River, San Francisco River, Middle Little Colorado River, Chevelon Canyon, and Silver Creek. Analysis was also done at the fifth level HUC watersheds, using the forests' GIS database, which is more detailed but only available with the planning area (within the forests' boundary). These data are displayed in table 24.

The ASNFs planning unit encompasses about 37 percent of the total extent of the fifth level HUC watersheds but contributes a disproportionate amount (51 percent) of perennial stream miles. Maintaining favorable conditions of water flow (quantity, quality, and timing) in perennial streams is critical in sustaining ecosystem diversity both on the forests and throughout the extent of perennial stream miles off-forests.

The watersheds displayed in table 24 are the fifth level HUCs that contribute to sustainability by watershed within the ASNFs based on areal extent or stream miles. Management activities that maintain perennial water quantity, quality, and timing of flow play a dominant role in overall ecological sustainability in these watersheds. Forest management and conditions on watersheds with large proportional extents such as Nutrioso Creek, Upper Blue River, Lower Blue River, and Upper Black River watershed play a large role in overall ecological sustainability within its boundary. Conversely, Haigler, Carrizo, and Corduroy Creeks and Upper North Fork White River fifth level HUC watersheds occupy less than six percent of the forests' watersheds in total. The forests' management activities that maintain perennial waters contribute little in overall ecological sustainability to these watersheds. All other watersheds occupy intermediate areas on the forests. Management activities that maintain perennial water quantity, quality and timing of flows play an important role in overall ecological sustainability in these watersheds.

Table 24. Proportional extent of sub-basin watersheds (HUC 4) and hydrologic unit code fifth level (HUC 5) watersheds areas and perennial stream miles within the ASNFs' boundary.

Sub Basin Hydrologic Unit Code (HUC 4) Watershed	Fifth Level Hydrologic Unit Code (HUC 5) Watershed	ASNFs' Area (acres)	Proportional Extent of ASNFs' HUC 5 Watersheds†	ASNFs Perennial Stream Miles‡	Proportional Extent of ASNFs' Perennial Stream MilesΔ
Little Colorado Riv Headwaters	Nutrioso Ck	88,023	41	70	36
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	80,656	38	96	49
	Coyote Ck	28,308	13	22	11
	Carnero Ck-Little Colorado Riv Headwaters	15,367	7	7	3
	Total HUC 4 watershed within ASNFs' boundary	212,354		194	
Upper Little Colorado Riv	Big Hollow Wash	8,490	18	1	11
	Oso Draw	39,755	82	12	89
	Total HUC 4 watershed within ASNFs' boundary	48,245		13	
Silver Ck	Show Low Ck	102,507	36	15	81
	Upper Silver Ck	55,751	20	4	19
	Cottonwood Ck	124,192	44	0	0
	Total HUC 4 watershed within ASNFs' boundary	282,450		19	
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	48,467	29	0	0
	Upper Clear Ck	84,942	51	35	72
	Lower Clear Ck	34,753	21	14	28
	Total HUC 4 watershed within ASNFs' boundary	168,162		49	
Chevelon Canyon	Upper Chevelon Canyon	171,601	52	35	95
	Black Canyon	135,103	41	0	0
	Lower Chevelon Canyon	26,219	8	2	5
	Total HUC 4 watershed within ASNFs' boundary	332,923		36	
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	20,084	100	0	0
	Total HUC 4 watershed within ASNFs' boundary	20,084		0	
San Francisco Riv	Centerfire Ck-San Francisco Riv	37,119	7	37	13
	Upper Blue Riv	168,325	31	158	54
	Pueblo Ck-San Francisco Riv	17,289	3	0	0
	Lower Blue Riv	197,420	37	70	24
	Mule Ck-San Francisco Riv	76,208	14	16	5
	Chase Ck-San Francisco Riv	38,964	7	12	4
	Total HUC 4 watershed within ASNFs' boundary	535,325		292	

Table 24. Continued.

Sub Basin Hydrologic Unit Code (HUC 4) Watershed	Hydrologic Unit Code (HUC 5) Watershed	ASNFs' Area (acres)	Proportional Extent of ASNFs' HUC 5 Watersheds†	ASNFs Perennial Stream Miles‡	Proportional Extent of ASNFs' Perennial Stream MilesΔ
Upper Gila Riv-San Carlos Reservoir	Willow Ck	23	< 1	0	0
	Upper Eagle Ck	81,529	52	32	82
	Lower Eagle Ck	76,616	48	7	18
	Total HUC 4 watershed within ASNFs' boundary	158,168		39	
Black Riv	Upper Black Riv	192,930	84	239	88
	Middle Black Riv	35,427	16	32	12
	Total HUC 4 watershed within ASNFs' boundary	228,357		263	
White Riv	Upper North Fork White Riv	3,104	100	0	0
	Total HUC 4 watershed within ASNFs' boundary	3,104		0	
Upper Salt Riv	Canyon Ck	16,147	99	0	0
	Corduroy Ck	237	1	0	0
	Total HUC 4 watershed within ASNFs' boundary	16,384		0	
Carrizo Ck	Carrizo Ck (Local Drainage)	3,943	100	0	0
	Total HUC 4 watershed within ASNFs' boundary	3,943		0	
Tonto Ck	Haigler Ck-Tonto Ck	5,373	100	0	0
	Total HUC 4 watershed within ASNFs' boundary	5,373		0	
Grand Total of HUC 4 watersheds within ASNFs' boundary		2,014,872			

† Perennial stream miles within the ASNFs forest boundary. Source ASNFs' GIS database

‡ Percent of stream miles within watersheds within ASNFs' forest boundary

Δ From table 3, not a sum of percentages of HUC 5 watershed but percent of ASNFs' contribution to HUC 4 watershed within ASNFs' boundary

Surface Water Condition and Trend

The extent of perennial stream courses in the ASNFs has changed little over time. Anecdotal historic information (Cline 1976, Tellman 1997) suggests that water was available for livestock use starting in the 1870s but does not identify where and how much. Visual observations of riparian vegetation along perennial streams have been conducted within the ASNFs since 1994 as part of riparian inventory documentation. The observations show that most streams have varying age distribution of riparian vegetation. This indicates that the perennial stream extent has been present for several decades and that disturbance has contributed towards vegetative composition and structure. Stream and associated riparian areas can be very resilient to disturbances (Baker et al. 1999). The data shows that some streams have abandoned higher floodplains and gallery riparian tree vegetation but the stream segment still exists in lower lying floodplains. It is evident that many stream reaches have downcut through these abandoned flood plains and created a straighter stream segment, having the effect of slightly reducing overall stream miles. It is not known how many streams have downcut or how many miles may be affected within the forests.

Perennial stream reaches amount to about 1,028 miles (ASNFs' GIS database 2007) on the forests; which equates to very little acreage compared to the total forests' area. However, a very large portion of plant and animal species rely on perennial stream water for survival. Analysis of stream flow data indicates water flow has been relatively static over time (see water yield section below). Maintaining riparian vegetation in proper functioning condition is necessary in sustaining perennial stream extent and associated plant and animal diversity.

An analysis was performed to estimate the amount of water yield from ASNFs' lands that reaches surface streams leaving the forests (Probst 2007). Water yield or water supply (the terms are used synonymously, in this case) is the amount of water which leaves the immediate site to become surface water or groundwater recharge. Essentially, it is the difference between total precipitation (rain and snow) and evapotranspiration[19]. It does not attempt to account for waters on the forests infiltrating to deep aquifers. Estimates are made for water yield from ASNFs' land by individual fifth level HUC watersheds. These estimates are then aggregated to individual fourth level HUC watersheds. Similar estimates are made for the water yield from entire fifth level and fourth level HUC watersheds containing portions of the ASNFs. Water yield from other forests adjacent to the ASNFs were not estimated. Current water yield from the forests is estimated to be about 384,650 acre feet per year.

Historic levels of water yield are unknown, however research shows (Baker et al. 1999) that water yield in open canopied ponderosa pine forests that are thought to have been present prior to Euro-American settlement times, are higher than in the closed canopy forests that are prevalent today. This is based on extensive research in Arizona showing that increased water yield follows reductions in canopy cover (Baker et al. 1999). Additionally, the authors reported from studies in paired watersheds in Arizona that although water yield increased with thinning in ponderosa pine forests, the increase was short lived. Timber harvesting using silvicultural treatments designed to improve water yield in forests at higher elevations and in higher precipitation zones have shown significant long term increases in water yields (Baker et al. 1999).

The forests have experienced several years of drought (roughly since about 1997) with occasional normal levels of seasonal moisture. Reduced precipitation results in reduced upland vegetative growth and reduced surface organic matter. This results in ineffective vegetative ground cover which puts the

[19] Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, & soil surfaces & by transpiration from plants (Lapedes 1974).

soil at risk of accelerated erosion and sediment delivery to connected streams during storm events. As vegetation dries out, there is also an increased risk of wildfire spread and subsequent accelerated erosion and watershed degradation. Perennial stream riparian vegetation in properly functioning condition is resilient to drought and has been shown to not be drastically altered during periods of drought. However, riparian vegetation in many ASNFs' wetland sites has been observed to dramatically decrease during periods of drought due to less ponded and available water, which results in lower plant and litter production and ecosystem diversity for those species that rely on this habitat for their survival. The recent period of drought is considered to be within the historical range of variability.

It is estimated that current surface water use on the forests is slightly higher today than in 1980 because new campgrounds and day-use areas have opened due to a sharp increase in recreational use. Forestwide, livestock are expected to continue to rely on stocktanks and perennial streams for water.

Flooding affects the riparian forests and wetland/cienega PNVTs as well as unmapped stream courses throughout all the PNVTs. If stream channels are not well protected by vegetative ground cover, flooding may cause localized soil loss, sediment delivery to the stream, reduced water quality, and degradation of streambanks and floodplains. Frequent and flash flooding is a natural process and disturbance. Flash flooding can occur in perennial, intermittent, and ephemeral stream channels in all PNVTs, especially in large watersheds where short duration, high intensity storms occur. Maintaining native vegetation described in the potential plant communities from ASTES (Laing et al. 1987) provides channel stability, functional riparian areas, and good water quality for wildlife and aquatic species.

Instream flow water rights have yet to be acquired by the ASNFs. Surface flow is highly dependent upon precipitation and the recent period of drought has had a negative impact on flows in some reaches occupied by threatened species. Water is currently available for administrative use such as fire fighting and road construction under the reserved water rights doctrine. Maintenance of these waters and rights are critical for forests' management and protection.

Baker et al. (1999) and others have concluded from studies in paired watersheds, that water yield increases with timber harvest or heavy thinning in the ponderosa pine type, but the increase is short lived, typically less than ten years. More dramatic harvests in wetter vegetation types have shown increased yield over longer periods. With the current levels of thinning of only five to seven thousand acres per year, the forestwide increase in water yield will be negligible. At local scales, thinning of overstocked forest vegetation in connected watersheds reduces evapotranspiration, increases runoff somewhat, reduces the risk of uncharacteristically large fires, and improves timing of water flows.

There is also growing evidence that climate may be changing in the Southwest to even warmer temperatures and increased variability of precipitation (IPCC 2007, Lenart 2007d). Hotter temperatures result in higher evaporation rates, while the increased variability of precipitation may cause an increased frequency of drought. Effects of climate change are described at the beginning of chapter 4.

Groundwater Condition and Trend

The areas of highest precipitation in the state occur on ASNFs' lands, which contribute substantial recharge to groundwater as it flows down watershed gradients. Three major groundwater basins originate on the forests; Little Colorado River, Morenci, and Black River basins. Large industry, including power generation, paper manufacturing, and mining, as well as municipalities are the major users of groundwater in the Little Colorado and Morenci basins. Groundwater in the Black River

basin is primarily used for livestock and domestic water, although the amounts are minimal.

It is assumed that the natural discharge/recharge in all three basins is in a steady state based on the stability of measured discharge from major springs over many years (Feth et al. 1963, Freethy et al. 1986, Brown 1989, Hart et al. 2002, ADWR 2006ab). Groundwater pumping was minimal prior to the 20th century. The Little Colorado River and Morenci basins associated with the forests have documented groundwater pumping to some level greater than inflow. Continued or increased pumping may negatively affect base flow of streams that are directly connected to major aquifers, such as Chevelon and Fossil Creeks. Groundwater pumping within the Coconino and Morenci aquifers may negatively affect forest wells used for stock watering and domestic use (Hart et al. 2002, ADWR 2006ab).

Two of the three groundwater basins associated with the forests have documented groundwater pumping to some level greater than inflow. Continued or increased pumping will negatively affect base flow of streams that are directly connected to major aquifers. Heavy industrial and municipal groundwater pumping within the Coconino and Morenci aquifers may negatively affect forests' wells used for stock watering and domestic use.

Spring, Seep, Stocktank, and Lake Conditions and Trends

Aerial photo analysis from circa 1940 to present indicates wetland extent was about the same as today; however, the amount of water ponded varies according to annual precipitation amounts. On-site assessments made during years of drought on select wetlands indicate soil mottling[20] is present even though riparian vegetation may or may not be present. Conversely, in wet years, riparian vegetation may extend to the outer perimeters of the wetland as do soil mottles. This indicates that wetland extent as defined by soil characteristics is static but the amount of ponded water and wetland vegetation varies according to annual precipitation.

Currently, proper functioning condition (PFC) assessments associated with springs and seeps are limited. Where information has been collected, unfenced areas are either "functional-at-risk" or "non-functional" (see riparian section below for discussion of PFC). Maintenance of these waters in proper functioning and diverse ecological condition is vital to sustaining those species that depend on these areas for their survival.

According to the Arizona Department of Water Resources (ADWR) Statement of Claim filings for water rights, there are 2,240 stocktank claims located on the forests and 9,899 stocktank claims located in all affected fourth level HUC watersheds (see Aquatic Specialist report). The forests have a water rights database with the most up-to-date filings which lists 3,547 forest-owned claims of all types (ASNFs' unpublished data). These claims include several watershed-level reserved water right claims allowing use of stock water for fire fighting and watering for road maintenance.

Historic use of springs and seeps is largely un-documented. Springs and seeps are natural water features that existed prior to Euro-American settlement and were probably largely in functional conditions due to the lack of human disturbances. Although Native Americans and wildlife used these waters and caused some level of disturbance, it was probably not as extensive as disturbances caused by livestock operations (Baker et al. 1999).

[20] Mottling refers to repetitive soil color changes that cannot be associated with compositional properties of the soil; mottles are indicators of lengthy periods of soil wetness without oxygen.

Stocktank construction for livestock watering began in the late 1800's. The vast majority were constructed in the mid to late 1900's, especially after the Second World War (post-1945) due to the availability of war surplus bulldozers. Stocktanks provide necessary water for livestock and wildlife. Livestock tend to congregate close to stocktanks and reduce soil and vegetative condition towards unsatisfactory conditions; however the spatial extent of disturbance diminishes as distance from water increases. There are several claimed stocktanks that currently are not functioning because they are breached or silted. Where public access is limited, some stocktanks are important because they are home to native plants and animals, and are recognized as important resources. Several stocktanks on the forests are currently managed to provide emergency habitat for leopard frog species.

There are an estimated 3,771 surface acres of perennial lakes and ponds within the ASNFs (Forest Service 2007a). These are primarily reservoirs constructed in the last century to supply water for irrigation and mining operations. Water rights are primarily owned by private, cooperative groups or other government entities and currently used for irrigation water storage, fish habitat, and recreation activities. No new lakes or ponds are being constructed or planned on ASNFs' lands.

Water Quality Condition and Trend

Water quality is assessed by comparing existing conditions (State Water Quality Category 1 - 5 which are described below and displayed in table 25) with desired conditions that are set by the States under authority of the Clean Water Act. Waters that are not impaired (those not on 303d list[21] or in category 4 or 5), are providing beneficial uses identified for that stream and can be considered in a desired condition. The Arizona Department of Environmental Quality (ADEQ) is the regulating authority for water quality in Arizona. Water quality has been assessed in major perennial stream reaches and lakes on the forests. The general classification used for surface water quality assessment by ADEQ (2005) is listed below:

- Category 1: Attaining All Uses - all designated uses[22] assessed as "attaining".
- Category 2: Attaining Some Uses - at least one designated use assessed as "attaining" and all other uses assessed as "inconclusive".
- Category 3: Inconclusive - all designated uses are "inconclusive" (by default, any surface water not assessed due to lack of credible data is included in this category).
- Category 4: Not attaining - at least one designated use is "not attaining" and no designated use is "impaired". Impaired waters that have a completed Total Maximum Daily Load (TMDL) assessment also are placed in this category; subsequent monitoring will determine whether a lower category is warranted.
- Category 5: Impaired - at least one designated use was assessed as "impaired".

Knowing which waters are "Impaired" or "Not Attaining" is important. These lakes and stream reaches have been identified by ADEQ (2005) and the US Environmental Protection Agency (EPA) as those with the most severe water quality problems. Permit requirements for discharge into these waters is very strict and ADEQ and the forests must make sure that any new discharges or modifications will not further degrade water quality.

[21] The State of Arizona maintains a list of "impaired" (category 5) waters called the 303d list. It is updated every other year & approved & supplemented by the EPA. These waters are then scheduled for TMDL assessments.

[22] Arizona sets narrative & numeric surface water standards for water quality based on the uses people & wildlife make of the water, such as aquatic & wildlife use, full body or partial body contact, domestic water use, fish consumption, agricultural irrigation, & livestock watering (ADEQ 2005).

Table 25. Current water quality and apparent trend for monitored streams by fourth and fifth hydrologic unit code (HUC) watersheds associated with the ASNFs.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Miles of Category 1, 2 & 3 Streams		Miles of Category 4 Streams/Lakes		Miles of Category 5 (Impaired) Streams/Lakes		Trend† of Category 4 & 5 (Impaired Streams) from 1987 - Present, Including 2006 Draft Assessment§
		Watershed‡	ASNFs	Watershed	ASNFs	Watershed	ASNFs	
Little Colorado Riv Headwaters	Nutrioso Ck	9	7	30	15	0	0	Upward -TMDLΔ completed & implemented
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	58	55	25	11	0	0	Upward - TMDL completed & implemented
	Coyote Ck	0	0	0	0	0	0	No data
	Carnero Ck-Little Colorado Riv Headwaters	0	0	16	0	0	0	Upward - TMDL completed & implemented
Upper Little Colorado Riv	Big Hollow Wash							No streams monitored
	Oso Draw	26	11	0	0	0	0	Static or no apparent trend
Silver Ck	Show Low Ck	61	43	0	0	0	0	Static or no apparent trend
	Upper Silver Ck	48	19	0	0	0	0	Static or no apparent trend
	Cottonwood Ck							No streams monitored
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake							No streams monitored
	Upper Clear Ck	87	31	0	0	0	0	Static or no apparent trend
	Lower Clear Ck	0	0	0	0	0	0	Static or no apparent trend
Chevelon Canyon	Upper Chevelon Canyon	54	54	0	0	0	0	Static or no apparent trend
	Black Canyon							No streams monitored
	Lower Chevelon Canyon	18	0	0	0	0	0	Static or no apparent trend
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	7	0	0	0	15	0	Static or no apparent trend

Table 25. Continued

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Miles of Category 1, 2 & 3 Streams		Miles of Category 4 Streams/Lakes		Miles of Category 5 (Impaired) Streams/Lakes		Trend† of Category 4 and 5 (Impaired Streams) from 1987 - Present, Including 2006 Draft Assessment§
		Watershed‡	ASNFs	Watershed	ASNFs	Watershed	ASNF	
San Francisco Riv	Centerfire Ck-San Francisco Riv	50	10	15	0	16	0	Upward - Luna Lake TMDL completed & implemented
	Upper Blue Riv	60	51	0	0	0	0	Static or no apparent trend
	Pueblo Ck-San Francisco Riv	51	0	19	0	0	0	Static or no apparent trend
	Lower Blue Riv	0	0	0	0	27	27	Down - *E. coli* exceeded 2006 draft assessment
	Mule Ck-San Francisco Riv	50	20	0	0	0	0	Static or no apparent trend
	Chase Ck-San Francisco Riv	53	19	0	0	0	0	Down - *E. coli* exceeded 2006 draft assessment
Upper Gila Riv-San Carlos Reservoir	Willow Ck							No streams monitored
	Upper Eagle Ck	12	6	0	0	0	0	Static or no apparent trend
	Lower Eagle Ck	29	7	0	0	0	0	Static or no apparent trend
Black Riv	Upper Black Riv	73	67	0	0	0	0	Static or no apparent trend
	Middle Black Riv	22	22	0	0	0	0	Static or no apparent trend
White Riv	Upper North Fork White Riv							No streams monitored
	East Fork White Riv							No streams monitored
Upper Salt Riv	Canyon Ck	9	1	0	0	0	0	Static or no apparent trend
Carrizo Ck	Corduroy Ck							No streams monitored
	Carrizo Ck (local drainage)							No streams monitored
Tonto Ck	Haigler Ck-Tonto Ck	32	0	0	0	8	0	Static or no apparent trend
Total		806	422	105	26	67	27	

† Trend is an evaluation of ADEQ water quality data (not shown in this document) from 1989 – 2006

‡ The water quality of streams/lakes dataset was provided by the ADEQ to Roy Jemison (2004)

Δ TMDL = total maximum daily load is a calculation of the maximum amount of a pollutant that a waterbody can receive & still meet water quality standards, & an allocation of that amount to the pollutant's sources

§ ADEQ 2007

Category 5 "Impaired" waters currently on the 303d list include the following on the forests: Bear Canyon Lake, Lower Blue River, and the San Francisco River below the confluence with Blue River. These waters were not listed prior to 2006 and are scheduled for further monitoring and TMDL assessments.

Category 4 "Not Attaining" waters on the forests include the following: Nutrioso Creek, Little Colorado River below the Greer Lakes, and Luna, Rainbow, and Crescent Lakes. These waters have approved TMDLs with recommendations that, when implemented, are believed to improve the water quality. Then, the ADEQ will monitor and, if appropriate, move them to a lower category.

Category 1 - 3 waters make up the rest of the waters on the forests. Category 3 "Inconclusive" waters are placed on ADEQ's planning list for additional monitoring.

Improvements to the Nation's waters over the past three decades are largely due to the control of traditional point sources of water pollution. However, a large number of water bodies remain impaired, and the goal of eliminating pollutant discharge and attaining fishable and swimmable waters in some areas is still unrealized. Non-point sources of pollution such as agriculture, construction, forestry, and mining are responsible for much of the Nation's remaining water quality impairment. Currently on ASNFs' land, the most important non-point source of pollution is due to sediment generated from roads in close proximity to drainages and from residual effects of past, and in some cases, current livestock and/or wildlife grazing.

On the ASNFs, before about 1992 and the initiation of Best Management Practices (BMPs)[23], timber harvesting was widespread and was also more of a non-point source of sediment pollution into adjoining stream courses. Currently, the forests implement and monitor site specific BMPs for all activities with the potential to pollute Arizona's waters. Trends in water quality are considered by the forests to be upward or improving, based on a number of the forests' implementation of mandatory and voluntary requirements imposed by the ADEQ (2003a), including BMPs. These include water quality monitoring, implementation of TMDL report recommendations, implementation and monitoring of BMPs for all projects that have the potential to increase non-point pollution, and state certification and mitigation of temporary point source pollution through the Clean Water Act's National Pollution Discharge Elimination System (NPDES) regulations. Wastewater treatment sites associated with campgrounds and administrative sites are the only potential point sources of water pollution the forests manage at this time.

There are about 67 miles of impaired (Category 5) waters listed in the level 5 HUC connected watersheds. The forests' directly contribute to about 27 miles. The forests' can indirectly affect the remaining 40 miles of impaired waters downstream of forests lands through tributaries. The major identified, non-point source pollutant that may be carried downstream from the forests' activities is sediment. TMDL assessments have been made on 26 miles of impaired streams on the forests out of 105 miles in the entire watersheds of Category 4 waters. The forests contribute a moderate amount (about 24 percent) towards maintaining water quality and ecological sustainability on these waters. Most of these waters occur in the Upper Little Colorado watershed and most were listed as impaired prior to implementation of TMDL report recommendations. These waters are assumed to be in an upward trend as improvement strategies are implemented by private and public entities and implementation of BMPs.

[23] BMPs are methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources (http://www.epa.gov/OCEPAterms/bterms.html).

Low dissolved oxygen levels have been reported in Bear Canyon Lake probably due to natural conditions from spring sources of water. High pH is documented in a number of eutrophic[24] lakes on the forests, and is attributed to addition of nutrients from forests' and non-forest sources. A sharp increase in nutrients can result in rapid growth of algae and other plants in a lake, which may result a drop in dissolved oxygen that can be devastating to other aquatic life, sometimes leading to fish kills. These lakes have TMDL assessments and mitigation is being implemented to reduce nutrient inputs.

Currently, water quality does not meet state standards due to presence of *Escherichia coli* bacteria in the Lower Blue River. Exceeding *E. coli* bacteria criteria may represent a public health concern if people are swimming or even wading in the water. Further monitoring is needed to determine sources of the bacterial contamination.

Trends in water quality are considered to be upward or improving, based on the implementation of a number of mandatory and voluntary requirements imposed by ADEQ, EPA, as well as forest management direction. These include implementation of TMDL report recommendations, watershed improvement projects, implementation and monitoring of BMPs for all projects that have the potential to increase non-point pollution, and state certification and mitigation of point source pollution. However, the risk to water quality is high throughout the forests as there is risk of uncharacteristic fire resulting in high burn severity to vegetation and soils on three quarters of the acres of forest PNVTs. Finally, the effects of climate change, estimated to bring higher temperatures, and more frequent drought to the Southwest may result in reduced water quality. Swetnam (2007) found that increasing spring and summer temperatures were correlated with increasing numbers of large forest fires in the past few decades, with the evidence indicating that earlier snowmelt acts to dry out forest fuels, triggering synchronous, large forest fires throughout the West. Severely burned watersheds produce high peak flows and huge increases in sediment. On a Rodeo-Chediski research plot in 2002, sediment yields were five times greater than pre-fire conditions, with peak flow increasing by 2,300 percent (Lenart 2007d). According to Lenart (2007d), stronger hydrological cycles that take place with global warming can produce seemingly paradoxical effects, including more drought and more floods. Higher temperatures increase the atmosphere's ability to hold air moisture. Evidence indicates this projected increase in air moisture and extreme precipitation events already is occurring globally.

Riparian Resources

Overview

Riparian areas are terrestrial ecosystems characterized by hydric (wet) soils[25] and plant species that are hydrophilic or dependent on the water table or its capillary fringe zone (Forest Service FSM 2526.05). Riparian areas include springs, streams, ponds, lakes, and their associated wet areas and floodplains. Riparian areas collect and transport water, soil, and organic material from upslope and upstream. They comprise the most potentially productive and diverse components of forest and range ecosystems. Fish, some wildlife, and some plant species depend on riparian areas for their existence. Riparian areas are basic to the hydrologic function of watersheds.

[24] In freshwater ecosystems, the term is used to refer to the process by which lakes, ponds, & streams become enriched with inorganic plant nutrients, especially phosphorus & nitrogen. (http://ei.cornell.edu/watersheds/Eutrophication_Experiments.pdf).

[25] A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic (without oxygen) conditions in the upper part.

Four riparian PNVTs were classified within the ASNFs, Montane Willow, Cottonwood-Willow, Mixed Broadleaf Deciduous Riparian Forests, and Wetland/Cienega Riparian Area PNVTs. These PNVTs are described within the vegetation sections. The following assessment is based on miles of riparian streams, which may not have been captured in the PNVT delineations due to scale in mapping (PNVT mapping is expressed in acres versus miles used for this riparian assessment). The ASNFs contain about 17 percent of total riparian acres in all fourth level HUC watersheds. This means lands outside the forests contain about 83 percent of all riparian areas within all watersheds. Private and other lands within the forests' boundary contain about four percent of total riparian acres in all fourth level HUC watersheds. At the fifth level HUC watershed scale the forests contain about 44 percent of the total acres of all intersecting watersheds; but contribute about 53 percent of total riparian areas (see Soil Specialist's report). Overall, forests' watersheds contribute more riparian area function toward ecological sustainability than watersheds off-forest.

Riparian Condition and Trend

Since the early 1990s, the forests have utilized Proper Functioning Condition (PFC) (Prichard et al. 1994, 1998, 2003) to determine condition of riparian areas. The PFC inventory for the forests was derived from either on-site evaluation (collected on about 25 percent) of known forest riparian areas from 1995-2007, or from visual estimates from site visits made by forest personnel trained in the PFC protocol. The protocol is a consistent approach to determine how well physical processes are functioning. It is a qualitative assessment based on quantitative science. Table 26 displays the riparian stream length and proportional extent by PFC class for ASNFs' watersheds (HUC 5).

PFC lotic (streams) and lentic (wetlands) classes are defined as follows:

- *Proper Functioning Condition (PFC)*: Riparian-wetland areas are functioning properly. Adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high flows, reducing erosion, and maintaining water quality; filter sediment; capture bedload; aid in floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks; develop diverse ponding and channel characteristics to provide habitat for fish, waterfowl, and other uses; and support greater biodiversity.
- *Functional-At-Risk (FAR)*: Riparian-wetland areas that are in functional condition, but an existing soil, water, or vegetation attribute makes them susceptible to degradation.
- *Non-functional (NF)*: Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and are not reducing erosion, improving water quality, etc.

Streams (Lotic) - The forests' PFC inventory shows there are about 2,822 linear miles of riparian areas on the forests. The assessment estimates that 28 percent of riparian areas are in proper functioning condition, 63 percent are FAR, and nine percent are NF. In general, areas currently in PFC are expected to remain in that condition based on BMP implementation for road, timber, and grazing management. Riparian areas with a FAR rating will remain static or show downward trend where activities are not managed to existing forest plan standards, or upward, where BMPs and other mitigations are effectively protecting riparian values. Areas where livestock have been removed, such as the main stem of the Blue River, are improving; however, these larger systems will take many decades to reach PFC even under exclosure (NRST 2000). Although there is a public perception that riparian areas are fragile, current information indicates that riparian systems are often resilient. Once stresses are relieved, many riparian systems can regain their equilibrium

Table 26. Riparian stream length and proportional extent by proper functioning condition class for ASNFs fourth and fifth hydrologic unit code watersheds (HUC 4 and 5).

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Proper Functioning Condition† (miles & percent)						
		PFC	%	FAR	%	NF	%	Total miles
Little Colorado Riv Headwaters	Nutrioso Ck	58	42	81	58	0	0	139
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	79	58	54	40	3	2	137
	Coyote Ck	4	15	21	82	1	3	25
	Carnero Ck-Little Colorado Riv Headwaters	2	15	10	85	0	0	12
Upper Little Colorado Riv	Big Hollow Wash	0	0	2	100	0	0	2
	Oso Draw	5	10	50	90	0	0	55
Silver Ck	Show Low Ck	4	7	53	88	3	5	60
	Upper Silver Ck	0	0	11	54	10	46	21
	Cottonwood Ck	8	5	136	80	27	16	171
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	0	0	38	88	5	12	43
	Upper Clear Ck	49	29	84	50	34	21	167
	Lower Clear Ck	14	100	0	0	0	0	14
Chevelon Canyon	Upper Chevelon Canyon	123	53	92	40	16	7	231
	Black Canyon	0	0	60	49	64	51	124
	Lower Chevelon Canyon	0	0	3	74	1	26	4
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	8	29	19	71	0	0	26
San Francisco Riv	Centerfire Ck-San Francisco Riv	8	11	58	84	3	5	69
	Upper Blue Riv	86	28	195	65	21	7	302
	Pueblo Ck-San Francisco Riv	0	0	12	100	0	0	12
	Lower Blue Riv	92	29	200	64	21	7	312
	Mule Ck-San Francisco Riv	27	22	86	70	9	8	123
	Chase Ck-San Francisco Riv	22	36	32	51	8	13	62
Upper Gila Riv-San Carlos Reservoir	Upper Eagle Ck	61	34	109	61	11	6	181
	Lower Eagle Ck	56	43	66	51	7	6	129
Black Riv	Upper Black Riv	54	15	299	81	14	4	368
	Middle Black Riv	23	45	28	55	0	0	51
White Riv	Upper North Fork White Riv	0	0	1	100	0	0	1
Upper Salt Riv	Canyon Ck	8	60	5	40	0	0	13
Carrizo Ck	Carrizo Ck (local drainage)	0	0	3	100	0	0	3
Total Miles & Average Percent		791	24	1,808	68	258	8	2,857

† Proper function condition ratings are: PFC = proper functioing condition; FAR = functioning at risk; & NF = non-functioning

within a few years because of resilient, native, herbaceous, riparian plants, such as, *Carex*, *Eleocharis*, *Juncus*, and *Scirpus* (Baker et al. 1999).

Riparian areas in and of themselves are not identified as fire-adapted ecosystems, but many exist within these types of ecosystems (such as within ponderosa pine forests or piñon-juniper woodlands) and therefore, can be pathways for wildfires. As noted above, most of the PNVTs are divergent from their historical FRCC. There is a high risk to the majority of wildlife on the ASNFs due to the degradation of riparian habitat as they rely on vegetation for food and cover, and water supplied by perennial streams, wetlands, and riparian areas (see species discussions below).

Livestock (cattle and sheep) and wildlife grazing occurs throughout many perennial streams, riparian areas, and some wetlands. Overgrazing has been observed to reduce effective vegetative ground cover and riparian vegetation, which contributes to accelerated erosion and soil compaction (Forest Service 1991, Tellman 1997 and others), as well as sedimentation into connected perennial waters. This will reduce or impair water quality. Elk grazing is largely uncontrolled and elk have been observed in riparian areas, especially in unfenced wetlands. The presence of elk in these areas has resulted in similar adverse effects on the vegetation, soil, and riparian condition and function as that caused by domestic livestock. Excessive or poorly timed domestic and wild animal grazing in riparian areas can reduce plant and animal diversity; negatively affect riparian habitat and those species that depend on it for their survival. Currently, the forests do not permit livestock grazing on federal lands along the mainstem portions of the Blue and San Francisco Rivers and Eagle Creek. Many other grazing allotments have reduced livestock use along perennial streams to hardened areas or to times when grazing pressure does not adversely affect riparian area condition.

Wetlands (lentic) - Not all wetlands have been inventoried on the ASNFs. Conditions of a limited number of wetlands have been determined through the use of the PFC protocol. Others have been described and evaluated for suitability for waterfowl and threatened and endangered species habitat. Many of the forests' wetlands are small and only seasonally wet. These maintain some characteristics of wetlands, such as soil mottling, but have areas that may lack hydrophytic vegetation as water levels recede. Little more than anecdotal information is available to document the historic range of variation, extent, and conditions of wetland and riparian areas. Cline (1976) inferred past conditions based on knowledge of current conditions. Wetland conditions prior to Euro-American settlement (early 1800's) was probably dominated by "proper functioning condition" because there was little human disturbance compared to today. Prior to Euro-American settlement wetland extent is largely unknown except for anecdotal excerpts from a few publications. More recent aerial photo analysis (post about 1940) indicates wetland extent was about the same as it is today, but water levels fluctuate according to annual precipitation. Current disturbances are similar to those listed in the streams section above. Non-functional wetlands include those that have been artificially drained by the practice of creating pit tanks for livestock watering (ASNFs' PFC inventory data 1995-2007). Others have been enhanced through watershed and wildlife improvement projects over many years.

Generally, the trend in riparian area condition is static or improving where management of riparian resources have been emphasized. There is little data showing actual trend in PFC across the forest, however, trend described during some PFC survey for those riparian areas that were classified as functional-at-risk show riparian conditions improving or remaining static. The improvement is expected to continue due to added emphasis in managing domestic livestock, wildlife grazing, and roads that affect riparian vegetation and physical integrity of stream banks and stream bottoms. However, the overall trend in riparian vegetation estimated in the 4 riparian PNVTs is assumed to be away. Until monitoring can determine that conditions have reversed overall across the PNVTs, we must assume that trend is away. Trend in riparian condition is positive where intensive management

has taken place, such as the Blue River and Eagle Creek. Timeframes to fully attain PFC in larger systems, such as the Blue River watershed, may take a century or more, even with exclusion of livestock and mitigating road impacts (NRST 2000).

Aquatic Biota Resources

Current and Reference Conditions

Aquatic and riparian habitat on the ASNFs is extremely limited in its extent (less than 1.5 percent of the ASNFs), but provides for a wide array of aquatic biota as well as terrestrial flora and fauna. Overall, the ASNFs account for 41 percent of the perennial streams and 38 percent of the stream reaches with native fish occurrences that exist on national forests in Arizona (Vander-Lee et al. 2007). The ASNFs are critical to sustaining the aquatic biota diversity in the Southwest.

The ASNFs historically provided habitat for 14 native fish species (table 27), from high elevation coldwater trout streams to lower elevation warmwater streams with primarily cyprinid (minnow family) species. Together, these 14 species have occurrences on approximately 477 miles (63 percent) of the 763 miles of perennial streams that exist on the ASNFs (Vander-Lee et al. 2007). Seven of the 14 fish species are protected under the Endangered Species Act (ESA); the Gila trout, Gila chub, and razorback sucker are listed as endangered species. The Little Colorado spinedace, Apache trout, spikedace, and loach minnow are listed as threatened species. Table 27 presents both the current and historical distributions of native fish species on the ASNFs by fourth and fifth level HUCs.

Table 27 also displays the current and historic numbers of fish and departure from HRV by fifth level HUC watersheds. Thirty-two percent of fifth level HUC watersheds are severely departed: Coyote Creek, Oso Draw, Upper Silver Creek, Cottonwood Creek, Black Canyon, Lower Chevelon Canyon, and Centerfire Creek-San Francisco River. Less than 5 percent of fifth level HUC watersheds are highly departed: South Fork Little Colorado River-Little Colorado River Headwaters. Over 25 percent of fifth level HUC watersheds are moderately departed: Nutrioso Creek, Lower Clear Creek, Lower Blue River, Mule Creek - San Francisco River, Chase Creek-San Francisco River, and Lower Eagle Creek. Eighteen percent of fifth level HUC watersheds are low in departure: Upper Clear Creek, Upper Chevelon Canyon, Upper Blue River, and Upper Eagle Creek.

Historical impacts that occurred 20 to 100+ years ago resulted in significant impacts to aquatic communities and their watersheds. The species and habitats of today have not recovered from these legacy actions. Fish populations have been reduced from large interconnected populations, to isolated populations within severely altered and degraded habitats. All the native species have lost much of their population redundancy[26] within and outside the forests. There are presently at least 12 native fish species inhabiting streams on the forests. The razorback sucker has not been found since the late 1980s and the spikedace has not been found recently, although neither is officially considered extirpated at this time.

Spinedace, spikedace, and loach minnow are declining range-wide. The roundtail chub, Little Colorado sucker, and the bluehead sucker have recently been included within a multi-state conservation agreement in an attempt to improve their status and potentially prevent them from future listing under ESA. The longfin dace, Sonora sucker, desert sucker, and speckled dace are also declining in their numbers and/or distributions across the ASNFs.

[26] Redundancy means having several distinct populations of a species, so that if some catastrophic event killed one population, the species would not go extinct.

Table 27. Current (C) and historical (H) occurrences for native fish species by fourth and fifth hydrologic unit code (HUCs) watersheds which had native fish historically within the ASNFs (based on forest data).

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Native Fish Species†														Total (Current)	Total (Historic)	Percent Departure of Current from Historic
		Longfin dace	Sonora sucker	Little Colorado sucker	Gila chub	Roundtail chub	Little Colorado spinedace	Spikedace	Apache trout	Gila trout	Desert sucker	Bluehead sucker	Speckled dace	Loach minnow	Razorback sucker			
Little Colorado Riv Headwaters	Nutrioso Ck			H		H	C		H			C	C			3	6	50
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters			H			H		H			C	C			2	5	60
	Coyote Ck								C‡							1	0	100
	Oso Draw								C‡							1	0	100
Silver Ck	Show Low Ck			H		H	H					H	C			1	5	80
	Upper Silver Ck						H				H	H	H			0	4	100
	Cottonwood Ck			H		H	H					H	H			0	5	100
	Upper Clear Ck			C		H	C					C	C			4	5	20
	Lower Clear Ck			C		H	H					C	C			3	5	40
Chevelon Canyon	Upper Chevelon Canyon			C		C	H					C	C			4	5	20
	Black Canyon			H		H	H					H	H			0	5	100
	Lower Chevelon Canyon			H		H	H					H	H			0	5	100
San Francisco Riv	Centerfire Ck-San Francisco Riv	H	H								H		H			0	4	100
	Upper Blue Riv	C	C		H	H			C	C	C		C	C		7	9	22
	Lower Blue Riv	C	C		H	H		H			C		C	C	H	5	9	44
	Mule Ck-San Francisco Riv	C	C		C	H		H			C		C	H	H	5	9	44
	Chase Ck-San Francisco Riv	C	C		H	H		H			C		C	H	H	4	9	56
	Upper Eagle Ck	C	C		C	C		C		H	C		C	C	H	8	10	20
	Lower Eagle Ck	C	C		H	H		H			C		C	H	H	4	9	56
Black Riv	Upper Black Riv		C			C			C		C		C	C		6	6	0
	Middle Black Riv		C			C			C		C		C			5	5	0
Current/Historic Numbers		6/7	8/9	3/9	2/6	3/16	2/10	1/5	5/7	1/2	8/10	6/10	14/19	4/7	0/5			
Percent Departure of Current from Historic		14	11	66	66	81	80	80	29	50	20	40	26	43	100			

† C = Species currently occurs within watershed & H = species historically occurred within watershed

‡ This species' populations, within these creeks, are likely outside their historic range of distribution (Novy and Lopez 1991)

Aquatic macroinvertebrate communities throughout the perennial and intermittent drainages on the ASNFs have declined in species richness and extent in concert with the native fish. These declines continue.

Current information regarding aquatic/riparian habitat information and aquatic biota information primarily consists of surveys and studies completed by state and federal agencies over the last ten to 20 years. These surveys show that at least 70 percent of the stream reaches that have been surveyed are not meeting a minimum standard of 60 percent[27]. Where repeat surveys have occurred, approximately 70 percent of those stream reaches surveyed have declined in their HCI rating over the last 20 years.

Fish population surveys and sampling efforts have also shown significant declines (50-75 percent) for many species over the last 20 years. According to Robinson et al. (2005), most of Arizona's stream length was assessed to be in the "most-disturbed"[28] ecological condition; 70 percent was in most-disturbed condition based on the aquatic vertebrate index of biotic integrity (IBI), and 57 percent was in most-disturbed based on a macroinvertebrate IBI.

In the reference conditions shown in table 27, it is assumed that native fish were present and had self-sustaining populations. Surface water and riparian reference conditions are discussed in their appropriate sections above. It is assumed that the full array of fish species and their distribution as shown in table 27 were present most of the time prior to Euro-American settlement.

Macroinvertebrate species and distribution is largely unknown, but is also assumed to be more extensive than presently. However, because of legacy disturbances, some HUCs, such as Silver Creek, are considered to have irreversible impacts, at least regarding fish and probably macroinvertebrates. A new baseline recognizes that water diversions and impoundments (e.g., lakes, reservoirs, stock ponds), large-scale stream channel down cutting and the lowering of the water table, bank destabilization, and the conversion of perennial streams to perennially-interrupted or intermittent streams has occurred on a wide spatial scale.

Current conditions for fisheries at the fifth level HUC are summarized in table 27 and can be attributed to many factors. Changes (departure from HRV) throughout the PNVTs have altered successional structure, composition and cover classes, and processes; which have also brought shifts in the FRCC as well (see table 36 in chapter 4). Several PNVTs have impaired soil conditions: Great Basin Grassland, Piñon-Juniper Woodland, Montane Willow, Mixed Broadleaf Deciduous, and Cottonwood-Willow Riparian Forest. Additionally, riparian condition is predominantly functional at risk (FAR). For more details regarding soil condition see table 17. Hydrologic conditions (groundwater, water quality, and stream flow) have also changed from historical conditions.

[27] The current forest plan provides a management emphasis & monitoring for fish species & riparian habitat using on the Habitat Condition Index (HCI), & for aquatic macroinvertebrates the Biologic Condition Index (BCI). The HCI is a multivariate rating of existing habitat conditions based on several factors; pool frequency & occurrence, substrate conditions & types, & stream bank cover, soil, & vegetation stability. The HCI evaluates the streams existing habitat conditions relative to its potential. The BCI incorporates stream habitat, water quality, & environmental tolerances of aquatic macroinvertebrate community species. It is a function of a Predicted Community Tolerance Quotient divided by the Actual Community Tolerance Quotient, & it evaluates a stream's condition in relation to its own potential. As required in the forest plan, minimum conditions (values) for the HCI should be 60% & 80% for the BCI.

[28] Most disturbed ecological condition for macroinvertebrates is defined as having lost more than 50% of the expected taxa (species naming hierarchy). For native aquatic vertebrates & habitat it is the 5% most divergent relative to the reference condition.

Additionally, non-native species (Appendix A table 1) have contributed to significant impacts and alterations of fish species across the ASNFs.

Prior to Euro-American settlement, non-native species were not present. However, due to legacy and current management, a new baseline exists. Almost all current lakes were cienegas or marshes until being dammed to create the current lakes. Because native fish did not evolve in reservoir habitats (large, still open waters), the new baseline for reservoirs is that they are managed for socially desirable non-native species.

Projected Future Condition and Trend

Existing fish and macroinvertebrate populations are the product of all the biophysical legacies and processes that have occurred over many scales, both temporally and spatially. Present aquatic species' distributions and population conditions across the ASNFs do not provide for the resiliency necessary for the long-term persistence of most native fish and their habitats. The projected trend is that the forests will lose these species as conditions continue to decline - both the number of species present and the extent and distribution of those species are shrinking. Non-native species are likely to continue to persist or increase and will continue to negatively impact native fish on the ASNFs. Appendix A table 1 displays the 25 non-native species that occur within the ASNFs, and their distributions by watersheds.

Many aquatic ecosystems have shown an amazing ability to return towards proper functioning conditions given the opportunity. However, it is unknown if the aquatic species will be able to survive long enough to allow for the restoration of historic functions and processes within the aquatic habitats. The species now lack redundancy; they may have lost the resiliency and ability necessary to survive further perturbations of the systems.

Comparison of Current, Reference, and Projected Future Conditions

Table 28 summarizes the current conditions for aquatic species on the ASNFs. The speckled dace, Sonora sucker, and desert sucker have the largest distributions on the ASNFs, while the Gila trout, Gila chub, and spike dace have the smallest. All of the streams with occurrences of the loach minnow on national forests in Arizona are on the ASNFs. In addition, within national forests in Arizona, over two-thirds of the stream reaches with occurrences of the bluehead sucker (95 percent), Apache trout (80 percent), Gila trout (71 percent), Little Colorado sucker (70 percent), and Little Colorado spinedace (66 percent) occur on the ASNFs (Vander-Lee et al. 2007).

Olden and Poff (2005) characterized the temporal trends in native fish distributions within the Lower Colorado River Basin, including 13 of the 14 (93 percent) native fish species on the ASNFs (not including the Little Colorado sucker). Ten of these 13 (71 percent) native fish species on the ASNFs have undergone declines in distribution across the basin, with the remaining three showing slight increases. Within national forests in Arizona, 26 percent of stream reaches with occurrence of five or more native fish species occur on the ASNFs. The Alpine and Clifton RDs, in particular, have significant lengths of streams with occurrences of five or more native fish species. According to the Arizona Freshwater Assessment, 63 stream reaches (ranging from less than one to 49 miles in length) on the ASNFs have occurrences of native fish species, with the number of species on each reach ranging from one to nine (Vander-Lee et al. 2007).

Table 28. Summary of fourth and fifth code hydrologic unit (HUCs) watershed acres, miles of perennial and intermittent streams, presence of crayfish, and numbers of native and non-native fish species on the ASNFs.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Code Hydrologic Unit Code (HUC) Watershed	ASNFs			Crayfish present	Number of Fish Species		
		Watershed acres	Perennial miles	Intermittent miles		Native	Non-native	Total
Little Colorado Riv Headwaters	Nutrioso Ck	88,023	70	213	✓	3	9	12
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	80,656	96	121	✓	2	8	10
	Coyote Ck	28,308	22	43		1	0	1
	Carnero Ck-Little Colorado Riv Headwaters	15,367	7	21		0	0	0
Upper Little Colorado Riv	Big Hollow Wash	8,490	1	19		0	0	0
	Oso Draw	39,755	12	93		1	0	1
Silver Ck	Show Low Ck	102,507	15	312	✓	1	16	17
	Upper Silver Ck	55,751	4	146		0	1	1
	Cottonwood Ck	124,192	0	443		0	0	0
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	48,467	0	136		0	0	0
	Upper Clear Ck	84,942	35	298	✓	4	9	13
	Lower Clear Ck	34,753	14	110	✓	3	3	6
Chevelon Canyon	Upper Chevelon Canyon	171,601	35	587	✓	4	4	8
	Black Canyon	135,103	0	388		0	0	0
	Lower Chevelon Canyon	26,219	2	55		0	0	0
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	20,084	0	61	✓	0	0	0
San Francisco Riv	Centerfire Ck-San Francisco Riv	37,119	37	119	✓	0	2	2
	Upper Blue Riv	168,325	158	563	✓	7	4	11
	Pueblo Ck-San Francisco Riv	17,289	0	59	✓	0	0	0
	Lower Blue Riv	197,420	70	727	✓	5	5	10
	Mule Ck-San Francisco Riv	76,208	16	356	✓	5	8	13
	Chase Ck-San Francisco Riv	38,964	12	209	✓	4	7	11

Table 28. Continued.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Code Hydrologic Unit Code (HUC) Watershed	ASNFs			Crayfish present	Number of Fish Species		
		Watershed acres	Perennial miles	Intermittent miles		Native	Non-native	Total
Upper Gila Riv-San Carlos Reservoir	Willow Ck	23	0	0	✓	0	0	0
	Upper Eagle Ck	81,529	32	322	✓	8	3	11
	Lower Eagle Ck	76,616	7	239	✓	4	8	12
	Upper Black Riv	192,930	231	491	✓	6	7	13
Black Riv	Middle Black Riv	35427	32	99	✓	5	6	11
White Riv	Upper North Fork White Riv	3,104	0	3		0	0	0
	East Fork White Riv	0	0	0		0	0	0
Upper Salt Riv	Canyon Ck	16,147	0	38		0	0	0
Carrizo Ck	Corduroy Ck	237	0	0		0	0	0
	Carrizo Ck (local drainage)	3,943	0	8		0	0	0
Upper Tonto Ck	Haigler Ck-Tonto Ck	5,373	0	5		0	0	0

Air Resources

The Forest Service air resource management program coordinates national forest activities with state, federal, local, and tribal efforts to control air quality. This includes managing and mitigating air pollution from Forest Service activities such as prescribed fire, and construction and use of roads. In addition, the Clean Air Act (CAA) gives the Forest Service an "affirmative responsibility" to protect Class I wilderness areas from adverse impacts created by external sources of air pollution, such as power plants. This responsibility requires coordination with the EPA and any state, county or tribal air regulatory agency such as ADEQ 1999, 2003b, 2004).

Surveys show that wilderness visitors expect to view scenery through clean, fresh air as an essential part of their wilderness experience. However, visibility impairment has been documented in all Class I areas of the Southwestern Region, generally due to regional haze. In the Intermountain West, sulfate, organics and elemental carbon are the main cause of visibility impairment.

Air pollution in the forms of gases, such as nitrogen (N) and sulfur oxides (SO, SO_2, SO_3), and aerosols reaches ecosystems through atmospheric deposition. Pollutants that are present through atmospheric deposition include NH_4^+ (ammonium), O_3 (ozone), SO_4^{-2} (sulfate), NO_3- (nitrate) and HNO_3 (nitric acid). These compounds can impair terrestrial and aquatic ecosystems as well as visibility. While impacts of air pollution on visibility have been well documented, in many cases the inventorying, monitoring, and research necessary to determine and mitigate sources has not been completed.

Several components of air pollution, e.g., sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and peroxyacyl nitrates ($CH_3COOONO_2$) can affect vegetation, but ozone generally results in the greatest amount of injury and damage. Acidity in rain, snow, cloudwater (direct condensation from clouds or fog) and dry deposition can affect soil fertility and nutrient cycling, resulting in acidification of lakes and streams with low buffering capacity. Aquatic ecosystems in Arizona are generally well-buffered and not subject to episodic or chronic acidification.

The EPA (1990) has established National Ambient Air Quality Standards (NAAQS) for six criteria pollutants. Concentrations higher than the standards are considered unhealthy and are a potential violation of law. The NAAQS were primarily set to protect human health, and may be inadequate to protect natural and cultural resources from air pollution. Each National Forest in the Southwestern Region has identified Air Quality Related Values (AQRV) for their Class I areas. They have also identified sensitive receptors for each AQRV and the appropriate level of protection from air pollution (limits of acceptable change). Currently there are no non-attainment areas for air quality within the ASNFs (EPA 2006).

Section 169A of the CAA set forth a national goal for visibility which is the prevention of any future and the remedying of any existing, impairment of visibility in Class I areas in which impairment results from manmade air pollution. The Regional Haze Rule (40 CFR Subpart A, 51.10 and 51.10)[29], calls for states to establish goals and emissions reduction strategies for improving visibility in all

[29] The EPA & other Agencies have been monitoring visibility in national parks & wilderness areas since 1988. In 1999, the EPA announced a major effort to improve air quality in national parks & wilderness areas. The Regional Haze Rule calls for state & federal agencies to work together to improve visibility in 156 national parks & wilderness areas such as the Grand Canyon, Yosemite, the Great Smokies, & Shenandoah. The rule requires the states, in coordination with the EPA, the National Park Service, U.S. Fish & Wildlife Service, the U.S. Forest Service, & other interested parties, to develop & implement air quality protection plans to reduce the pollution that causes visibility impairment. The first State plans for regional haze are due in the 2003-2008 timeframe. Five multi-state regional planning organizations are working together now to develop the technical basis for these plans (http://www.epa.gov/visibility/program.html).

Class I national parks and wilderness areas. The national visibility goal for each Class I area is to return to natural visibility conditions by 2064. To reach this goal states are developing milestones, with the help of regional planning organizations and EPA (1999), for visibility to reach natural conditions by the year 2064.

Visibility is measured in deciviews (dv). Deciviews are a measurement of visibility proportional to the logarithm of the atmospheric extinction[30]. Current and historic visibility conditions, as well as trends, are documented through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program (CSU 2006). This includes data for all of the Class I areas that have IMPROVE monitors in Northern Arizona (table 29).

The pollutants that contribute to visibility impairment also contribute to atmospheric deposition and other ecosystem effects. The National Atmospheric Deposition Program (NADP 2006) network contains nitrate and sulfate data for the Petrified Forest National Park site, the closest monitoring site to the Mount Baldy Wilderness Area Class I airshed with this type of analysis, for 2005, the precipitation-weighted mean concentration was 1.15 mg/L for nitrate and 0.90 mg/L for sulfate.

Table 29. Baseline conditions and projected 2064 natural conditions for selected Arizona Class I Airsheds.

Class I Airsheds	Baseline Data		2064 as Measured by Deciview
	Measured by Deciview	Years	
Grand Canyon National Park	11.6 dv	1999-2004†	6.95 dv
Mount Baldy Wilderness Area	11.5 dv	2003-2004	6.95 dv
Sycamore Canyon Wilderness Area	15.2 dv	2001-2004	6.96 dv

† Does not include 2001 data. Source: IMPROVE Data (CSU 2006)

In 1990, air quality related values[31] (AQRVs) were identified for the Mount Baldy Wilderness Area. A report by Blankenship (1990) identified 14 sensitive receptors or indicators that could be monitored to determine whether AQRVs for visual, aquatic and terrestrial resources were being impacted by air pollution. Examples of receptors identified included; light extinction using photography three times a day for visibility, change in water pH for potential affects to Apache trout, visual damage to conifer needles for vegetation productivity, and change in pH of high elevation soils to estimate loss of soil productivity. However, due to funding limitations, only the photographic series was initially monitored. The photographic series was halted in 2000, and was replaced by the IMPROVE monitoring station (see above) near Greer, AZ, which provides basic data that can be used to model many of the effects to AQRVs.

Summary of Ecological Sustainability

Vegetation

The ecological sustainability of the ASNFs is a culmination of ecosystem characteristics (including PNVT, soil, water, and air) and species diversity and status. Based on the ecosystem and species risk

[30] Extinction is the loss of light as it travels through the air. Light can be lost by being absorbed by gases, solid particles, & liquid droplets that are small enough to be suspended in the air (http://www.wrapair.org/WRAP/glossary.htm).

[31] An air quality related value is a feature or property of an area that is affected in some way by air pollution. Identified values are visibility, odor, flora, fauna, soil, water, geologic feature, & cultural resources (Forest Service FSM 2580.5).

assessment findings described above and displayed in table 30, the ASNFs contribute to the ecological sustainability within each resource analyzed in this report.

Table 30. Major sustainability findings identified during the evaluation of the Apache-Sitgreaves National Forests' (ASNFs) ecological assessment by potential natural vegetation type (PNVT) and surface water resource.

Potential Natural Vegetation Type (PNVT) & Surface Water Resource	Apache-Sitgreaves National Forests				Midscale Vegetation (trend in relation to HRV)			Fire Return Interval (in years)†	
	Relative size rank	Percent	Percent of ecoregion section	Contribution to the ecoregion section (%)	Overall ecoregion departure	ASNFs' departure & trend	ASNFs' current fire regime condition class (FRCC) & trend	HRV	current‡
Forests									
Ponderosa Pine	1	30	34	13	severe	severe static	3 static	1:2-17	1:155
Mixed Conifer with Frequent Fire	3	14	6	38	severe	severe static	3 static	1:10-22	1:325
Spruce-Fir with Wet Mixed Conifer	7	3	1	46	moderate	moderate toward	2 toward	1:150-400	1:3,335
Woodlands									
Madrean Pine-Oak	2	20	5	65	high	high away	3 static	1:3-8	1:715
Piñon-Juniper	4	12	22	8	low	low static	1 away	1:6-400	1:885
Grasslands									
Great Basin	5	9	13	10	low	high awayΔ	3 static	1:10-30	1:5,000
Semi-desert	6	5	6	14	low	high awayΔ	3 static	1:3-10	1:3,335
Montane/Subalpine	8	3	1	32	moderate	moderate awayΔ	2 away	1:2-400	1:3,335
Chaparral									
Interior	9	3	2	24	low	within HRV static	1 static	1:20-100	1:130
Riparian Areas/Riparian Forests									
Wetland/Cienega	10	0.6	0.1	64	no data	moderateƒ ATBA§	2 away	STA∫	1:3,335
Mixed Broadleaf Deciduous	11	0.3	0.1	35	low	low ATBA	1 away	STA	1:2,500
Montane Willow	12	0.3	0.1	23	no data	highƒ ATBA	3 static	STA	1:1,430
Cottonwood-Willow	13	0.3	< 0.1	81	low	moderate ATBA	2 away	STA	1:265
Surface Water Resource	14	0.2	< 0.1	19	na*	na	na	na	na

Table 30. Continued.

Potential Natural Vegetation Type (PNVT) & Surface Water Resource	Soil (trend is in relation to HRV)					Roads	
	Soil loss-soil condition (% unsatisfactory) & trend	Soil erosion hazard (% severe)	Soil condition (% impaired) & trend	Soil productivity departure & trend	Soil organic matter departure & trend	Linear miles	Linear miles/ square mile
Forests							
Ponderosa Pine	6 static	30	6 static	slight static	slight static	5,606	6
Mixed Conifer with Frequent Fire	13 static	75	13 static	slight static	slight static	3,296	7
Spruce-Fir with Wet Mixed Conifer	0 static	59	0 static	slight static	slight static	16	1
Woodlands							
Madrean Pine-Oak	77 away	80	89 away	slight away	slight away	508	1
Piñon-Juniper	0 away	80	83 away	slight away	slight away	1,892	5
Grasslands							
Great Basin	0 away	0	95 away	medium away	slight-medium away	1,625	5
Semi-desert	52 away	47	85 away	slight away	medium away	304	2
Montane/Subalpine	0 away	11	8 away	medium-high away	medium-high away	1,569	17
Chaparral							
Interior	100 static	100	95 away	slight away	slight away	160	2
Riparian Areas/Riparian Forests							
Wetland/Cienega	0 away	0	0 away	slight static	slight away	1,019	52
Mixed Broadleaf Deciduous	0 static	0	72 static	slight static	slight static	173	14
Montane Willow	0 away	0	72 away	slight away	slight away	505	44
Cottonwood-Willow	0 away	0	82 away	medium away	slight away	350	36
Surface Water Resource	na	na	na	na	na	na	na

Table 30. Continued.

Potential Natural Vegetation Type (PNVT) & Surface Water Resource	Percent of Area Affected by Insects, Pathogens & Disease	Non-native Invasive Weeds		Number of T&E, SOC & SOI Terrestrial Species€	Niche (trend is in relation to HRV)	
		Number of species	Infested acres		Contribution to sustainability & trend	Risk to sustainability≠
Forests						
Ponderosa Pine	28	38	8,950 - 13,450	14	high static	high
Mixed Conifer with Frequent Fire	47	15	2,650 - 4,000	4	high static	high
Spruce-Fir with Wet Mixed Conifer	75	11	500 - 750	7	moderate toward	moderate
Woodlands						
Madrean Pine-Oak	16	28	850 - 1,300	0	moderate away	high
Piñon-Juniper	38	38	2,450 - 3,700	6	moderate static	moderate
Grasslands						
Great Basin	15	34	2,050 - 3,050	7	moderate away	high
Semi-desert	7	29	350 - 500	1	moderate away	high
Montane/Subalpine	17	29	1,100 - 1,650	8	moderate away	moderate
Chaparral						
Interior	19	22	100 - 150	0	low static	low
Riparian Areas/Riparian Forests						
Wetland/Cienega	23	49	250 - 350	27	moderate ATBA	high
Mixed Broadleaf Deciduous	11	52	500 - 750	0	moderate ATBA	high
Montane Willow	17	49	150 - 250	9	high ATBA	high
Cottonwood-Willow	16	52	100 - 150	2	high ATBA	high
Surface Water Resource	na	na	na	39	high static	moderate

† Fire return example: 1:2-17 = a fire occurs at least once sometime between 2 & 17 years

‡ Arithmetic average of all fire-return intervals for a specific area (individual PNVTs on the ASNFs) for a specific interval of time (nearly 50 years)

Δ 68, 80, & 10% woody species invasion Great Basin, Semi-desert, & Montane/Subalpine Grassland PNVTs, respectively; 70 & 36% of those invaded acres may be irreversible for Great Basin & Semi-desert Grassland PNVTs, respectively (Gori and Enquist 2003)

f Departure assessments are based on information other than a departure index. White (2002) sampled several Wetland/Cienega & Montane Willow PNVTs & found them to have low similarities with ASTES data. Also, 72% of the soils within the Montane Willow PNVT have been classified as "impaired". In addition, 69% and 92% of these PNVTs are within FRCCs 2 and 3, wetland/cienega & montane willow, respectively

§ ATBA = Departure in trend is assumed to be away

∫ STA = Similar to adjacent

* na = Not applicable

€ T&E = Threatened & Endangered (T&E) – Species that are federally listed as T&E under the ESA; SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA; & SOI = species-of-interest – 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, or species such as invasive for which control measures may be desirable. These numbers only account for terrestrial species & do not include the 14 native fish species

≠ For more information concerning risk to sustainability see chapter 4

Nine out of the 13 PNVTs found on the ASNFs (Mixed Conifer with Frequent Fire and Spruce-Fir with Wet Mixed Conifer Forests, Madrean Pine-Oak Woodland, Montane/Subalpine Grassland, Interior Chaparral, Wetland/Cienega, and Mixed Broadleaf Deciduous, Montane Willow and Cottonwood-Willow Riparian Forests) have greater representation on the ASNFs than they do in the surrounding landscape of the ecoregion section. Mixed Conifer with Frequent Fire has severe divergence, Spruce-Fir with Wet Mixed Conifer has moderate divergence, Madrean Pine-Oak has high divergence, Montane/Subalpine has moderate divergence from their respective HRVs, and Interior Chaparral is within its HRV, and Wetland/Cienega and Cottonwood-Willow have moderate divergence, Montane Willow has high divergence, and Mixed Broadleaf Deciduous has low divergence from their respective HRVs.

Ponderosa Pine and Mixed Conifer with Frequent Fire are static in regards to trend toward HRV. Overall, the ASNFs provide a high contribution to sustainability of these PNVTs. Because of the proportion and departure of these PNVTs on and off-forests there is a high risk to their sustainability. Spruce-Fir with Wet Mixed Conifer, on-the-other-hand, is trending toward its HRV. Overall, the ASNFs provide a moderate contribution to sustainability of this PNVT. Because of the proportion and departure of this PNVT off-forest there is a moderate risk to its sustainability. Within all of these PNVTs, control and eradication of non-native invasive weeds, reduction in road densities, high levels of tree mortality due to insects, disease and drought, reduction in FRCC, and a return of fire as a natural ecosystem process are desirable. Given these conditions, there are some risks to the ecosystem diversity within these PNVTs, particularly with Ponderosa Pine and Mixed Conifer with Frequent Fire Forests, on the ASNFs.

Although there are no models to determine trends for the Mixed Broadleaf Deciduous, Montane Willow and Cottonwood-Willow Riparian Forests, based on ASNFs management actions it is assumed that there is some movement away from HRV for these PNVTs. Overall, the ASNFs provide a moderate to high contribution to sustainability of these PNVTs. Because of the proportion and departure of these PNVTs on and off-forests there is a high risk to their sustainability. Based on levels of departure and trends in relation to HRV, improvement in riparian PFC, control and eradication of non-native invasive weeds, reduction in road densities, reduction in FRCC, and a return of fire as a natural ecosystem process are desirable. In addition to the threats and risks identified in tables 37 and 38 and discussed in chapter 4, these items coupled with the number of species associated with these communities, there continue to be risks to ecosystem diversity within these PNVTs on the ASNFs; and within the ecoregion.

Madrean Pine-Oak Woodland and Great Basin and Semi-desert Grasslands are highly divergent while Montane/Subalpine Grassland is moderately divergent from their respective HRVs and all of them continue to trend away. Overall, the ASNFs provide a moderate contribution to sustainability of these PNVTs. Because of the proportion and departure of these PNVTs on and off-forests there is a high risk to their sustainability. Based on levels of departure and trends in relation to HRV, control and eradication of non-native invasive weeds, reduction in road densities, reduction in FRCC, and a return of fire as a natural ecosystem process are desirable. In addition to the threats and risks identified in table 37 and 38, these items coupled with the number of species associated with these communities, there continue to be risks to ecosystem diversity within these PNVTs on the ASNFs; and within the ecoregion.

Ponderosa Pine Forest has a static trend in relation to HRV. However, it is severely departed and as the largest PNVT on the ASNFs it encompasses the greatest species diversity, and ranks number one for the greatest number of mammals, plants and reptiles and amphibians dependent upon habitat provided by this type. Based on levels of departure and trends in relation to HRV, control and

eradication of non-native invasive weeds, reduction in road densities, reduction in FRCC, and a return of fire as a natural ecosystem process are desirable. In addition to the threats and risks identified in tables 37 and 38 , these items coupled with the number of species associated with this community, there continue to be risks to ecosystem diversity within this PNVT on the ASNFs.

Piñon-Juniper Woodland also has a static trend with low departure in relation to HRV. However, it has a high percentage of impaired, unsatisfactory and/or unstable soils. It also has high diversity of species and ranks second in the number of mammals and third in the number of birds, plants and reptiles and amphibians dependent upon habitat provided by this type. Control and eradication of non-native invasive weeds, reduction in road densities, high levels of tree mortality due to insects, disease and drought, reduction in FRCC, and a return of fire as a natural ecosystem process are desirable. In addition to the threats and risks identified in tables 37 and 38, these items coupled with the number of species associated with this community, there continue to be some risks to ecosystem diversity within this PNVT on the ASNFs.

The structural characteristics discussed in the species diversity section are lacking in many PNVTs and risks will remain while these systems are brought back towards HRV. During that time, protection of areas currently providing all ecological components may be considered.

Soil, Aquatic, Riparian, and Air Resources

In terms of overall soil conditions (figure 7), about 51 percent of the soils on the ASNFs are in satisfactory soil condition while about 21 percent are impaired, 11 percent unsatisfactory, and 17 percent inherently unstable. Given these conditions, there are some risks to ecosystem diversity on the ASNFs (presented in tables 39 and 40 and discussed in chapter 4).

Groundwater depletion is occurring in the Little Colorado River basin and Morenci basin; though this depletion is outside of the agency's control, it has the potential to affect forests management as well as habitat quality.

Management activities on the ASNFs do not cause long term changes in air quality and meet state and federal air quality standards. This attainment of air quality standards is expected to continue into the future.

Risk to aquatic resources by watershed is summarized in table 31. The qualitative assessment of risk was based on a number of factors, including relative proportional extent of forest streams, seeps and springs, and wetlands compared to entire fifth level HUC watersheds, as well as data representing activities or conditions demonstrated to reduce the quality or amount of aquatic resources. Risk to watershed condition is a combination of risk to PNVT and soil condition, where generally soil and vegetation risk is low in watersheds with low departures from HRV and trends are static or moving toward HRV. Risk is high where there currently exists a high or moderate departure from HRV and trends are static or away from HRV.

Risk was assigned to watersheds where most of the riparian miles within the watershed were either FAR or NF. Risk to watersheds based on water quality was assigned where ADEQ has documented non-attainment of water quality standards for a designated use on the forests. Watersheds were also assigned a high risk where fish habitat and macroinvertebrate populations would not sustain species diversity.

Threats and risks relate to unfavorable characteristics for aquatic biota through amount, timing, and quality of water flowing within the ASNFs. There are no physical aquatic resources that are deemed

irretrievable or unrestorable within the ASNFs at this time, however, some components of aquatic systems, such as the riparian condition of the Blue River, may take a century or more to return to proper functioning condition (NRST, 2000). A more detailed analysis of threats and risks to aquatic resources can be found in the Aquatic Resources Specialists' reports.

Table 31. Major sustainability findings identified during the evaluation of the ASNFs' ecological assessment aquatic biota and abiotic resources. Displayed is the ASNFs' contribution to the fourth and fifth hydrologic unit code (HUC) watersheds for area, miles of perennial streams, perennial and intermittent streams, springs and seeps, and wetlands. ASNFs' road densities per watershed are also provided. Highlighted cells denote areas where conditions are such that the forests have elevated concerns or they represent high proportional extent.

Watershed Name		ASNFs' Percent Contribution to Watershed					ASNFs' Road Density/Watershed (miles/square mile)
Fourth hydrologic unit code (HUC)	Fifth hydrologic unit code (HUC)	Area	Perennial streams miles	Perennial & intermittent streams miles	Seeps & springs	Wetland	
Little Colorado Riv Headwaters	Nutrioso Ck	80	70	74	92	100	3
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	78	77	75	100	100	3
	Coyote Ck	19	70	20	36	0	2
	Carnero Ck-Little Colorado Riv Headwaters	10	19	11	53	13	3
Upper Little Colorado Riv	Big Hollow Wash	10	67	14	na†	na	4
	Oso Draw	22	57	26	na	9	3
Silver Ck	Show low Ck	70	50	71	na	94	6
	Upper Silver Ck	47	23	62	na	0	2
	Cottonwood Ck	68	0	73	na	na	3
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	45	0	45	0	na	2
	Upper Clear Ck	42	11	37	13	na	6
	Lower Clear Ck	19	17	25	na	na	2
Chevelon Canyon	Upper Chevelon Canyon	99	100	99	na	na	3
	Black Canyon	66	0	68	na	0	3
	Lower Chevelon Canyon	18	0	16	na	0	2
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	8	0	9	45	0	0
San Francisco Riv	Centerfire Ck-San Francisco Riv	14	72	82	42	59	4
	Upper Blue Riv	85	88	96	97	na	1
	Pueblo Ck-San Francisco Riv	8	100	100	4	na	0
	Lower Blue Riv	100	99	100	99	na	0
	Mule Ck-San Francisco Riv	31	96	98	62	na	1
	Chase Ck-San Francisco Riv	40	27	41	61	na	0
Upper Gila Riv-San Carlos Reservoir	Willow Ck	0	1	0	0	na	12
	Upper Eagle Ck	64	70	63	91	na	1
	Lower Eagle Ck	39	12	39	-	na	1

Table 31. Continued.

Watershed Name		ASNFs' Percent Contribution to Watershed					ASNFs' Road Density/Watershed (miles/square mile)
Fourth hydrologic unit code (HUC)	Fifth hydrologic unit code (HUC)	Area	Perennial streams miles	Perennial & intermittent streams miles	Seeps & springs	Wetland	
Black Riv	Upper Black Riv	97	94	95	99	96	4
	Middle Black Riv	15	21	13	29	35	3
White Riv	Upper North Fork White Riv	2	0	1	2	0	1
	East Fork White Riv	0	0	0	0	na	na
Upper Salt Riv	Canyon Ck	8	0	4	0	na	6
Carrizo Ck	Corduroy Ck	0	0	0	0	na	32
	Carrizo Ck (local drainage)	2	0	1	0	na	4
Tonto Ck	Haigler Ck-Tonto Ck	4	0	1	0	na	7

† na = Not applicable

Chapter 3 – Species Diversity

Overview

Species diversity is used in conjunction with ecosystem diversity to help formulate plan components for ecological sustainability (Forest Service FSH 1909.12). In the revised plan, the combination of plan components for ecosystem diversity and plan components for species diversity will help provide appropriate ecological conditions for all species that have been identified as federally listed species, species-of-concern, and species-of-interest. This chapter summarizes the process used to establish which species and/or risk factors should be addressed by the revised plan. Those species not taken care of by ecosystem diversity may require new or revised plan components to provide sustainable species diversity. The Wildlife, Fish, and Rare Plants (WFRP) Specialist Report describes the species lists identified in the planning process, as well as the components of information collection, habitat associations, and species threats and risks. These elements are summarized in this chapter as well as Chapter 4.

Species Lists

Initial species lists were generated according to Forest Service Handbook (Forest Service 2006) direction. The list of threatened and endangered (T&E) species is reviewed with the US Fish and Wildlife Service on an annual basis. The T&E list was extracted from the list of all known species to produce the list of T&E for this planning effort. The remaining species in the list were obtained by querying the NatureServe website at various times during 2007 and 2008 (www.natureserve.org/explorer) for the state of Arizona. Species-of-concern (SOC) were determined based on Global and Territorial ranks in NatureServe for species whose home range included the planning unit. Potential species-of-interest (SOI) were determined based on state and national ranks, supplemented by The Nature Conservancy, Arizona Game and Fish Department (AGFD) information from the State Heritage System (2007), USFWS Birds of Concern (US Fish and Wildlife Service 2002), the Arizona Partners in Flight Bird Conservation Plan (Latta et al. 1999), Partners in Amphibian and Reptile Conservation website (www.parcplace.org), and the Arizona Comprehensive Wildlife Conservation Strategy (AGFD 2006). The initial lists contained 12 T&E, 105 SOC, and 292 SOI, including 84 non-native invasive species (table 32). All these species had ranges which included the ASNFs.

Screening

Meetings were held with other agencies (Arizona Game and Fish Department, US Fish and Wildlife Service), representatives of non-governmental organizations (The Nature Conservancy, Wildlands Council, Grand Canyon Trust, Audubon Society, and others) and other interested members of the public. These stakeholders formed a Revision Species Diversity Discussion Group to collaborate with the Forest Service on the development of species lists. Meetings were held to screen lists for SOC and SOI, using expert knowledge and literature reviews. Some species were added through this process, and others were dropped from further consideration. Information (e.g. distribution, abundance, habitat requirements) used to screen species lists was then collected according to Forest Service FSH 1909.12, Ch. 43.23. From the initial lists, species were screened (dropped from further consideration) based on criteria from Forest Service FSH 1909.12, Ch 43.22d: 1) there are no known occurrences or suitable habitat for the species on the forests; 2) the species is secure within the planning area, as ranked by NatureServe; 3) management of the forests does not affect the species, including occasional and accidental species; or, 4) there is so little information known about the species that no

management direction can be made at this time. The results of screening are shown in table 32. For complete lists of species, see the WFRP Specialist report. Those species that were not screened out due to the four factors listed above were analyzed for threats and risks.

Table 32. Initial species and the number carried forward into the risk analysis for ASNFs' plan revision, 2008.

Status†	Initial Species	Species Carried Forward by Collaborative Discussion Groups	Species Carried Forward Individually for Threat Assessment
T&E	12	11	3
SOC	105	NA*	5 (18)
SOI	208	74	4 (10)
[INV]	[84]	[84]	[84]
Total	408	214	12 (28) [84]

† Status = T&E = threatened and endangered – these are species that are federally listed as T&E under the ESA; SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA; SOI = species-of-interest – 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, or species such as invasives [INV] for which control measures may be desirable. INV = these are species that are non-native to the habitat and pose a threat to ecosystems or species diversity.

The number in parentheses () includes species that may be threatened by collection, although at present no evidence exists showing that collection is significant to those species.

* SOC are defined by FS Manual and are non-discretionary – all SOC species the reasons for carrying forward or not are listed in the WFRP Specialist Report.

Habitat Associations and Initial Species Groups

Species from the screened lists were placed in groups, if possible, according to Forest Service FSH 1909.12, Ch.43.24. Since the relatively large number of species makes analysis by individual species impractical, the purpose of the groups is to simplify analysis and improve planning efficiency. Initial groups were based on habitat associations and the mix of ecosystem diversity characteristics within that association. If a group of species is associated with a specific ecosystem diversity characteristic, then the risks to those species are the same as the risks for that particular PNVT. Table 33 shows the number of species with associations to terrestrial vegetation characteristics within specific PNVTs. Each species will be analyzed during the plan formation to ensure its particular requirements have been considered and addressed. The list of species associated with each ecosystem characteristic is given in the WFRP Specialist report.

Table 33. Number of threatened and endangered (T&E), species-of-concern (SOC), and species-of-interest (SOI) associated with the particular potential natural vegetation types (PNVTs). Those species associated with Spruce-Fir with Wet Mixed Conifer Forest and Interior Chaparral will not be carried forward into plan revision because those PNVTs are trending towards or within their respective HRV.

Potential Natural Vegetation Type (PNVT)	T&E†	SOC‡	SOIΔ	Total
Forests				
Ponderosa Pine		9	5	14
Mixed Conifer with Frequent Fire	1	2	1	4
Spruce-Fir with Wet Mixed Conifer		3	4	7
Woodlands				
Piñon-Juniper		3	3	6

Table 33. Continued.

Potential Natural Vegetation Type (PNVT)	T&E†	SOC‡	SOIΔ	Total
Grasslands				
Great Basin		2	5	7
Semi-desert		1	0	1
Riparian Areas/Riparian Forests				
Montane/Subalpine		1	7	8
Wetland/Cienega		10	17	27
Montane Willow	1	2	7	9
Cottonwood-Willow	1	1	0	2

† T&E = Threatened & Endangered – these are species that are federally listed as T&E under the ESA

‡ SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA

Δ SOI = species-of-interest – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives

Species Associated with Ecosystem Characteristics

Some species may be associated with some special feature such as cliffs or caves that were not analyzed as part of the ecosystem diversity analysis but are still managed under the forest plan. Table 34 displays the initial groupings of species by ecological characteristic or specific habitat component requirements. Identified threats and risks to those features are also threats to the species. A listing of species by each feature is given in the WFRP Specialist report.

Table 34. Number of species associated with a particular ecosystem characteristic on the ASNFs. This table does NOT include those aquatic species identified in the aquatic biota section.

Ecosystem Characteristic	T&E†	SOC‡	SOIΔ	Total
Aquatic, riparian or emergent vegetation	2	22	17	41
Dry meadows		4	6	10
Dead & down wood, cavities in snags	1	2	6	9
Cliffs, caves, mines		8	0	8
Specific plant species		6	0	6
Specific soil types		10	4	14

† T&E = Threatened & Endangered – these are species that are federally listed as T&E under the ESA

‡ SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA

Δ SOI = species-of-interest – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives

Species Grouped on Other Factors

All of the species grouped above by either habitat associations (PNVTs) or ecological features/characteristics will be provided for in the revised forest plan by ensuring it contains objectives or other provisions that restore or protect the unique features providing for species diversity. Some species do not have an association with a specific PNVT or special feature. Others may have additional threats that would not be addressed simply by providing for ecological diversity. These species must be analyzed individually for threats and risks. Table 35 displays the species determined to have no specific associations and/or other, non-habitat related considerations. The relatively large number is mostly due to threats from collecting – some plants and butterflies are subject to both permitted and illegal collection. Forest Service control over illegal collection, as well as any poaching, is limited by the number of field-going personnel. Other concerns are related to intentional harassment or shooting, and non-native species interactions. A full list of these species is

given in the WFRP report. There is some overlap among species because some have concerns related to habitat (e.g. fragmentation, snags, logs) and other factors such as shooting/poisoning and non-native predators.

Table 35. Number of threatened and endangered (T&E), species-of-concern (SOC) and species-of-interest (SOI) with specific, non-habitat related threats and how many species are potentially affected by each on the ASNFs. Numbers in parentheses () are those species potentially threatened by collection.

Species Count	Number of Species
T&E†	3
SOC‡	5 (18)
SOIΔ	4 (10)
Total	12 (28)β

† T&E = Threatened & Endangered – these are species that are federally listed as T&E under the ESA

‡ SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA

Δ SOI = species-of-interest – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives

β Collection may or may not be a significant threat to these species, because the amount of collection has never been tracked, and illegal collection has not been shown conclusively to be a significant threat.

Summary of Major Findings on Sustainability

Invasive and Non-native Species

Non-native invasive species that are impacting native species are also identified as a separate category of SOI as denoted by [INV] in table 32. Many native species are currently experiencing heavy impacts as the invasive species prey on them, out-compete them, and degrade habitats on which many native species depend. The most vulnerable species are those tied to aquatic systems, including riparian habitats. The 25 non-native fish species (see Aquatic Biota section), along with the American bullfrog and crayfish, impact all native fish, amphibian, reptile, macroinvertebrate, and plant species in those systems. They contributed to the listing of seven of the native fish species and the Chiricahua leopard frog (Marshall et al. 2006, Robinson et al. 2006). They also contributed to the recent classification of the Mexican gartersnake as a candidate for listing under the ESA, and are largely responsible for the decline in narrow-headed gartersnake populations.

Rocky Mountain elk are a subspecies of elk that were brought to Arizona in the early 20th century to replace the native Merriam's elk that had been hunted to extinction. This species is a desirable non-native species in the state and is found throughout most of the ASNFs. However, at high population levels this mammal can be a threat to some native species. Elk do not compete directly with those species mostly affected, but at high population numbers, they sometimes impact habitats in ways similar to improperly managed domestic livestock. Those species depending on lush grasses in meadows, such as the New Mexican meadow jumping mouse, Springerville pocket mouse, and shrews may be negatively impacted. In turn, lower than optimal prey species populations affect numbers of predators such as Mexican spotted owls, northern goshawks, and Mexican gray wolves. In addition, lack of riparian vegetation cover is a problem for riparian habitats and associated dependent species.

Two avian species are considered to be invasive and causing problems for several bird species. Competition for nest sites, nest parasitism, and predation are problems associated with starlings and the brown-headed cowbird.

Highly Interactive Species

The Gunnison's prairie dog is a highly interactive species that provides habitat features (burrows) and are prey for other species such as ferruginous hawks and western borrowing owls. The prairie dog has been considered a pest species, and attempts to eradicate this important keystone species continue. Habitat is present on the forests, but disease and intentional shooting/poisoning efforts have resulted in small numbers of populations and individuals.

Chapter 4 – Integration of Ecosystem and Species Diversity Risk Assessment

Threats and Risks

Forest Service FSH 1909.12, discusses risk as having two components; the likelihood of a negative outcome, and the potential severity of a negative outcome. Throughout this process it is important to distinguish between potential likelihood and likely severity. A threat which has low likelihood but high severity may require equal attention to one that has a high likelihood and lower potential severity. The evaluation of risk should also take into account the following components of severity: geographic extent, duration, intensity, consequences of a threat, and reversibility of the outcome to a given ecosystem characteristic.

Climate Change

Climate scientists agree that human activities have led to elevated atmospheric concentrations of CO_2 and other greenhouse gases that cause global warming, and observed concentrations are projected to increase. Climate change can intensify the risk of ecosystem change for terrestrial and aquatic systems, affecting ecosystem composition, structure, function, and productivity (Collins and Larry 2007).

Currently, there appears to be broad agreement among climate modelers that the Southwestern United States is experiencing a drying trend that will continue well into the later part of the 21st century (Sprigg and Hinkley 2000). Climate models depict temperatures rising approximately 4° to 5° F by 2030 and between 7° to 12° F by 2090 (Seager et al. 2007). Many researchers have identified the types of ecological change that could be attributed as an effect of climate change. These include species population declines (e.g. drought induced mortality), changes in phenology, shifts in distribution in either elevation or latitude, and increases in invasive species (native and non-native) (Parmesan and Yohe 2003, Root et al. 2003).

According to Sprigg and Hinkley (2000), natural ecosystems are regulated by climate. Long-term or short-term climate variability may cause shifts in the structure, composition, functioning, and process of ecosystems, particularly in the fragile boundaries of the semiarid regions. These areas already contain plants, insects, and animals highly specialized and adapted to the landscape. A change climate could alter their range, type, and number throughout the Southwest. Responding differently to shifts in climate, the somewhat tenuous balance among ecosystem components will also change. As the health of the ecosystem is a function of water availability, temperature, carbon dioxide (CO_2), and many other factors, it is difficult to determine accurately the extent, type, and magnitude of ecosystem change under future climate scenarios. Yet, should vegetation cover and moisture exchanging properties of the land change, important local and regional climate characteristics such as light reflectivity, humidity, wind, and temperature will also change.

The potential ecological implications of climate change trends in the Southwest also include:

- More extreme disturbance events, including wildfires, intense rain and floods, wind events, drought, epidemic insect and disease outbreaks, etc (Swetnam et al. 1999, Lenart 2007d).
- Long-term shifts in vegetation patterns (Westerling et al. 2006, Millar et al. 2007).
- Changes in the timing and synchronization of seasonal plant and animal life history events (Brown et al. 1999, Root et al. 2005, Parmesan 2006, Parmesan 2007); declines in species

populations (Pounds et al. 2006, Martin 2007); shifts in species distributions (Root et al. 2003, Jetz et al. 2007, LaSorte and Thompson 2007, McCain 2007).

- Reduced precipitation will act as a limiting factor to overall forest health (Forest Service 2005).
- Shifts in the timing of snowmelt, 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 et al. 2005, Millar et al. 2007).
- Increasing temperatures, water shortages, and changing ecological conditions will likely affect biological diversity, and put pressure on wildlife populations, distribution, viability, and migration patterns. There may also be more vulnerability from non-native invasive plant and animal species.

There is no perfect way to examine these complex ecological implications with the limited resources currently available. The risks are especially profound when coupled with the synergistic effects of land use change (Sala et al. 2000, Hansen et al. 2001, Root et al. 2003). Climate change is likely to exacerbate the effects of natural and altered disturbance regimes, including wildfire, insect outbreaks, flooding, and erosion, across all ASNFs' PNVTs and may prompt abrupt ecological changes. This is particularly true in ecosystems such as grasslands, riparian areas, and forests where the effects of past management and land use change are substantial.

Vegetation (Potential Natural Vegetation Types [PNVTs])

In determining the risks to ecosystem diversity, an analysis of the reversible or irreversible nature of the departures from HRV for each PNVT (table 36) is developed to highlight potential negative outcomes. This risk assessment also includes analysis of potential threats to ecosystem diversity within each PNVT (tables 37 and 38). Only those threats that are under the authority of the Forest Service and those that the Forest Service has the ability to control or influence with management were considered in the risk assessment. Threats that were outside of the Forest Service's ability to control or influence with management were not considered but they are identified and included in table 37.

Table 36. Summary of departure ratings for potential natural vegetation types (PNVTs) from their historic range of variability (HRV) and fire regime condition class (FRCC†) on the ASNFs.

Departure from Historic Range of Variability (HRV) Conditions				
Severe departure	High departure	Moderate departure	Low departure	No departure
Ponderosa Pine Forest (3)	Madrean Pine-Oak Woodland (3)	Spruce-Fire with Wet Mixed Conifer (2)	Piñon-Juniper (1)	Interior Chaparral (1)
Mixed Conifer with Frequent Fire (3)	Great Basin Grassland (3)	Montane/Subalpine Grassland (2)	Mixed Broadleaf Deciduous Riparian Forest (1)	
	Semi-desert Grassland (3)	Wetland/Cienega Riparian Areas (2)		
	Montane Willow Riparian Forest (3)	Cottonwood-Willow Riparian Forest (2)		

Many of these threats/risks, both human and natural, singularly or in combination, pose the same or similar risks; primarily changing vegetation composition, structure, function and ecological processes. Disease, parasites and pathogens, human-caused fire, improper livestock and excessive wildlife grazing, drought, insect and/or disease outbreaks, uncharacteristic wildfire and wind events (blowdown) have the potential to affect vegetation over large areas and to directly remove a variety of plant species; resulting in increased uncharacteristic soil erosion, loss of soil micro-flora and -fauna,

Table 37. ASNFs' risks† to forest, woodland, and grassland potential natural vegetation types (PNVTs) based on identified threats. Threats are categorized as either under agency management authority or outside agency management authority as well as threat type and estimated risk of high, moderate, or low.

Threat	Threat Type	Estimated Risk‡		Potential Natural Vegetation Type (PNVT)							
		Likelihood of occurrence	Severity	Forests∆			Woodlands§		Grasslands*		
				PP	MCwFF	SFwWMC	MPO	PJ	GB	SD	MS
Under Agency Management Authority											
Channelization	Habitat conversion	low (L)	high (H)								
Fire suppression policy	Modification of natural processes	H	H	CSFP	CSFP	CSFP	CSFP		CSFP	CSFP	CSFP
Flooding (diversions, dams & impoundments)	Habitat conversion	H	H								
Forest management practices (vegetation treatments)	Consumptive biological use	moderate (M)	M	CSF	CSF	CSF	CFS	CFS			
Unauthorized livestock grazing	Consumptive biological use	M	H				CSFP	CSFP	CSFP	CSFP	CSFP
Non-native invasive plant species	Invasive species/ habitat conversion	H	M	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP
Driving off roads & trails	Non-consumptive biological use	M	H	CFP	CFP			CFP	CFP	CFP	CFP
Recreation activities	Non-consumptive biological use	M	M								
Roads, highways & utility corridors	Transportation/ habitat conversion	H	H	CSP	CSP	CSP		CSP	CSP	CSP	CSP
Woody species encroachment & establishment	Habitat conversion	H	H						CSFP	CSFP	CSFP
Outside Agency Management Authority											
Drought	Habitat conversion	M	M	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP		CSFP
Excessive ungulate grazing/browsing	Consumptive biological use	M	H					CSFP	CSFP	CSFP	CSFP
Flooding	Habitat conversion	M	M								
Groundwater depletion/contamination	Habitat conversion	H	H								
Human caused fire	Habitat conversion	H	H	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP	CSFP
Insect, disease, parasites &/or pathogens outbreaks (epidemic)	Invasive species/ habitat conversion	H	H	CSFP	CSFP	CSFP	CSFP	CSFP			

Table 37. Continued.

Threat	Threat Type	Estimated Risk‡		Potential Natural Vegetation Type (PNVT)							
		Likelihood of occurrence	Severity	Forests∆			Woodlands§		Grasslands*		
				PP	MCwFF	SFwWMC	MPO	PJ	GB	SD	MS
Uncharacteristic erosion	Habitat conversion	M	H				CSFP	CSFP	CSFP	CSFP	
Uncharacteristic sedimentation	Habitat conversion	M	H				CSFP	CSFP	CSFP	CSFP	
Uncharacteristic wildfire	Habitat conversion	M	H	CSFP	CSFP	CSFP	CSFP		CSFP	CSFP	CSFP
Urban development	Habitat conversion	H	H	CSF				CSF	CSF		
Water withdrawal	Abiotic resource use	L	H								
Wind events (blowdown)	Habitat conversion	L	L	CSP	CSP	CSP					
Total (under/outside agency management authority)				6/5	6/4	5/4	5/5	6/6	7/6	7/4	7/3

† Risks are assessed as affecting changes in one or more of the following ecosystem characteristics: vegetation composition (C), vegetation structure (S); vegetation function (F) &/or ecological process (P). Function (F) is the total life activities of organisms in habitats & the effects of those activities on the non-living components of the environment. Ecological Process (P) is the dynamic biogeochemical interactions that occur among & between biotic & abiotic components of the ecosystem. Including but not limited to, transpiration; bioaccumulation; biodiversity; biogeochemical cycling; contaminant transport; ecological competition; energy cycling eutrophication; extinction & extirpation; habitat alteration; hydrologic cycling; migration; pollination, & succession, etc.

‡ Estimated Risk is divided into Likelihood of Occurrence (defined as the probability of a significant departure from reference conditions) & Severity (defined as the magnitude of the departure from reference conditions)

∆ Forests: PP = Ponderosa Pine; MCwFF = Mixed Conifer with Frequent Fire & SFwWMC = Spruce-Fir with Wet Mixed Conifer

§ Woodlands: MPO = Madrean Pine-Oak & PJ = Piñon-Juniper

* Grasslands: GB = Great Basin; SD = Semi-desert & MS = Montane/Subalpine

Table 38. ASNFs' risks† to chaparral and riparian area/riparian forest potential natural vegetation types (PNVTs) based on identified threats. Threats are categorized as either under agency management authority or outside agency management authority as well as threat type and estimated risk of high, moderate, or low.

Threat	Threat Type	Estimated Risk‡		Potential Natural Vegetation Type (PNVT)				
		Likelihood of occurrence	Severity	Chaparral	Riparian Areas/Riparian ForestsΔ			
				Interior	WC	MBD	MW	CW
Under Agency Management Authority								
Channelization	Habitat conversion	low (L)	high (H)		CSP	CSP	CSP	CSP
Fire suppression	Modification of natural processes	H	H		CSFP		CSFP	CSFP
Flooding (diversions, dams & impoundments)	Habitat conversion	H	H		CSFP	CSFP	CSFP	CSFP
Forest management practices (vegetation treatments)	Consumptive biological use	moderate (M)	M					
Unauthorized livestock grazing	Consumptive biological use	M	H		CSFP	CSFP	CSFP	CSFP
Non-native invasive plant species	Invasive species/ habitat conversion	H	M	CSFP	CSFP	CSFP	CSFP	CSFP
Driving off roads & trails	Non-consumptive biological use	M	H		CFP	CFP	CFP	CFP
Recreation activities	Non-consumptive biological use	M	M			CFP	CFP	CFP
Roads, highways & utility corridors	Transportation/ habitat conversion	H	H		CSP	CSP	CSP	CSP
Woody species encroachment & establishment	Habitat conversion	H	H					
Outside Agency Management Authority								
Drought	Habitat conversion	M	M		CSFP			
Excessive ungulate grazing/browsing	Consumptive biological use	H	M		CSFP	CSFP	CSFP	CSFP
Flooding	Habitat conversion	M	M		CS	CS	CS	CS
Groundwater depletion/contamination	Habitat conversion	H	H		FP	FP	FP	FP
Human caused fire	Habitat conversion	H	H	CSFP	CSFP	CSFP	CSFP	CSFP
Insect, disease, parasites &/or pathogens outbreaks (epidemic)	Invasive species/ habitat conversion	H	H					

Table 38 Continued.

Threat	Threat Type	Estimated Risk‡		Potential Natural Vegetation Type (PNVT)				
		Likelihood of occurrence	Severity	Chaparral	Riparian Areas/Riparian ForestsΔ			
				Interior	WC	MBD	MW	CW
Uncharacteristic erosion	Habitat conversion	M	H	CSFP	CSFP	CSFP	CSFP	CSFP
Uncharacteristic sedimentation	Habitat conversion	M	H	CSFP	CSFP	CSFP	CSFP	CSFP
Uncharacteristic wildfire	Habitat conversion	M	H		CSFP		CSFP	CSFP
Urban development	Habitat conversion	H	H			CSF	CSF	CSF
Water withdrawal	Abiotic resource use	L	H		CSF	CSF	CSF	CSF
Wind events (blowdown)	Habitat conversion	L	L					
Total (under/outside agency management authority)				2/2	8/8	8/7	9/8	9/8

† Risks are assessed as affecting changes in one or more of the following ecosystem characteristics: vegetation composition (C), vegetation structure (S); vegetation function (F) &/or ecological process (P). Function (F) is the total life activities of organisms in habitats & the effects of those activities on the non-living components of the environment. Ecological Process (P) is the dynamic biogeochemical interactions that occur among & between biotic & abiotic components of the ecosystem. Including but not limited to, transpiration; bioaccumulation; biodiversity; biogeochemical cycling; contaminant transport; ecological competition; energy cycling eutrophication; extinction & extirpation; habitat alteration; hydrologic cycling; migration; pollination, & succession, etc.

‡ Estimated Risk is divided into Likelihood of Occurrence (defined as the probability of a significant departure from reference conditions) & Severity (defined as the magnitude of the departure from reference conditions)

Δ Riparian Areas/Riparian Forests: WC = Wetland/Cienega; MBD = Mixed Broadleaf Deciduous; MW = Montane Willow & CW = Cottonwood-Willow

loss of soil productivity; increasing fuel-loads and snag recruitment/elimination, and increased opportunities for non-native invasive plant species establishment. Fire suppression has disrupted the major natural environment disturbance process the ASNFs' forest, woodland, and grassland PNVTs evolved under.

The introduction of livestock and non-native wild ungulate species has resulted in the presence of a disturbance process that is outside of the ASNFs' woodland, grassland, and riparian PNVTs' respective HRV; altering plant composition and structure (setting the stage for woody species invasion and establishment), function and processes, and providing increased opportunities for introduction and spread of non-native invasive weed species, increased bareground and soil erosion, loss of soil and soil productivity, alteration of the natural fire regime, the removal of whole suites of species, and the disruption of many plant species' competitive abilities. Aquatic non-native invasive species also directly compete for food with native fish, prey on fish and amphibians, further disrupting ecological processes.

Driving off roads and trails, roads, highways, and utility corridors have increased soil compaction and the introduction and spread of non-native invasive plant species as well as the direct removal of many individual plants. The result is changes in species composition and the natural fire regimes of the ASNFs' forest, woodland, grassland, and riparian PNVTs. Human caused fires often occur outside of the HRV in both timing and intensity creating additional disruptions in community composition, structure, function, and processes within the forest, woodland, grassland, and riparian PNVTs. Forest management practices (vegetation treatments) have specifically altered community composition and structure primarily within the ASNFs' forest and woodland PNVTs.

Many recreation activities are concentrated in or near riparian communities; with associated vehicle traffic, increased human caused fire hazard, soil compaction, and increased erosion. Channelization, natural flooding, flooding (diversions, dams and impoundments), and groundwater depletion/contamination all have special relation to riparian habitats in that they affect water availability and timing and can influence vegetation composition, structure, function and ecological processes specific to the forests' riparian PNVTs.

These threats/risks all relate to unfavorable characteristics as a result of habitat conversion for those native plant and animal species dependent upon these forest, woodland, grassland, and riparian PNVTs located on the ASNFs.

Within the forest, woodland, chaparral, and riparian PNVTs, there are no areas considered to be irreversible. However, this is not the case with the grassland PNVTs; particularly Great Basin and Semi-desert. As mentioned earlier, approximately 68 and 80 percent of these two grassland PNVTs have been invaded by woody species with subsequent changes in species composition, structure, loss of soil cover, and productivity, and concurrent changes in the hydrologic, nutrient, and energy cycles. According to Vander-Lee et al. (2007) approximately 70 and 36 percent (Great Basin and Semi-desert, respectively) of these invaded acres are non restorable to their former grassland condition.

Soil Resources

Threats to soil resources are similar to those discussed in the threats to vegetation, and were used in the vegetation soil and aquatic risk assessments below. Components of the threats analyses specific to the soil resource are contained in the Soil Specialist's report

Aquatic Resources

In determining the risks to ecosystem diversity, an analysis of the reversible or irreversible nature of the departures is developed to highlight potential negative outcomes. This risk assessment also includes analysis of potential threats to ecosystem diversity within each watershed. Threats the Forest Service has the ability to control or influence with management were considered in the risk assessment. Threats that were outside of the Forest Service's ability to control or influence with management were listed but are not further considered.

Many of these risk and threats, both human and natural, singularly or in combination, pose the same or similar risks: primarily changing timing and duration of water flow which affects water quantity and uses, as well as water quality and its affect on designated uses. Conditions, threats and risks of vegetation as described above section influence aquatic resources. Table 39 summarize risks to biotic and abiotic resources based on analysis of risk to vegetation composition, structure, disturbance processes, soil function, riparian function, water quality related to primary designated uses, and habitat characteristics. Tables 40 and 41 display the results of the analyses of the most significant threats to aquatic resources by fifth level HUC watersheds on the ASNFs, both under and outside Forest Service management authority (highlighted areas denote areas where conditions warrant elevated concerns or large proportional extent, or both).

Table 39. Major sustainability findings identified during the evaluation of the ASNFs' ecological assessment aquatic biota and abiotic resources. Displayed is the ASNFs' within watershed condition risk (based on PNVT and soil condition risk), proper functioning condition (based on functioning at risk and non-functioning conditions), water quality, macroinvertebrate, and fish stream habitat. The overall summary of the ASNFs' biotic and abiotic contribution to sustainability and risk is also presented. Highlighted cells denote areas where conditions are such that the forests have elevated concerns or they represent high proportional extent.

Watershed Name		Within Watershed Condition Risk		Proper Functioning Condition Percent FAR & NF	Water Quality Risk (ADEQ Impaired Category 4 or 5)	Macro-invertebrates & Fish Stream Habitat Risk	Summary of Biotic & Abiotic Contribution to Sustainability & Risk	
Fourth hydrologic unit code (HUC)	Fifth hydrologic unit code (HUC)	PNVT risk	Refined soil condition risk				Contribution†	Risk‡
Little Colorado Riv Headwaters	Nutrioso Ck	riskΔ	risk	58	risk	risk	high (H)	H
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	risk		42	risk	risk	H	H
	Coyote Ck	risk		85	no data	risk	high	H
	Carnero Ck-Little Colorado Riv Headwaters	risk		85	risk	no data	moderate (M)	M
Upper Little Colorado Riv	Big Hollow Wash	risk		100	risk	no data	low (L)	L
	Oso Draw	risk		90	risk	risk	M	M
Silver Ck	Show low Ck	risk	risk	93		risk	H	H
	Upper Silver Ck	risk	risk	100		risk	H	H
	Cottonwood Ck	risk	risk	96	no data	no data	H	H
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	risk	risk	100		no data	H	M
	Upper Clear Ck	risk		71	risk	risk	M	H
	Lower Clear Ck		risk	0		risk	L	L
Chevelon Canyon	Upper Chevelon Canyon	risk		47		risk	H	M
	Black Canyon	risk	risk	100		no data	H	L
	Lower Chevelon Canyon	risk	risk	100		no data	L	L
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	risk	risk	71	risk	no data	L	L

Table 39. Continued.

Watershed Name		Within Watershed Condition Risk		Proper Functioning Condition Percent FAR & NF	Water Quality Risk (ADEQ Impaired Category 4 or 5)	Macro-invertebrates & Fish Stream Habitat Risk	Summary of Biotic & Abiotic Contribution to Sustainability & Risk	
Fourth hydrologic unit code (HUC)	Fifth hydrologic unit code (HUC)	PNVT risk	Refined soil condition risk				Contribution†	Risk‡
San Francisco Riv	Centerfire Ck-San Francisco Riv	risk		89	risk	risk	M	M
	Upper Blue Riv	risk		72		risk	H	H
	Pueblo Ck-San Francisco Riv	risk	risk	100	risk	risk	L	L
	Lower Blue Riv	risk	risk	71	risk	risk	H	H
	Mule Ck-San Francisco Riv	risk	risk	78	risk	risk	H	H
	Chase Ck-San Francisco Riv	risk	risk	64	risk	risk	H	H
Upper Gila Riv-San Carlos Reservoir	Willow Ck		risk	not rated	no data	no data	L	L
	Upper Eagle Ck	risk	risk	67		risk	H	H
	Lower Eagle Ck	risk	risk	57		risk	M	M
Black Riv	Upper Black Riv	risk		85	risk	risk	H	H
	Middle Black Riv	risk		55		risk	M	H
White Riv	Upper North Fork White Riv	risk		100	no data	no data	L	L
	East Fork White Riv	risk		not rated	no data		L	L
Upper Salt Riv	Canyon Ck	risk		40		no data	L	L
Carrizo Ck	Corduroy Ck	risk		not rated	no data		L	L
	Carrizo Ck (local drainage)	risk		100	no data	no data	L	L
Tonto Ck	Haigler Ck-Tonto Ck	risk		not rated		no data	L	L

† This rating is based on a qualitative assessment of proportional extent of ASNFs' lands, streams, riparian areas, and fish occurrence within each watershed
‡ This rating is based on a qualitative assessment of threats and contribution to sustainability of aquatic biota and abiotic resources
Δ Risk = determined to be at risk to the selected characteristics of ecosystem diversity

Table 40. Threats and estimated risk to ecological sustainability by fifth hydrologic unit code (HUC) watersheds within the Little Colorado River System on the ASNFs. Threats are categorized as either under agency management authority or outside agency management authority as well as threat type and estimated risk of high, moderate, or low.

		Estimated Risk†		Little Colorado River System Fifth Hydrologic Unit Code (HUC) Watershed														
Threat	Threat Type	Likelihood of occurrence	Severity	Nutrioso Ck	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	Coyote Ck	Carnero Ck-Little Colorado Riv Headwaters	Big Hollow Wash	Oso Draw	Show Low Ck	Upper Silver Ck	Cottonwood Ck	Phoenix Park Wash-Dry Lake	Upper Clear Ck	Lower Clear Ck	Upper Chevelon Canyon	Black Canyon	Lower Chevelon Canyon
Under Agency Management Authority																		
Channelization/material removal	Habitat conversion	low (L)	high (H)							✓		✓					✓	
Fire suppression	Modification of natural processes	H	H	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flooding (diversions, dams & impoundments)	Habitat conversion	H	H	✓	✓		✓			✓				✓		✓		
Forest management practices (vegetation treatments)	Consumptive biological use	moderate (M)	M	✓	✓				✓	✓		✓				✓	✓	
Unauthorized livestock grazing	Consumptive biological use	M	H	✓	✓	✓	✓		✓	✓	✓	✓	✓				✓	✓
Noxious & invasive plant species	Invasive species/ habitat conversion	H	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Driving off roads & trails	Non-consumptive biological use	M	H	✓	✓					✓	✓	✓	✓	✓		✓	✓	
Recreation activities	Non-consumptive biological use	M	M		✓					✓						✓		

Table 40. Continued.

Threat	Threat Type	Estimated Risk†		Little Colorado River System Fifth Hydrologic Unit Code (HUC) Watershed														
		Likelihood of occurrence	Severity	Nutrioso Ck	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	Coyote Ck	Carnero Ck-Little Colorado Riv Headwaters	Big Hollow Wash	Oso Draw	Show Low Ck	Upper Silver Ck	Cottonwood Ck	Phoenix Park Wash-Dry Lake	Upper Clear Ck	Lower Clear Ck	Upper Chevelon Canyon	Black Canyon	Lower Chevelon Canyon
Roads, highways & utility corridors	Transportation/ habitat conversion	H	H			✓	✓	✓	✓	✓	✓	✓				✓		
Outside Agency Management Authority																		
Drought	Habitat conversion	M	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Excessive ungulate grazing/browsing	Consumptive biological use	M	H	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	
Flooding	Habitat conversion	M	M								✓						✓	
Groundwater depletion/ contamination	Habitat conversion	H	H	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Human caused fire	Habitat conversion	H	H	✓	✓					✓	✓	✓					✓	
Insect, disease, parasites &/or pathogens epidemic	Invasive species/ habitat conversion	H	H	✓	✓	✓												
Uncharacteristic erosion	Habitat conversion	M	H							✓		✓	✓				✓	
Uncharacteristic sedimentation	Habitat conversion	M	H							✓		✓	✓				✓	
Uncharacteristic wildfire	Habitat conversion	M	H	✓	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓	
Urban development	Habitat conversion	H	H	✓	✓					✓		✓					✓	
Water withdrawal	Abiotic resource use	L	H	✓	✓		✓		✓	✓	✓	✓						
Total (under/outside agency management authority)				7/7	8/7	4/5	5/5	3/3	5/5	10/8	6/5	8/8	4/6	4/4	2/2	7/4	7/8	3/2

† Estimated Risk is divided into Likelihood of Occurrence (defined as the probability of a significant departure from reference conditions) & Severity (defined as the magnitude of the departure from reference conditions)

Table 41. Threats and estimated risk to ecological sustainability by fifth hydrologic unit code (HUC) watersheds within the Gila and Salt River System on the ASNFs. Threats are categorized as either under agency management authority or outside agency management authority as well as threat type and estimated risk of high, moderate, or low.

Threat	Threat Type	Estimated Risk†		Gila and Salt River System Fifth Hydrologic Unit Code (HUC) Watersheds														
		Likelihood of occurrence	Severity	Apache Ck-Upper Gila Riv	Centerfire Ck-San Francisco Riv	Upper Blue Riv	Pueblo Ck-San Francisco Riv	Lower Blue Riv	Mule Ck-San Francisco Riv	Chase Ck-San Francisco Riv	Upper Eagle Ck	Lower Eagle Ck	Upper Black Riv	Middle Black Riv	Upper North Fork White Riv	Canyon Ck	Corduroy Ck	Carrizo Ck (local drainage)	Haigler Ck-Tonto Ck
Under Agency Management Authority																			
Channelization/material removal	Habitat conversion	low (L)	high (H)			✓													
Fire suppression	Modification of natural processes	H	H	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Flooding (diversions, dams & impoundments)	Habitat conversion	H	H		✓	✓					✓	✓							
Forest management practices (vegetation treatments)	Consumptive biological use	moderate (M)	M		✓	✓		✓	✓		✓					✓			
Unauthorized livestock grazing	Consumptive biological use	M	H					✓	✓	✓	✓	✓	✓				✓	✓	
Noxious & invasive plant species	Invasive species/ habitat conversion	H	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Driving off roads & trails	Non-consumptive biological use	M	H																
Recreation activities	Non-consumptive biological use	M	M		✓	✓					✓		✓	✓					
Roads, highways & utility corridors	Transportation/ habitat conversion	H	H			✓			✓										

Table 41. Continued.

Threat	Threat Type	Estimated Risk†		Gila and Salt River System Fifth Hydrologic Unit Code (HUC) Watersheds															
		Likelihood of occurrence	Severity	Apache Ck-Upper Gila Riv	Centerfire Ck-San Francisco Riv	Upper Blue Riv	Pueblo Ck-San Francisco Riv	Lower Blue Riv	Mule Ck-San Francisco Riv	Chase Ck-San Francisco Riv	Upper Eagle Ck	Lower Eagle Ck	Upper Black Riv	Middle Black Riv	Upper North Fork White Riv	Canyon Ck	Corduroy Ck	Carrizo Ck (local drainage)	Haigler Ck-Tonto Ck
Outside Agency Management Authority																			
Drought	Habitat conversion	M	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Excessive ungulate grazing/browsing	Consumptive biological use	M	H		✓	✓							✓	✓					
Flooding	Habitat conversion	M	M			✓		✓	✓	✓	✓	✓							
Groundwater depletion/ contamination	Habitat conversion	H	H																
Human caused fire	Habitat conversion	H	H		✓	✓					✓	✓							
Insect, disease, parasites &/or pathogens epidemic	Invasive species/ habitat conversion	H	H		✓								✓	✓					
Uncharacteristic erosion	Habitat conversion	M	H			✓					✓		✓						
Uncharacteristic sedimentation	Habitat conversion	M	H			✓					✓		✓						
Uncharacteristic wildfire	Habitat conversion	M	H		✓	✓					✓		✓	✓					✓
Urban development	Habitat conversion	H	H		✓	✓													
Water withdrawal	Abiotic resource use	L	H		✓	✓					✓								
Total (under/outside agency management authority)				2/1	6/6	8/8	2/1	4/2	5/2	3/2	7/6	5/2	4/6	3/4	2/1	3/1	3/1	3/1	2/2

† Estimated Risk is divided into Likelihood of Occurrence (defined as the probability of a significant departure from reference conditions) & Severity (defined as the magnitude of the departure from reference conditions)

Table 42 is a summary of risk and number of species of native fish by fourth level HUCs for the ASNFs. It is widely recognized that native freshwater fish in the United States are highly imperiled, and Arizona has one of the highest percentages of threatened fish species (85 percent) (Warren and Burr 1994). It is thought that the first and most dramatic decline in native fish in the Southwest occurred between 1890 and 1935 as a result of intensive water management, introduction of non-native species, and the construction of dams. Today many native fish species in the Southwest have limited distributions, making their viability particularly vulnerable to local and regional threats.

Within Arizona, national forests have a vital role in assuring the sustainability of these species. The ASNFs and Tonto National Forests, in particular, have substantial stream miles with native fish. Compared to other landowners, national forests have a greater proportion (as much as one-half) of the stream miles with high native fish species richness. From a planning perspective, these areas may serve as important areas when considering the sustainability of aquatic vertebrate species. According to Vander-Lee et al. (2007), given the magnitude and rate of loss of native fish in the Southwest, it is vital that these systems and the species that depend upon them are an integral component of the ecological sustainability.

Table 42. Summary of risk and number of native and non-native fish by fourth hydrologic unit code (HUC) watersheds on the ASNFs.

Fourth Hydrologic Unit Code (HUC) Watershed	Risk (negative outcome)		Number of Fish Species		
	Likelihood of occurrence	Severity	Native	Non-native	Total
Little Colorado Riv Headwaters	high (H)	H	4	12	16
Upper Little Colorado Riv	moderate (M)	M	1	0	1
Silver Ck	H	M	1	16	17
Middle Little Colorado Riv	H	H	4	9	13
Chevelon Canyon	H	H	4	4	8
Mangus Ck-Upper Gila Riv	low (L)	L	0	0	0
San Francisco Riv	H	H	8	12	20
Upper Gila Riv-San Carlos Reservoir	H	H	8	10	18
Black Riv	H	H	6	7	13
White Riv	L	L	0	0	0
Upper Salt Riv	L	L	0	0	0
Carrizo Ck	L	L	0	0	0
Tonto Ck	L	L	0	0	0

The threats facing aquatic ecosystems and fish habitat include, but are not limited to, degraded watershed and hydrologic conditions; altered water infiltration rates associated with soil compaction and loss of vegetative ground cover; excessive sedimentation associated with roads and significantly increased drainage densities, loss of vegetative ground cover, and stream channel down cutting. In addition, altered PNVTs and fire regimes continue to alter and degrade riparian conditions. Non-native fish species (see Appendix A table 1), bullfrogs, and crayfish threaten species richness and diversity. In some watersheds, a lack of aquatic habitat diversity, productivity, and resiliency has resulted. Table 43 displays threats and overall risks associated with fourth and fifth level HUCs. Under these threats to aquatic macroinvertebrates and fish species, population fragmentation and declines continue.

Table 43. Threats and the estimated level of risk to sustainability by riparian/aquatic habitat alteration and fragmentation to native fish species by fourth and fifth hydrologic unit code (HUC) watersheds on the ASNFs.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Threat†											
		Ground disturbing activities within watershed	Sediment load	Fire suppression	Roads, highways & utility corridors	Recreation activities	Livestock/wildlife ungulate grazing/ browsing	Dams	Stock ponds	Streamflow diversions	Non-native aquatic species‡	Chemical treatments	Estimated Risk to Sustainability∆
Little Colorado Riv Headwaters	Nutrioso Ck	H	H	H	H	H	H	H	H	H	H	L	H
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters	H	H	H	H	H	H	H	H	H	H	H	H
	Coyote Ck	H	H	M	H	M	H	L	M	M	L	M	H
	Carnero Ck-Little Colorado Riv Headwaters	M	M	M	M	M	H	L	H	H	L	L	M
Upper Little Colorado Riv	Big Hollow Wash	M	M	M	M	L	M	L	M	M	L	L	M
	Oso Draw	M	M	M	M	L	M	L	M	M	L	L	M
Silver Ck	Show Low Ck	H	M	M	H	H	M	H	H	H	H	M	H
	Upper Silver Ck	M	M	M	M	H	M	L	H	H	M	L	H
	Cottonwood Ck	H	M	M	H	H	H	M	H	M	L	L	H
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake	M	M	M	H	M	M	L	M	L	L	L	M
	Upper Clear Ck	M	M	M	H	H	H	H	H	M	H	L	H
	Lower Clear Ck	M	M	M	H	M	M	L	M	M	H	L	M
Chevelon Canyon	Upper Chevelon Canyon	H	M	M	H	H	H	H	H	M	H	M	H
	Black Canyon	M	M	M	H	M	H	L	H	M	L	L	M
	Lower Chevelon Canyon	M	M	M	M	M	M	L	M	L	L	L	M
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv	M	H	H	H	L	H	L	H	H	L	L	H

Table 43. Continued.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Threat†											
		Ground disturbing activities within watershed	Sediment load	Fire suppression	Roads, highways & utility corridors	Recreation activities	Livestock/wildlife ungulate grazing/ browsing	Dams	Stock ponds	Streamflow diversions	Non-native aquatic species‡	Chemical treatments	Estimated Risk to SustainabilityΔ
San Francisco Riv	Centerfire Ck-San Francisco Riv	M	H	M	H	H	H	H	H	H	M	L	H
	Upper Blue Riv	H	H	H	H	H	H	M	H	H	H	M	H
	Pueblo Ck-San Francisco Riv	M	M	M	M	L	M	L	M	L	L	L	M
	Lower Blue Riv	H	H	H	H	M	H	M	H	H	H	M	H
	Mule Ck-San Francisco Riv	H	H	H	H	L	H	L	H	H	H	L	H
	Chase Ck-San Francisco Riv	H	H	H	H	L	H	L	H	H	H	L	H
Upper Gila Riv-San Carlos Reservoir	Willow Ck	L	L	L	L	L	L	L	L	L	L	L	L
	Upper Eagle Ck	H	H	H	H	H	H	L	H	H	H	L	H
	Lower Eagle Ck	H	H	H	H	M	H	L	H	H	H	L	H
Black Riv	Upper Black Riv	H	H	H	H	H	H	H	H	M	H	H	H
	Middle Black Riv	H	H	H	H	H	H	L	H	L	H	H	H
White Riv	Upper North Fork White Riv	L	L	L	L	L	M	L	L	L	L	L	L
	East Fork White Riv	L	L	L	L	L	L	L	L	L	L	L	L
Upper Salt Riv	Canyon Ck	M	M	M	M	M	M	L	L	L	L	L	M
Carrizo Ck	Corduroy Ck	L	L	L	L	L	L	L	L	L	L	L	L
	Carrizo Ck (local drainage)	L	L	L	L	L	L	L	L	L	L	L	L
Tonto Ck	Haigler Ck-Tonto Ck	L	L	L	L	L	L	L	L	L	L	L	L

† Threat level = high (H), moderate (M), & low (L)

‡ Some aspects of this threat are not under agency management authority

Δ Risk to sustainability = high (H), moderate (M), & low (L)

Air Resources

In determining the risks to ecosystem diversity, an analysis of the reversible or irreversible nature of the departures is developed to highlight potential negative outcomes. This risk assessment also includes analysis of potential threats to ecosystem diversity within airsheds. Threats the Forest Service has the ability to control or influence include dust from unsurfaced roads, smoke from prescribed fire, and to some extent, dust generated from deicing salts applied to state highways by Arizona Department of Transportation during the winter. Threats that were outside of the Forest Service's ability to control or influence with management include smoke from uncontrolled wildfire, dust from landscape scale wind events, and pollutants from urban areas as well as from heavy industry, such as copper processing and power generation plants upwind of the forests. These will not be analyzed; however, the forests and ADEQ continue to monitor these pollutants to determine trends and compliance to state and federal standards.

Forest Service FSH 1909.12 discusses risk as having two components; the likelihood of a negative outcome, and the potential severity of a negative outcome. Many of the threats/risks, both human and natural, singularly or in combination, pose the same or similar risks. Poor air quality can affect human, animal, and plant health. Many visitors to the forests want to view the forests through unsoiled air.

Risks to human, animal, and plant health from air quality issues on the forests is low to moderate in likelihood and high in severity. Generally dust generated from unpaved roads settles out quickly, but may affect vegetation production and potentially human health close to these roads. Smoke generated from prescribed fire is generally low to moderate in likelihood, as duration is generally low and extent is moderate in extent and problematic in more populated areas, however, severity can be high in adults and children with respiratory problems. Smoke duration and extent from prescribed fire is currently allocated statewide by ADEQ and involves all federal and state agencies as well as many tribes. Effects from airborne salt dust is low in likelihood (extent) and low to moderate in severity, therefore risk is low.

Species Diversity

In the analysis of ecosystem diversity, structure, composition, and process characteristics at risk were identified along with associated activities which contribute to that risk. Species were identified and associated with ecological conditions. The various threats identified for the individual PNVTs and their ecological components were considered threats to those species. The species specific needs will be considered when developing the revised forest plan components. This section focuses on the specific threats not addressed through ecological characteristics. In determining the risks to species diversity, an analysis of the reversible or irreversible nature of the departures was developed to highlight potential negative outcomes. Threats the Forest Service has the ability to control or influence with management were considered in the risk assessment. Threats that were outside of the Forest Service's ability to control or influence with management were listed but were not further considered.

Since Euro-American settlement, massive changes to species diversity have occurred throughout the Southwest as well as in the planning area. Many top predators and other highly interactive species were extirpated or became extinct due to habitat modification, over harvesting, and deliberate eradication efforts (Estes 1996). It has now been shown that such actions have profound effects on other species not considered when the targeted species were driven out of an area (Soule et al. 2005, Ripple and Beschta 2006). Restoration of the full compliment of species present prior to settlement is

not considered possible or desirable due to both ecological and social implications. Therefore, this analysis focuses on reducing risks to the current compliment of species within the planning area.

Species Associated with Ecosystem Diversity Characteristics

The numbers of species associated with each terrestrial and aquatic ecosystem characteristic are displayed in table 33. These species were further evaluated to determine if there were additional threats beyond those identified in ecosystem diversity. The number of species for each ecosystem characteristic and the additional threats are given in table 44; a full listing of the species and the additional threats is given in the WFRP Specialist report.

Table 44. Ecosystem diversity characteristics and the species associated with them. Additional threats to species diversity beyond those to the habitats themselves are shown.

Ecosystem Characteristic	Number of Species	Number of Species with Additional Threats Not Related to Ecosystem Diversity	Threats
Forests			
Ponderosa Pine	14	1- Black River Beardtongue	Collection
Mixed Conifer with Frequent Fire	4	1 - Mt. Graham beardtongue	Collection
Spruce-Fir with Wet Mixed Conifer	7	1 – beautiful Jacob's ladder	Collection
Grasslands			
Great Basin	7	4 - Gunnison's prairie dog, ferruginous hawk, western burrowing owl & paperspine fishhook cactus	Collection, shooting/ poisoning
Riparian Areas			
Wetland/Cienega	27	7 - crenulate moonwort, Apache beardtongue, yellow Jacob's ladder, lesser yellow lady's slipper, hooded lady's slipper, longbract frog orchid & Cochise adder's mouth orchid	Collection
Montane Willow	9	1 - SW Willow flycatcher	Nest parasitism

Species Associated with Ecological Characteristics

Certain species were associated with specific features not necessarily addressed in the ecosystem diversity (PNVT) analysis (table 34). Activities which potentially affect those specific features, and the number of species associated with them, are presented on the following page (table 45).

Table 45. Ecological characteristics and additional threats to species diversity not addressed in the ecosystem diversity analysis, number of species associated with feature, and threats to the features on the ASNFs.

Habitat/Ecological Feature	Number of Species Associated with Feature	Threats to the Features
Aquatic/Riparian	40 + 14 fish spp	See riparian & aquatic biota sections
Dry meadows	10	Roads, driving off roads & trails, grazing (wild and domestic, authorized and unauthorized), large recreation events
Cliffs	8	No threats to features
Specific plant species	6	Collection, chemical treatments, driving off roads & trails, grazing (wild and domestic, authorized and unauthorized)
Specific soils	14	Driving off roads & trails, roads, grazing (wild and domestic, authorized and unauthorized), fuelwood/ specialty wood poaching, vegetation treatments
Snags/Logs	9	Fire suppression, fuelwood/specialty wood poaching

In addition, some of the species associated with the ecological features above also may have additional threats not related to the features with which they are associated. Those additional threats and the number of species potentially at risk are displayed below (table 46).

Table 46. Ecological characteristics and additional threats to species diversity not related to the features with which they are associated, number of species associated with feature, number of species with additional threats, and additional threats on the ASNFs.

Habitat/Ecological Feature	Number of Species Associated with Feature	Number of Species with Additional Threats	Additional Threats
Aquatic/Riparian	40 + 14 fish	8 + 14 fish	Non-native species, roads, collection
Cliffs, caves	8	6	Rock climbing, collection
Specific plant species	6	6	Collection
Specific soils	14	4	Collection

Species Not Associated with Ecosystem Diversity Characteristics or Features

Tables 44 and 46 list the number of species that have specific associations but have additional threats beyond those associated with habitat, as shown above. Threats to these species were identified by individual species. The species were then grouped by common threats (table 47). The revised forest plan may need additional components to address the 12 species (and 14 fish) with additional threats plus the 24 plants and invertebrates potentially threatened by collection.

Table 47. Species not associated with any habitat or feature as well as those that have additional threats beyond threats and risks associated with habitat on the ASNFs.

Threat	Species Affected
Non-native species	Chiricahua leopard frog (T&E†), Mexican gray wolf (T&E), all native fish (T&E-SOC‡), Mexican gartersnake (SOC), narrow-headed gartersnake (SOC), northern leopard frog (SOIΔ)
Nest predation/parasitism	Southwestern willow flycatcher (T&E)

Table 47. Continued.

Threat	Species Affected
Collection	Crenulate moonwort (SOC), Senator Mine alumroot (SOC), Chiricahua alum-root (SOC), New Mexico alum-root (SOC), Mt. Graham beardtongue (SOC), Maguire's penstemon (SOC), Apache beardtongue (SOC), Black River beardtongue (SOC), Rydberg's penstemon (SOC), yellow Jacob's ladder (SOC), beautiful Jacob's ladder (SOC), Davidson's sage (SOC), lesser yellow lady's slipper (SOI), longbract frog orchid (SOI), paperspine fishhook cactus (SOI), Cochise adder's-mouth orchid (SOI), Ferris' copper (SOC), Alberta arctic (SOC), atronis fritillary (SOC), nokomis fritillary (SOC), nitocris fritillary (SOC), nanomis fritillary (SOC), & xami hairstreak (SOI)
Rock climbing	Peregrine falcon (SOC)
Shooting/poaching, poisoning	Gunnison's prairie dog (SOI), bald eagle (SOC) & Mexican gray wolf (T&E)
Diseases, parasites, other pathogens	Chiricahua leopard frog (T&E), northern leopard frog (SOI) & Gunnison's prairie dog (SOI)

† T&E = Threatened & Endangered – these are species that are federally listed as T&E under the ESA

‡ SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA

Δ SOI = species-of-interest – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives

Table 48 on the following page displays the most significant threats not related to habitats; e.g. rock climbing near peregrine falcon nests. Fishermen may intentionally or accidentally introduce non-native species into streams. These species can then have significant effects on native fauna.

Table 48. Non-habitat related threats to species diversity on the ASNFs.

Species	Threat†				
	Recreation and other activities‡	Non-native species	Chemical treatments (herbicides/ piscicide)	Collection	Intentional harassment (shooting/ poisoning/ chasing/illegal harvest)
Apache trout (T&EΔ)	high (H)	H	medium (M)	not applicable (na)	na
Bluehead sucker (SOI§)	low (L)	M	H	na	na
Desert sucker (SOI)	M	M	L	na	na
Gila chub (T&E)	M	H	M	na	na
Gila trout (T&E)	H	H	M	na	na
Little Colorado spinedace (T&E)	M	H	M	na	na
Little Colorado sucker (SOC*f*)	L	M	M	na	na
Loach minnow (T&E)	M	H	M	na	na
Longfin dace (SOI)	L	M	M	na	na
Razorback sucker (T&E)	L	H	L	na	na
Roundtail chub (SOC)	H	H	H	na	na
Sonora sucker (SOC)	M	M	M	na	na
Speckled dace (SOI)	L	M	H	na	na
Spikedace (T&E)	M	H	M	na	na
Southwest willow flycatcher (T&E)	L	M	L	L	L
Chiricahua leopard frog (T&E)	L	H	H	na	na
Mexican gray wolf (T&E)	L	H	L	L	M
Peregrine falcon (SOC)	M	L	L	L	L
Bald eagle (SOC)	L	L	M	L	L
Mexican garter snake (SOC)	M	H	M	L	na
Narrow-headed garter snake (SOC)	M	H	M	L	na
Gunnison's prairie dog (SOI)	L	M	M	na	H
Beaver (SOI)	na	L	M	na	na
Ferruginous hawk (SOI)	L	L	M	L	M
Northern goshawk (SOI)	L	na	L	L	L
Northern leopard frog (SOI)	L	H	M	na	Na
Crenulate moonwort (SOC),	L	na	L	M	na
Senator Mine alumroot (SOC)	L	na	M	M	na
Chiricahua Mtn. alum-root (SOC)	L	na	L	M	na
NM alum-root (SOC)	L	na	L	M	na
Black River beardtongue	na	na	M	H	na

Table 48. Non-habitat related threats to species diversity on the ASNFs.

Species	Threat†				
	Recreation and other activities‡	Non-native species	Chemical treatments (herbicides/ piscicide)	Collection	Intentional harassment (shooting/ poisoning/ chasing/illegal harvest)
(SOC)					
Superb penstemon (SOC)	na	na	L	L	na
Mt. Graham beardtongue (SOC)	L	na	L	L	na
Maguire's penstemon (SOC)	L	na	M	H	na
Davidson's wavewing	L	na	L	H	na
Davidson's sage (SOC)	L	na	L	M	na
Yellow Jacob's ladder (SOC)	L	na	M	M	na
Beautiful Jacob's ladder (SOC)	L	na	M	M	na
Ferris' copper (SOC)	L	M	M	H	na
Alberta arctic (SOC)	L	M	M	H	na
atronis fritillary (SOC)	L	M	M	H	na
nokomis fritillary (SOC)	L	M	M	H	na
nitocris fritillary (SOC)	L	M	M	H	na
nanomis fritillary (SOC)	L	M	M	H	na
Lesser yellow lady's slipper (SOI)	L	na	M	H	na
Lesser yellow lady's tresses (SOI)	L	na	M	H	na
Longbract frog orchid (SOI)	L	na	M	H	na
Cochise adder's mouth orchid (SOI)	L	na	M	H	na
Paperspine fishhook cactus (SOI)	na	na	M	H	na

† Some of these threats are not under agency management authority

‡ Activities & uses include but are not limited to displacement by the presence of humans, driving off roads & trails, communication sites, powerlines, etc.

Δ T&E = Threatened & Endangered – these are species that are federally listed as T&E under the ESA

§ SOI = species-of-interest – these are species for which management actions may be necessary to achieve ecological or other multiple-use objectives

ƒ SOC = species-of-concern – these are species for which management actions may be necessary to prevent listing under the ESA

Species Diversity Summary

Though the majority of these species should be provided for if there are improved ecological conditions in the vegetation communities, there are species that are dependent on changes in specific ecological characteristics (e.g. logs, tree cavities) or non-habitat related conditions (e.g. collection, poisoning) or affected by threats (e.g. invasive species, shooting).

Characteristics and species most at risk are related to riparian/aquatic ecosystems. The sustainability of all the native fish, amphibians such as Chiricahua leopard frog, and reptiles like the Mexican gartersnake are all at risk for sustainability over the long term. Some are at risk in the immediate future due to non-native invasive species and/or due to non-native desirable species. See the aquatic biota section for detailed information concerning native fish and aquatic invertebrates. Ecological characteristics such as lowered water quality and quantity, stream bank instability, as well as non-native predators and competitors threaten ecological and species diversity. Additional threats include accidental and incidental poisoning, genetic swamping[32] of some subspecies by non-native trout, and continued dewatering from over-pumping and diversions. Most of the T&E species as well as most of the species being considered in detail are associated with riparian/aquatic features.

Collection has the potential to affect many species, especially plants. Whether it is large trees for fireplace mantels and furniture, rare plants or butterfly specimens, over-collecting can directly affect species, and can affect other species depending on what was collected. While it is unclear to what extent collecting on the forests currently takes place, it may have catastrophic impacts in limited situations and on small populations of rare plants.

Illegal hunting (poaching), although usually minor, can also affect species. In addition, legal hunting of "varmints," particularly prairie dogs, may be leading towards listing of the species. In addition, declines of other species such as ferruginous hawks and western burrowing owls may be correlated with the declining, highly interactive prairie dogs (Soule et al. 2005).

[32] Genetic swamping or pollution is undesirable gene flow into wild populations. The term, in this context, is used to describe gene flow from a domestic, feral, non-native or invasive species to a wild indigenous population (http://en.wikipedia.org/wiki/Genetic_pollution).

Chapter 5 – Ecological Need for Change

Climate

There is a need to maintain or improve forest ecosystem conditions to be resistant to and resilient in response to climate change.

According to Tausch (2008), a warming climate will often lead to an upward elevational migration of plant species. Because of the rapidity of expected changes in climate, individuals of a native plant species may be lost from their lower-elevation limits faster than they will be able to migrate upward and establish into newly created habitat. This will result in stressed communities with fewer plant species distributed over large areas of the landscape. As ecosystems become simplified, their trophic levels[33] are truncated and their trophic interactions reduced (Tausch 2008).

Such ecosystems potentially have an increase in the quantity of unused resources. These stressed communities thus become more open and their resources more available for the invasion and establishment of non-native invasive plant species. These invaders may also be better adapted than native species to the new environmental conditions resulting from climate change. An exception might be native species of plants that can migrate from adjacent areas or regions into locations where they previously were excluded by climate as the new locations become more suitable. The greater the change, the more likely this facilitation of non-native invasives will be. In addition to climate change are the species of invaders involved, the effects of the interactions of their species composition on the ecosystems, and the disturbance patterns those ecosystems are experiencing. On landscape scales, these ecosystem spatial and temporal variabilities have major effects on ecosystem susceptibility to non-native invasive species. Climate change and associated vegetation change interacting with non-native invasive species are also increasingly leading to uncharacteristic wildfires that can further facilitate the establishment of additional non-native invasive plant species (Tausch 2008).

Vegetation

There are 13 vegetation communities represented on the ASNFs, all of which deviate from HRV in regards to successional structure, composition and cover classes, and processes (table 49) to some degree. Vegetation attributes (composition, structure, and function) have been significantly altered from the historical range in 12 of the 13 PNVTs. These areas may need high levels of restoration treatments, such as hand or mechanical clearing, before fire is used as a tool to restore historical fire regimes. Fire regimes, and the ecological process and function fire provides, have been significantly altered from their historical range in ten of the 13 vegetation communities, e.g. fire frequencies have departed from historical range by multiple return intervals, as well as FRCC. Dramatic changes in fire size, frequency, intensity, severity, or landscape pattern has resulted as evidenced by numerous fires on the ASNFs since 2002.

As discussed earlier in this document, wildlife, fish, and plants are tied to the conditions of their primary habitats, and certain components within those habitats. The conditions and attributes are in

[33] Trophic levels are the feeding position in a food chain such as primary producers, herbivore, primary carnivore, etc. Green plants form the first trophic level, the producers. Herbivores form the second trophic level, while carnivores form the third and even the fourth trophic levels. In an ecosystem there are many different food chains and many of these are cross-linked to form a food web. Ultimately all plants and animals in an ecosystem are part of this complex food web (http://www.botany.uwc.ac.za/sci_Ed/grade10/ecology/trophics/troph.htm).

turn affected by all actions and processes (natural and human caused) that occur within those habitats, or in many cases, away from those habitats.

Table 49. Need for ecological change in the potential natural vegetation types (PNVT) identified through the ASNFs' risk assessment. Highlighted cells denote PNVTs that have an ecological need for change.

Potential Natural Vegetation Type (PNVT)	Deviation from HRV	Trend in Relation to HRV	Contribution to Sustainability	Estimated Risk to Sustainability	Need for Ecological Change
Forests					
Ponderosa Pine	severe (S)	static (ST)	high (H)	H	yes (Y)
Mixed Conifer with Frequent Fire	S	ST	H	H	Y
Spruce-Fir with Wet Mixed Conifer	moderate (M)	toward (T)	M	M	no (N)
Woodlands					
Madrean Pine-Oak	H	away (A)	M	H	Y
Piñon-Juniper	low (L)	away (A)	M	M	Y
Grasslands					
Great Basin	H	A	M	H	Y
Semi-desert	H	A	M	H	Y
Montane/Subalpine	M	A	M	M	Y
Chaparral					
Interior	within HRV	ST	L	L	N
Riparian Areas/Riparian Forests					
Wetland/Cienega	M	ATBA†	M	H	Y
Mixed Broadleaf Deciduous	L	ATBA†	M	H	Y
Montane Willow	H	ATBA†	H	H	Y
Cottonwood-Willow	M	ATBA†	H	H	Y

† ATBA = Assumed to be away. No vegetation model exists at this time to predict vegetation trend in relation to HRV for these PNVT. When models are developed, there is a need to revisit this analysis to reassess trend. Other data, including PFC assessments as well as sampled sites (White 2002) show low similarity with ASTES data in many locations. These data indicate that trend in these PNVTs are moving away from HRV for soil condition; bare ground has increased while vegetation & litter cover have declined. Since 1995, domestic livestock grazing has been removed or limited from a substantial portion of these PNVTs; however, as yet there is no data to indicate affect on trend across these riparian communities. In addition, these areas on the ASNFs are a focal point for humans & terrestrial wildlife, as well as species that are dependent on wetland & aquatic areas. Therefore, both demand & impacts are high

High numbers of species are tied to coniferous forests or ecological characteristics within them. Aquatic and riparian habitats within these types are critical to many species, as are forest openings and meadows with long, dense grass, dead and down material, cavities, and overstory conditions with large trees, connecting canopies, and deciduous tree species. Habitats (ecological characteristics) were discussed under vegetation. Here, those needs for change specific to species and species groups outside of ecological diversity within a particular PNVT will be discussed.

Invasive non-native plant species out-compete native plants in many areas, causing declines in native plant biological diversity, changes in fire regimes, and changes in habitat for native wildlife.

Forest PNVTS

Need for Change - Ponderosa Pine and Mixed Conifer with Frequent Fire PNVTs: As the largest and third largest PNVTs on the ASNFs, the Ponderosa Pine and Mixed Conifer with Frequent Fire Forests have experienced the most significant shifts in stand structure; from large trees with open canopies to small and mid-size trees with closed canopies (increased densities of shade tolerant conifers) than any of the other PNVTs on the forests. There are many more small stems per acre than historically with a subsequent reduction in understory vegetation (grass, forbs, and shrubs). Over-crowding and shading

has resulted in an overall reduction in forest health. Along with modification of natural processes, there has been a change in ecological potential, which has made these communities more susceptible to drought stress, insect, and disease infestations, and uncharacteristic wildfire.

Modeling future transitions within the Spruce-Fir with Wet Mixed Conifer PNVTs indicate that continuation of current management will cause a shift in this vegetation type that will more closely approximate its HRV. However, this vegetation community has experienced high percentages of insect and disease mortality, 74 percent, which has left large amounts of dead trees on the landscape that could add to uncharacteristic wildfire activity.

Due to the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs provide a significant contribution to the sustainability of both Ponderosa Pine and Mixed Conifer with Frequent Fire and a notable contribution to sustainability of Spruce-Fir with Wet Mixed Conifer.

Early- to mid-aged forests with closed canopies are over represented. There is an ecological need to provide a framework for sustainability of composition and structure (a balanced ratio of tree density and number of large trees) and ecological processes (re-establishment of natural fire and other disturbance regimes) in these forested PNVTs. The current rate of management activities will not substantially alter the composition or structure and cover of these PNVTs on the ASNFs to anything approaching their HRV, and therefore, will not likely reduce the potential fire severity, or improve forest health. In addition, the presence of non-native invasive species will continue to displace native species with the potential to reduce biological diversity, and disrupt and/or modify ecological processes, such as the fire regime.

Need for Change - Aspen: An additional issue that drives an ecological need for change within these forested communities is the loss of aspen. Aspen makes up a key component of Spruce Fir with Wet Mixed Conifer Forest PNVTs.

There is an ecological need to provide a framework for sustainability of composition, structure and function, and ecological processes provided by aspen within these forested communities. Aspen is declining; the need is to increase and maintain aspen regeneration. Current fire and ungulate management is not likely to restore the natural cycle of aspen regeneration. Restore natural fire and other disturbance regimes, retain snags, logs, and live trees with cavities, and increase number of small openings. In addition, non-native invasive species will continue to displace native species and disrupt and/or modify ecological processes within this community.

Woodland PNVTs

Need for Change - Madrean Pine-Oak and Piñon-Juniper PNVTs: These two PNVTs have experienced similar stand structural shifts as in the Ponderosa Pine and Mixed Conifer with Frequent Fire PNVTs. More woody stems per acre have resulted in decreased herbaceous vegetation, increased bare ground with subsequent reductions in organic matter, soil fertility and concurrent increases in erosion and sedimentation. Modeling future transitions within these woodlands indicate that continuation of current management will not cause a shift in these vegetation type that will more closely approximate their HRVs.

There is an ecological need to provide a framework for sustainability of composition and structure and function, and ecological processes in these woodland communities. Within the Madrean Pine-Oak there is an over representation of young aged woody species with a closed canopy aspect, while in the Piñon-Juniper, medium to very large sized trees with an open canopy aspect are over represented. The current type and rate of management activities (where recurring disturbances, such as grazing (e.g.

zootic disclimax[34]) exert the predominant influence in maintaining the structure and composition of the steady-state vegetation within these PNVTs) will not restore or move the composition and structure of these woodlands on the ASNFs to anything approaching their HRV, and therefore, will not likely prevent additional losses of soil and site productivity or to reduce the fire severity or change fire frequency. There has been a steady-state shift in understory vegetation structure and composition from tall- and mid-grass cool-season species to mid- and short-grass warm-season species. Together these woodlands contribute roughly 40 percent of the ASNFs' acres and are continuing to expand their range into neighboring grassland communities. In addition, non-native invasive species will continue to displace native species and disrupt and/or modify ecological processes within these communities.

Because of the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs provide a notable contribution to the sustainability of both of these woodland PNVTs.

Grassland PNVTs

Need for Change - Great Basin, Semi-desert and Montane/Subalpine PNVTs: All three grasslands on the ASNFs have experienced woody species invasion, at approximately 80, 68 and ten percent of the acreage for Semi-desert, Great Basin and Montane/Subalpine Grasslands, respectively. As in the woodland PNVTs, the current type and rate of management activities will not restore or move the composition and structure of these grasslands on the ASNFs to anything approaching their HRV, and therefore, will not likely prevent additional losses of soil and site productivity or to reduce the fire severity or change fire frequency. There has also been a steady-state shift in overstory (encroachment of trees and shrubs) and understory vegetation structure and composition from tall- and mid-grass cool-season species to mid- and short-grass warm-season species (White 2002).

There is an ecological need to provide a framework for sustainability of all three native grasslands; halting the ongoing encroachment and establishment of woody species. This would provide for stabilizing and sustaining community structure (e.g. species composition and diversity at all scales); which includes the natural balance between warm- and cool-season grass species. Restore grassland ecosystem processes (e.g. net primary productivity and nutrient cycling) which includes reducing soil erosion and runoff. This can help improve water quality as well. Stabilizing and restoring these communities would promote the growth of more fine fuels for the reestablishment of fire as a natural process to help maintain these communities in an "open" grassland condition. In addition, non-native invasive species will continue to displace native species and disrupt and/or modify ecological processes within these communities.

Concerning the spatial niche, within the ecoregion section these grasslands are all rated as moderately departed from their respective HRVs were these PNVTs occur. Because of the degree of departure and proportion of each of these PNVTs off-forests; the ASNFs has a notable contribution to the sustainability of all three grasslands.

[34] Disclimax or "disturbance climax" describes a community that is held at an earlier successional stage by repeated but unpredictable disturbances that prevent succession from reaching the climax community that might be expected for the climate of the area. A zootic or "animal**"** disclimax describes a community that is held at an earlier successional stage by some animal influence such as domestic livestock, for example; a grassland community that has been altered to woodland/shrubland by overgrazing.

Chaparral PNVT

Need for Change - Interior PNVT: Overall, this PNVT is within its HRV, however, there is a ecological need to change species composition with regards to non-native invasive species within this community.

Riparian Area/Riparian Forest PNVTs/Riparian Resources

Need for Change - Wetland/Cienega, Mixed Broadleaf Deciduous, Montane Willow and Cottonwood-Willow PNVTs: These areas on the ASNFs are a focal point for humans, terrestrial wildlife, and livestock activities, as well as species that are obligate-dependence[35] on wetland, riparian and aquatic areas. Aquatic and riparian habitats provide connectivity both within and between watersheds for native species.

There is an ecological need for change to address the current state of the ASNFs' riparian habitats. The current rate of management activities will not substantially alter the composition or structure and cover in both Mixed Broadleaf Deciduous, and Cottonwood-Willow communities on the ASNFs to anything approaching their respective HRV, and therefore, will not likely reduce fire severity, in these non-fire disturbance communities, or improve riparian health. There has been an increase in the representation of large trees and a reduction in smaller trees (lack of recruitment of seedlings/saplings and shrub species). There has been a reduction in composition and cover in all structural classes within Montane Willow communities. Furthermore, there has been a loss of wetland/cienegas due to both draining and flooding (dams/impoundments).

In addition, non-native invasive species will continue to displace native species and disrupt and/or modify ecological processes within these riparian communities.

There is a need to improve an estimated 72 percent of the forests' riparian areas which are currently in functioning-at-risk (FAR) or non-functioning (NF) condition to proper functioning condition (PFC). These unsatisfactory riparian conditions are characterized as having low vertical and horizontal stability, which results in lowered water tables and loss of active floodplains, which in turn reduces plant regeneration of those species that require occasional disturbance for establishing seedbeds. There is a large disparity between current and estimated historic conditions.

Soil Resources

Need for Change - Soil condition: There is an ecological need for change to improve soil condition by reducing soil loss, improving the soils ability to infiltrate water, and improving nutrient cycling over existing conditions on 32 percent of the forests, and most prominently in eight of 13 of the forests' PNVTs. There also is a gap between historic and current soil productivity and organic matter conditions in most PNVTs. Estimates for trend in many of the PNVTs is tied to overstory conditions and in many cases, trend is away from HRV. Great Basin and Semi-desert Grassland PNVTs have been encroached on heavily within the forests by juniper species and piñon. Some areas are not expected to return to grassland without very intensive treatments (Vander-Lee et al. 2006). Coarse woody material (greater than three inch diameter) amounts are variable across Ponderosa Pine and Mixed Conifer with Frequent Fire Forest PNVTs, but has been observed to be below recommended levels in some areas following timber sales, thinning or debris pile burning (ASNFs' BMP monitoring

[35] Obligate-dependence wetland species occur almost always (estimated probability 99%) under natural conditions in wetlands (http://plants.usda.gov/wetinfo.html).

2006 and 2007). There is a need to maximize ground cover in areas classified as unstable/unsuited condition within most PNVT areas to minimize accelerated soil loss and sedimentation to streams.

Need for Change - Microbiotic Soil Crusts: There is an ecological need for change to maintain and increase microbiotic soil crusts to improve water infiltration and resist erosion (Belnap et al. 2001, 2006), especially in chaparral, grassland, and woodland vegetation communities. There are few areas on the forests where crust occurrence is formally documented; however, studies on undisturbed sites (such as the Grand Canyon National Park, and other areas north of the forests) show crust density can be much higher than levels noted on-forests.

Aquatic Resources

Need for Change - Surface Water Yield/Favorable Flow: There is an ecological need to change upland watershed conditions to improve and maintain stream flows in all PNVTs, especially instream flows in the Blue River and Eagle, Chevelon, and Mineral Creeks, and the major headwater drainages of the Little Colorado River. This need has become critically evident during the recent period of drought, where reaches of generally perennial streams stopped flowing; reducing both the quality and amount of aquatic habitat for federally listed species, such as the loach minnow.

Need for Change - Groundwater: Current estimates of groundwater use in both the Little Colorado River and Morenci basins exceed inflow. Historic conditions for groundwater levels were described as being in steady state, i.e. where inflow from rainfall equaled outflow to springs and rivers downstream or to lower aquifers. There is an ecological need for change to retain groundwater levels. This is outside the forests' ability to control.

Need for Change – Water Quality: There are about 67 miles of impaired (Category 5) waters listed in the level 5 HUC connected watersheds. The forests' directly contribute to about 27 miles. The forests' can indirectly affect the remaining 40 miles of impaired (Category 5) waters downstream of forests lands through tributaries. The major identified, non-point source pollutant that may be carried downstream from forests' activities is sediment. TMDL assessments have been made on 26 miles of impaired streams on the forests out of 105 miles in the watersheds of Category 4 waters. The forests contribute a moderate amount (about 24 percent) towards maintaining water quality and ecological sustainability on these waters. Most of these waters occur in the Upper Little Colorado watershed and most were listed as impaired prior to implementation of TMDL Report recommendations. There is an ecological need to reduce sediment and other pollutant input to streams.

Low dissolved oxygen levels have been reported in Bear Canyon Lake probably due to natural conditions from spring sources of water. High pH is documented in a number of eutrophic lakes on the forests, and is attributed to addition of nutrients from forests and non-forest sources. A sharp increase in nutrients can result in rapid growth of algae and other plants in a lake, which may result a drop in dissolved oxygen that can be devastating to other aquatic life, sometimes leading to fish kills. These lakes have TMDL assessments and mitigation is being implemented to reduce nutrient inputs. There is an ecological need to reduce nutrients and other pollutant input to lakes.

Air Resources

Need for Change - Air Resources: Current conditions and trends indicate there are no airsheds outside of regulatory requirements. Future conditions/trends may change depending on conditions outside the forests' control.

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Appendices

Appendix A - List of All Known Non-native Fish Species Present on the ASNFs

Appendix A Table 1. Non-native fish species by fourth and fifth level hydrologic unit code (HUC) watersheds on the ASNFs.

Fourth Hydrologic Unit Code (HUC) Watershed	Fifth Hydrologic Unit Code (HUC) Watershed	Non-native Fish Species†‡																								
		Black bullhead	Goldfish	Rio Grande sucker	Common carp	Red shiner	Northern pike	Mosquitofish	Channel catfish	Green sunfish	Bluegill	Redear sunfish	Smallmouth bass	Largemouth bass	Golden shiner	Cutthroat trout	Rainbow trout	Yellow perch	Fathead minnow	White crappie	Black crappie	Flathead catfish	Brook tout	Brown trout	Walleye	Arctic grayling	Total
Little Colorado Riv Headwaters	Nutrioso Ck								C	C				C		C	C		C		C		C	C			9
	South Fork Little Colorado Riv-Little Colorado Riv Headwaters				C											C	C	C	C				C	C		C	8
	Coyote Ck																										0
	Carnero Ck-Little Colorado Riv Headwaters																										0
Upper Little Colorado Riv	Big Hollow Wash																										0
	Oso Draw																										0
Silver Ck	Show Low Ck		C		C		C	C	C	C	C	C	C	C			C		C	C	C			C	C		16
	Upper Silver Ck									C																	1
	Cottonwood Ck																										0
Middle Little Colorado Riv	Phoenix Park Wash-Dry Lake																										0
	Upper Clear Ck									C			C	C	C		C		C				C	C		C	9
	Lower Clear Ck														C		C		C								3
Chevelon Canyon	Upper Chevelon Canyon									C				C	C				C								4
	Black Canyon																										0
	Lower Chevelon Canyon																										0
Mangus Ck-Upper Gila Riv	Apache Ck-Upper Gila Riv																										0

Appendix A Table 1. Continued.

Fourth Hydrologic Unit Code (HUC) Name	Fifth Hydrologic Unit Code (HUC) Name	Non-native Fish Species†‡																							
		Black bullhead	Goldfish	Rio Grande sucker	Common carp	Red shiner	Northern pike	Mosquitofish	Channel catfish	Green sunfish	Bluegill	Redear sunfish	Smallmouth bass	Largemouth bass	Golden shiner	Cutthroat trout	Rainbow trout	Yellow perch	Fathead minnow	White crappie	Black crappie	Flathead catfish	Brook tout	Brown trout	Walleye	Arctic grayling	Total
San Francisco Riv	Centerfire Ck-San Francisco Riv			C															C								2
	Upper Blue Riv					C											C						C	C			4
	Pueblo Ck-San Francisco Riv																										0
	Lower Blue Riv				C	C											C		C			C					5
	Mule Ck-San Francisco Riv				C	C		C	C	C			C						C			C					8
	Chase Ck-San Francisco Riv				C	C		C	C	C			C									C					7
Upper Gila Riv-San Carlos Reservoir	Willow Ck																										0
	Upper Eagle Ck															C	C										2
	Lower Eagle Ck	C			C	C		C	C				C	C					C								8
Black Riv	Upper Black Riv												C			C	C		C				C	C		C	7
	Middle Black Riv												C			C	C		C				C	C			6
White Riv	Upper North Fork White Riv																										0
	East Fork White Riv																										0
Upper Salt Riv	Canyon Ck																										0
Carrizo Ck	Corduroy Ck																										0
	Carrizo Ck (local drainage)																										0
Tonto Ck	Haigler Ck-Tonto Ck																										0

† C = Species currently occurs within watershed

‡ These are all classified as 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, or species such as invasive for which control measures may be desirable. All of the above listed species are non-native