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Assessment Report of Ecological / Social / Economic Conditions, Trends, and Risks to Sustainability, Cibola National Forest Mountain Ranger Districts

Volume I

Ecological Assessment

Cibola National Forest Mountain Ranger Districts Assessment

Volume I

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ABSTRACT: The Assessment presents and evaluates existing information about relevant ecological, economic, and social conditions, trends, and risks to sustainability and their relationship to the 1985 Cibola Forest Plan, within the context of the broader landscape.

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Introduction

Purpose

The Cibola National Forest (Cibola) is managed by the United States Forest Service (USFS), an agency of the U.S. Department of Agriculture (USDA). The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations.

The primary challenges of administering National Forest System lands for the citizens of the United States include identifying, managing, and monitoring the health and status of the physical resources (e.g., soil, water, air) that create the environment in which the vegetation and animals live and interact, while balancing the many human uses of the forests (e.g., recreation, livestock grazing, firewood gathering, logging, opportunities for solitude).

The land and resource management plan (forest plan) is the principal document that guides forest managers' decisions about management of the land and resources. Forest plans are required by the National Forest Management Act of 1976. The current Cibola forest plan was originally approved in 1985. Since then, the forest plan has been amended 14 times to adjust for situations in specific projects or to reflect changes in social, economic, or ecological conditions. The 1985 forest plan was written following the guidance in the 1982 forest planning regulations. The Cibola will revise the 1985 plan using the provisions of the 2012 planning rule as outlined in 36 Code of Federal Regulations (CFR) Part 219, April 2012.

In preparation for plan revision of the 1985 plan, the Cibola has identified and evaluated existing information about relevant ecological, economic, and social conditions, trends and risks to sustainability and their relationship to the 1985 plan within the context of the broader landscape. This draft assessment report documents that work. Interested readers should keep in mind that the Cibola NF includes two ranger districts that are part of the National Grasslands system and which are not part of this plan revision effort, as a new grasslands plan for those districts was recently completed. Hereinafter, “the Cibola” refers only to the four mountainous ranger districts [“Mountain Districts”] of the Cibola National Forest.

Even though the evaluation of the existing conditions, trends, and risks to sustainability as identified in this report is expected to be the primary driver of the development of needs for change and ultimately, a revised forest plan, this document does not specifically address the needs for change to the current plan. Needs for change will be developed collaboratively with the public, other government agencies, tribes, and interested stakeholders from a variety of institutions and organizations, after these entities have studied this assessment report. The identification of needs for change to the 1985 plan will occur in the months following the release of this draft assessment, through a variety of collaborative efforts, including public and open house meetings, educational/collaborative forums, and through a variety of web-based tools.

Organization of the Report

In the following two volumes, this report examines the conditions, trends, and risks to sustainability for 15 resource topic areas. Volume one assesses key concepts of ecological analyses and risks to ecological integrity and sustainability for vegetation, soils, water, air, carbon, and federally recognized species as well as other species of conservation concern. In volume one, chapter one, the concepts of reference condition, departure from reference condition, and risks to ecological integrity are addressed, and in the remaining chapters of volume one, these concepts are applied to the condition, trend, and risks to integrity and sustainability of the Cibola’s unique ecological resources.

Volume two assesses conditions, trends, and risks to sustainability for the goods and services the Cibola produces: specifically, cultural, historic, and tribal resources and areas; social, cultural, and economic conditions on and around the Cibola; multiple uses (range, timber, watershed, fish and wildlife, recreation) provided by the Cibola; existing designated areas on the Cibola; infrastructure on the Cibola; land status, ownership pattern, and use on and around the Cibola, and finally, renewable and nonrenewable energy and mineral resources present on the Cibola. Examination of the conditions, trends, and risks to sustainability of these goods and services is approached using an ecosystem services framework, which is explained further below. Interested readers will find considerable cross referencing between the two volumes and within each volume in order to accomplish an interdisciplinary consideration of condition, trend, and risks to sustainability. Finally, a literature cited section and glossary at the end of volume two conclude the report.

Plan Area of Analysis

The Cibola is one of five National Forests in New Mexico, occupying approximately 1.63 million acres within 10 counties (Figure 1). The four ranger districts addressed in the draft assessment are the Sandia, Mountainair, Magdalena, and Mt. Taylor ranger districts (RDs). Within these four districts are nine separate mountainous parcels ("sky islands") scattered throughout central New Mexico (Figure 2). They are: Sandia Mountains, Manzano Mountains, Gallinas Mountains, Magdalena Mountains, San Mateo Mountains, Bear Mountains, Datil Mountains, Zuni Mountains, and Mt Taylor. These mountain ranges are also referred to as Geographic Areas (Table 1). (A small mountain range called the Manzanita Mountains lies between the Sandia and Manzano Mountains and is included in the Sandia RD and Sandia Geographic Area.) These RDs and their respective mountain ranges under National Forest System administration are the focus of this assessment and will be the focus of the revision effort of the 1985 Cibola Forest Plan.[1]

Background

Human populations have occupied what is now the Cibola for at least 12,000 years. Early hunters and gatherers used the forest on a seasonal basis, obtaining plant and animal resources when and where available. Later, agricultural populations farmed some parts of the mountains, while continuing to hunt and gather native foods. For reasons that are not known, large portions of what is now the Cibola were abandoned by those native people by about 1350 A.D. Around 1500 A.D., peoples ancestral to the Apache and Navajo began to move into the area. When the Spanish entered the region in 1539, they found native Puebloan peoples settled in northern, western, and central New Mexico, and nomadic Apacheans extending from the New Mexico mountains out into the Great Plains.

Early Euro-American settlement favored the major river valleys of the Southwest, but sometime in the late 1800s, farming and ranching extended into the mountains. What is now the Cibola began as several forest reserves in 1906 and was proclaimed as a national forest in 1931. More detailed and recent historical context is provided in the section on Cultural and Historic Resources and Uses, found in Volume II of this report.

[1] The four national grasslands administered by the Cibola Supervisor's Office are managed under a recently developed land and resource management plan that was approved and implemented in 2012. The four national grasslands are not addressed in this assessment.

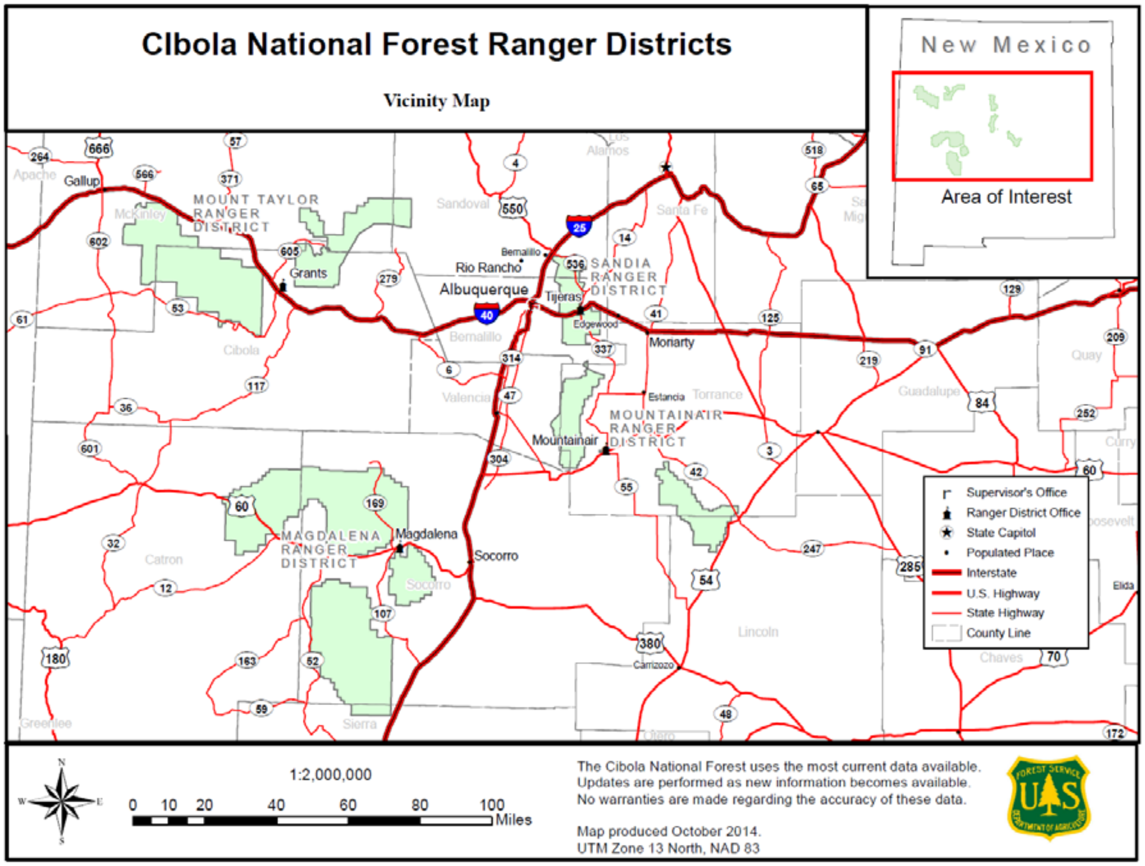

Figure 1. Vicinity Map of the Cibola National Forest Mountain Ranger Districts.

Distinctive Features

Elevations within the four forested, mountainous ranger districts extend from 5,200 feet (along the eastern edge of the Magdalena RD) to over 11,300 feet (at the summit of Mt. Taylor) above mean sea level (MSL). The lower elevations of the forest are rolling, hilly terrain cut by sandy washes and small canyons. Rock outcrops are prevalent. With an increase in elevation, the terrain becomes truly mountainous, with prominent canyons and exposed rock faces. There are numerous peaks in excess of 9,000 feet.

Elevation is the dominant localized influence on climate. The lower elevations receive less than 10 inches of precipitation per year, with temperature extremes above 100 degrees in the summer and well below freezing in the winter. The higher elevations receive in excess of 24 inches of precipitation each year, with summer temperatures in the 80s and winter temperature at zero or below.

The most predominant vegetation type on the Cibola is pinyon-juniper woodland (about 42% of the Forest). The remainder comprises primarily ponderosa pine forest (nearly 30%), mixed conifer forest (about 12%), and semi-desert grassland (about 7%). The Cibola is predominantly a dry forest ecosystem. The main vegetation system drivers on the forest are fire disturbances (or lack thereof), regional climate regime, insects, and natural vegetation succession. More details on vegetation and drivers and stressors are provided in Volume I of this report.

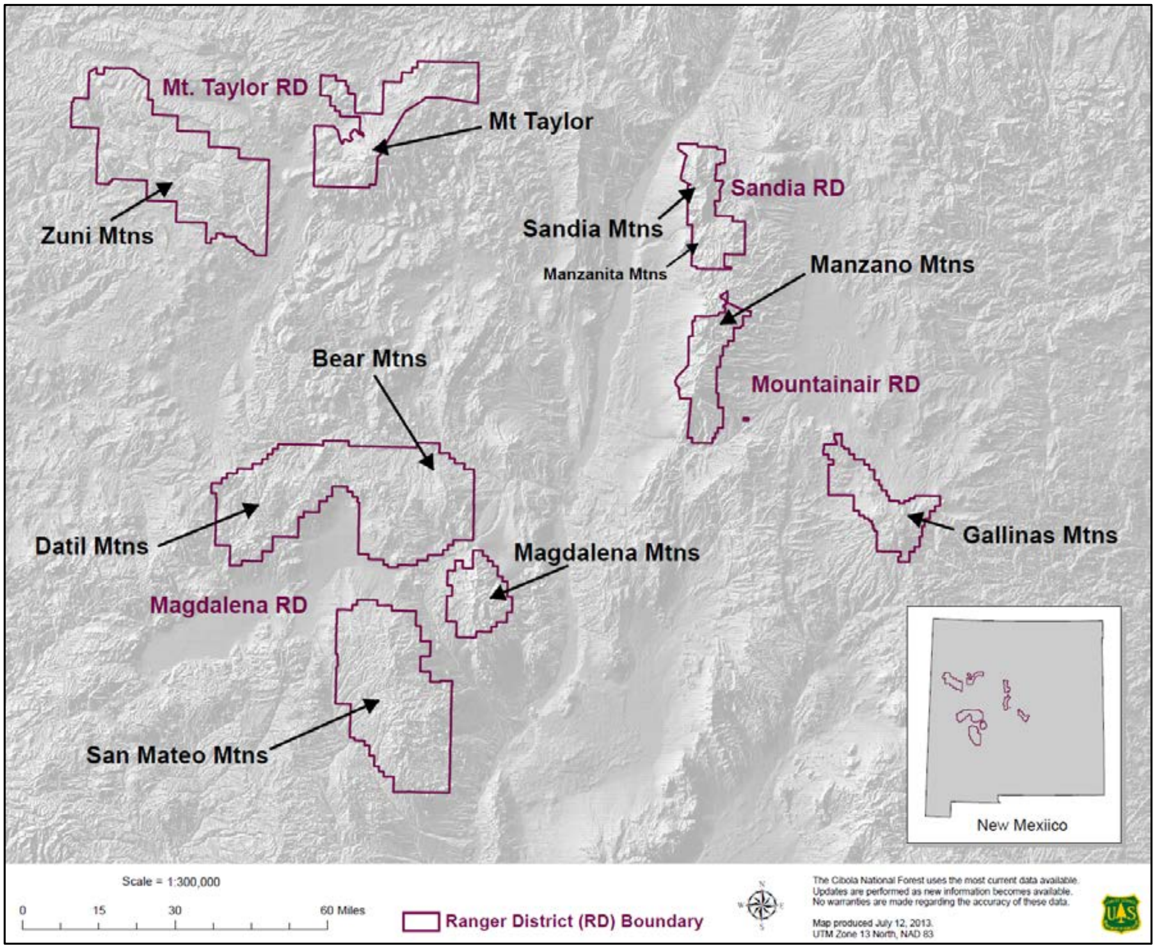

Figure 2. Cibola NF mountain ranger districts and associated mountain ranges (Geographic Areas).

Table 1. Forest Service-owned acreage of the Cibola's Geographic Areas.

Geographic Area	Acreage	Geographic Area	Acreage
San Mateo Mtns	391,198	Manzano Mtns	111,319
Zuni Mtns	329,396	Sandia Mtns	100,239
Mt Taylor	185,636	Gallinas Mtns	94,462
Datil Mtns	159,299	Magdalena Mtns	91,706
Bear Mtns	149,043	**Total**	**1,612,298**

Important Social and Economic Influences on the Cibola

Volume II of this assessment report discusses in detail the important social and economic influences that influence conditions and trends on the Cibola. It can be expected that environmental attitudes, recreation demand upon the Cibola, and traditional, cultural, and religious uses of the forest are all likely to be affected by changing demographics, income, poverty, and unemployment. For example, recreation use pressures will likely increase proportionately over traditional uses due to in-migration. Similarly, as the population increases in the counties where the Cibola resides, use of the forest will intensify.

Use pressures are greatest on the Sandia and Mountainair RDs, and will continue to rise as populations continue to rise near these districts. There has been a significant population change from 2000 to 2011 in the 10-county area in which the Cibola resides, with a 16 percent increase in population resulting in a nearly 144,000 increase in population of this 10-county region. The greatest change occurred in Sandoval and Bernalillo Counties near the Sandia RD, and the greatest decrease was in Sierra and McKinley Counties, near the Magdalena and Mt. Taylor RDs, respectively.

Demographics relate to forest use and beliefs regarding forest management. Improved economic conditions may cause communities to be less reliant on the forest for subsistence activities (e.g., herb gathering and hunting) and household cash income (e.g., from the sale of firewood, pinyon nuts, or Christmas trees). However, agriculture and natural resources are an important component of the traditional way of life in rural areas. Therefore even as reliance on forest products might become less imperative, the Cibola may continue to be an important source of subsistence and cash income for individuals and families. This may be especially true in the more rural Magdalena, Mountainair, and Mt. Taylor ranger districts.

The development of private land inholdings and of lands surrounding the Cibola has decreased open defensible space on the forest’s boundaries. In the decade between 2000 and 2010 within the 10-county area in which the Cibola resides, there has been a 32 percent increase in residential acres. Many of these lands now have houses and residents that present unique challenges to the Cibola in terms of wildland and urban interface fire prevention and suppression and the creation of defensible space.

The median age in all 10 counties in which the Cibola resides, for the same period, is increasing. The age category with the most number of both women and men is 45-64 years of age. The oldest age categories occur in Catron, Sierra and Lincoln Counties (49-57), and the youngest median ages (30-37) occur in Bernalillo and McKinley and Socorro Counties. The age category with the largest decrease for both men and women for the 10-county area was the 35-44 year category. The shifting of age classes of people using the Cibola generally results in a fluid change in recreational demands upon the Cibola NF.

Ethnicity and race also affect recreation participation behavior, such as day versus multi-day use, hiking, hunting, fishing, wildlife viewing, or equestrian activity. In 2011, people of white or Hispanic origin in the 10-county area comprised 66 percent of the overall population, with American Indians comprising 11 percent, African Americans 2 percent, and Asian Americans less than 2 percent. Overall in the 10-county area, Hispanics are the largest culturally identifiable group, slightly more than non-Hispanic whites. In Catron, Lincoln, Sandoval, Sierra, Torrance Counties, whites are more numerous than Hispanics. McKinley and Bernalillo and Sandoval and Cibola Counties have highest numbers of American Indians.

The importance of these and other social and economic influences upon the Cibola are explored in Volume II of this report in the section on social, cultural, and economic influences upon the plan area.

Roles and Contributions of the Cibola to Ecological, Social, and Economic Sustainability

Ecosystems and Wildlife Habitat: The Cibola contributes to ecosystem diversity by housing four major ecological types (see Volume I, *Ecosystem Conditions and Trends*) with regard to vegetation, elevational gradients and climate, geology, and habitats and associated wildlife. The forest’s diverse landscapes span a climatic and elevational gradient from low-elevation semidesert grasslands to high-elevation alpine meadows, and provide habitat for 11 federally recognized species and at least 9 species of conservation concern that may be at-risk for long-term persistence.

Recreation and Scenery: Recreation opportunities on the Cibola greatly contribute to the quality of life enjoyed by visitors. The Cibola provides outstanding opportunities for hunting, fishing, camping, hiking, winter sports, viewing birds and other wildlife, appreciating landscape scenic vistas and open spaces, and visiting historic sites. The developed recreation sites of the Cibola provide opportunities and activities available for visitors to enjoy that are unique within this region. Outdoor recreational activities on the forest are very important to the local tourism economy, generating 547 jobs and $14.24 million in income for local businesses in 2010 (UNM-BBER 2013).

Livestock Grazing: Livestock grazing on the Cibola contributes to maintaining the ranching culture and lifestyle of these rural areas, improves the fiscal sustainability of local ranching operations, and contributes to historical disturbance processes. Approximately 95 percent of the Cibola (excluding Sandia RD) is used by permit holders to graze their cattle, within the constraints of topography and capacity to produce forage. This use of the Cibola contributes to the social and economic well-being of the 10-county area while sustaining forest ecosystems. In 2010, livestock grazing on the Cibola generated 166 jobs and $1.79 million in income (UNM-BBER 2013).

Timber and Forest Products: The Cibola contributes $19,660,000 in labor income and provides 209 full-time timber harvest and production jobs annually (2008–2010 annual average). Further discussion of economic contribution of agriculture and forestry on and around the Cibola mountain districts is found in Volume II of this report in the section addressing plan area influences on key social, cultural and economic conditions.

Energy Development: The Cibola may play an important future role for alternative energy developments such as wind, but currently there are no proposals for or active alternative energy developments on the Cibola. Geothermal resources are not known to occur on the forest, nor are there hydropower, oil or gas resource developments. The Cibola has received two proposals for uranium mining activity and several proposals for uranium mineral exploration on the Mt. Taylor RD, and environmental analyses on these proposals is underway.

Heritage, and Paleontological Resources: The Cibola contains significant heritage (historic and prehistoric) and paleontological (fossil) resources. These resources offer opportunities for the public to learn about the past and appreciate the resources of the Cibola. These important resources provide opportunities to base tourism businesses, including those related to visiting historic, cultural, and paleontological sites.

Scientific Investigations: The Cibola has ongoing or recent scientific research and discovery activity on the effects of wildland fire, watershed health, different silvicultural systems, herbivory, climate change, wildlife occurrence and interactions, and plant and insect occurrence and interactions. Ongoing geologic and meteorological research is also occurring, as well as archaeological and historical research. There is currently one research natural area on the Cibola, located on the Sandia RD.

Areas of Interest: Many features on the Cibola are formally designated as “special areas” to highlight and preserve their unique, primitive, ecological, historic, or scenic characteristics. Designated areas within the Cibola include four wildernesses; one research natural area; four nationally or state designated Scenic Byways; one National Recreation Trail; the Langmuir Research Site and Magdalena Ridge Observatory, and two National Historic Landmarks. Several other special areas are adjacent to the Cibola, but are managed by other agencies.

Wildfire Prevention: The Forest Service plays a cooperating role in working with federal, state, and local partners by contributing federal firefighting resources to help protect valuable natural resources along with private properties and communities.

Understanding the Concept of Key Ecosystem Services as Utilized in This Report

Functioning ecosystems may be characterized as ecological life- and cultural-support systems, especially since they provide a full suite of goods and services that are vital to human health, livelihood, and well-being. Ecosystem services are the ecosystem products or qualities that people enjoy or from which they benefit, including but not limited to scenic views, fish and wildlife, recreation opportunities, food, fiber, fuel, energy, clean water, timber, and cultural amenities. The Millennium Ecosystem Assessment (MEA 2005) has served as the initial inspiration for applying the ecosystem services concept to national forest (NF) management. The Millennium Ecosystem Assessment groups ecosystem services into four broad categories (Figure 3):

- **Provisioning Services** are the products people obtain from ecosystems, such as food, fuel, fiber, fresh water, and genetic resources.
- **Regulating Services** are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification.
- **Cultural Services** are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.
- **Supporting Services** are those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation (MEA 2005).

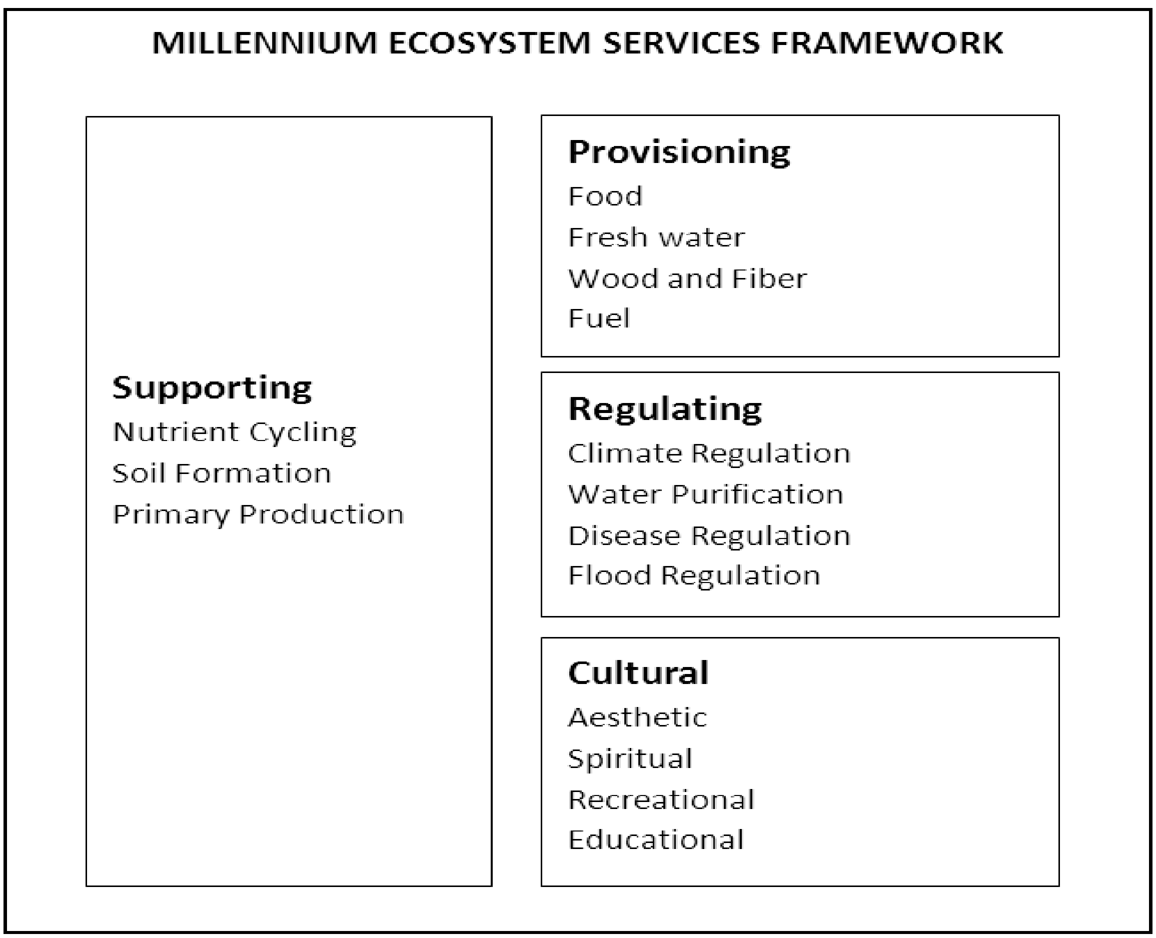

Figure 3. Millennium Ecosystem Services assessment categories (MEA 2005).

This ecosystem services framework is helpful in explaining the benefits people obtain from the Cibola (Figure 4).

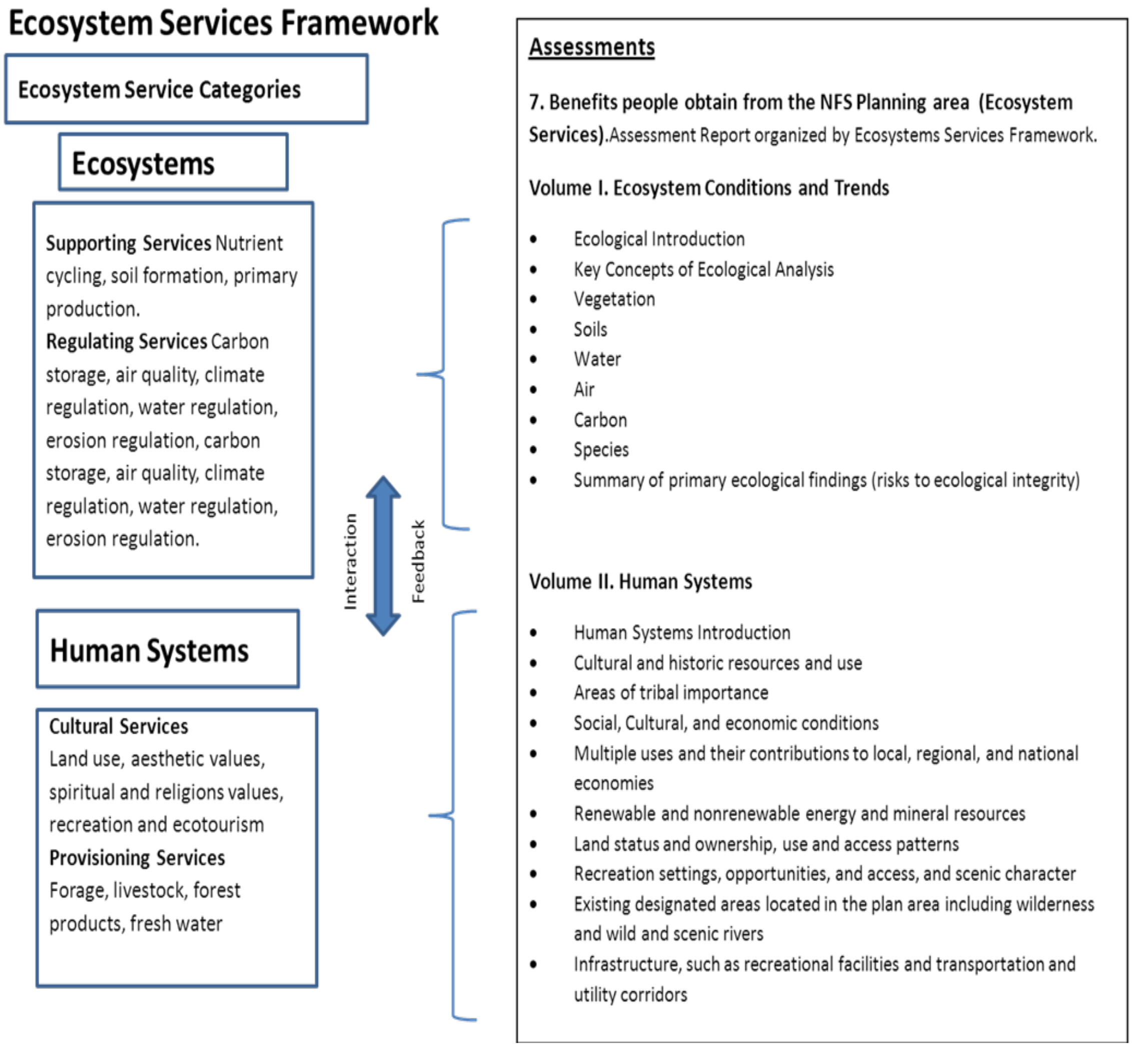

Figure 4. Cibola ecosystem services framework.

The use of the ecosystems services concept and the analyses of ecosystem services is woven into the chapters of Volumes one and two, accompanied by a discussion of ecological, social and economic conditions and trends, rather than stand-alone, separate analyses. The chapters of Volume one characterize condition and trend of what may be called first-level ecosystem services, which, among other resources, include clean air, water, or carbon cycling. These first-level ecosystem services might be described as the raw materials from which second-level ecosystem services, such as grazing, wood fiber, recreation, and spiritual and cultural values are derived. These second-level ecosystem services are characterized in each of the assessment topic areas addressed in volume two, *Human Systems*.

Within this framework, we acknowledge that interaction and feedback exists between the Ecosystems and Human Systems: each system affects the other. For example, water quantity and quality may both be classified as primary ecosystem services under the regulating services heading. However, water is also a key provisioning service, and to a large degree an important cultural service, considered important in sociocultural, economic, and spiritual terms in the Southwestern United States.

Best Available Science Used in this Assessment

The Cibola used the best available data and science relevant to the Cibola plan area and management to inform the evaluation of conditions, trends and risks to sustainability for the 15 topics of the assessment addressed in volumes one and two. In particular, criteria applied to all data, studies, and reports supporting this assessment included : (1) quality data was used, and (2) the studies and reports used accepted and standardized scientific methodology and are replicable.

Additionally, some topic areas such as climate change, may be updated in the final assessment to reflect evolving scientific information. A comprehensive list of literature reviewed, considered, and cited during preparation of this report is located at the end of Volume II. Additional sources of data, reports, and studies may be found on the Cibola Forest Plan Revision website, http://www.fs.usda.gov/detail/cibola/landmanagement/planning/?cid=fsbdev3_065627, under the link Assessment Data Sources for Mountain District Forest Plan Revision, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5417645.pdf

During the 60-day public review of this document, the Cibola welcomes the suggestion of additional or new sources of best available science that would help further inform the assessment for the purpose of identifying needs for change to the current forest plan management direction.

Important Sources of Information Utilized in this Assessment

In compiling this assessment of the conditions and trends of the Cibola's resources, goods, and services provided to the public, many major sources of information were reviewed and information incorporated. Among the most notable were:

- NatureServe Data Explorer 2013
- Biota Information System of New Mexico Database 2013
- Comprehensive Wildlife Conservation Strategy for New Mexico 2006
- U.S. Fish and Wildlife Service Listed and Sensitive Species Lists 2013
- U.S. Forest Service Regional Forester's Sensitive Species List 2013
- Resources Planning Act (RPA) Assessment 2010
- Forest Inventory and Analysis (FIA) National Program 2013
- USDA Forest Service — National Forest Health Monitoring Program 2008
- Cibola National Forest Watershed Condition Framework 2011
- The Nature Conservancy-Southwest Forest Assessment Project 2006
- The Nature Conservancy-Southwest Regional Reports & Data 2006
- USDA NRCS PLANTS Database 2013
- Fire Effects Information System (FEIS) 2013
- LANDFIRE 2013
- USDA NRCS Ecological Site Information System (ESIS)

- New Mexico Statewide Resources Assessment 2010
- New Mexico Resource Geographic Information System (RGIS)
- Southwest Regional Gap Analysis Project (SWReGAP) 2004
- New Mexico Environment Dept. Air Monitoring Website 2013
- City of Albuquerque/Bernalillo Co. Air Quality Website 2013
- U.S. Environmental Protection Agency Air Emissions Sources 2013
- U.S. Environmental Protection Agency National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data 2013
- Western Regional Air Partnership Haze Planning 2013
- County Comprehensive Land Use Plans for 10 NM Counties
- Available Tribal Land and Resource Management Plans
- Secure Rural Schools (SRS): payments and receipts 2012
- Payments in Lieu of Taxes (PILT) 2012
- Headwaters Economics - Economic Sustainability Position Toolkit 2013
- Univ. of New Mexico Bureau of Business and Economic Research, Socioeconomic Assessment of the Cibola NF, June 2007
- UNM BBER Socioeconomic Assessment Supplement, January 2013
- USFS Land Areas Report 2012
- Visitor Use Report, Cibola NF 2011
- New Mexico Statewide Comprehensive Outdoor Recreation Plan 2010–2014
- New Mexico Wind Map and Wind Resource Potential 2010
- Values, Attitudes, and Beliefs Toward National Forest System Lands: The Cibola National Forest 2005

There are no appendices to this draft report. Important supporting information is referenced in the narrative and Literature Cited section of this report, and source material is in the planning record and is identified and provided on the website mentioned above.

Volume I. Ecosystem Conditions and Trends

Ecological Introduction

Each ecosystem characteristic was assessed in its absolute (current) condition, in its relative condition (compared to its “reference condition”), and in its projected condition (trend). The goal of looking at current conditions relative to reference conditions is to gain perspective on the risks to the sustainability of the resource—the closer current conditions are to reference conditions (the smaller the departure), the lower are the risks to the sustainability of the resource. The goal of looking at trend is to ascertain, to the best of our knowledge, the future condition of the resource given current management. While this portion of the assessment concentrates on the ecological properties of each resource, these same resources are simultaneously assessed in their social and economic contexts in Volume II.

The Cibola includes nine distinct sky island mountain ranges (Figure 2) that lie almost entirely within four ecological sections[2]: Navajo Canyonlands, Central Rio Grande Intermontaine, Sacramento-Manzano Mountains, and White Mountains-San Francisco Peaks-Mogollon Rim (Figure 5). The Cibola’s diverse landscapes span a climatic and elevational gradient from low-elevation semidesert grasslands to high-elevation alpine meadows.

[2] See McNab et al. 2005 for descriptions of Ecological Sections.

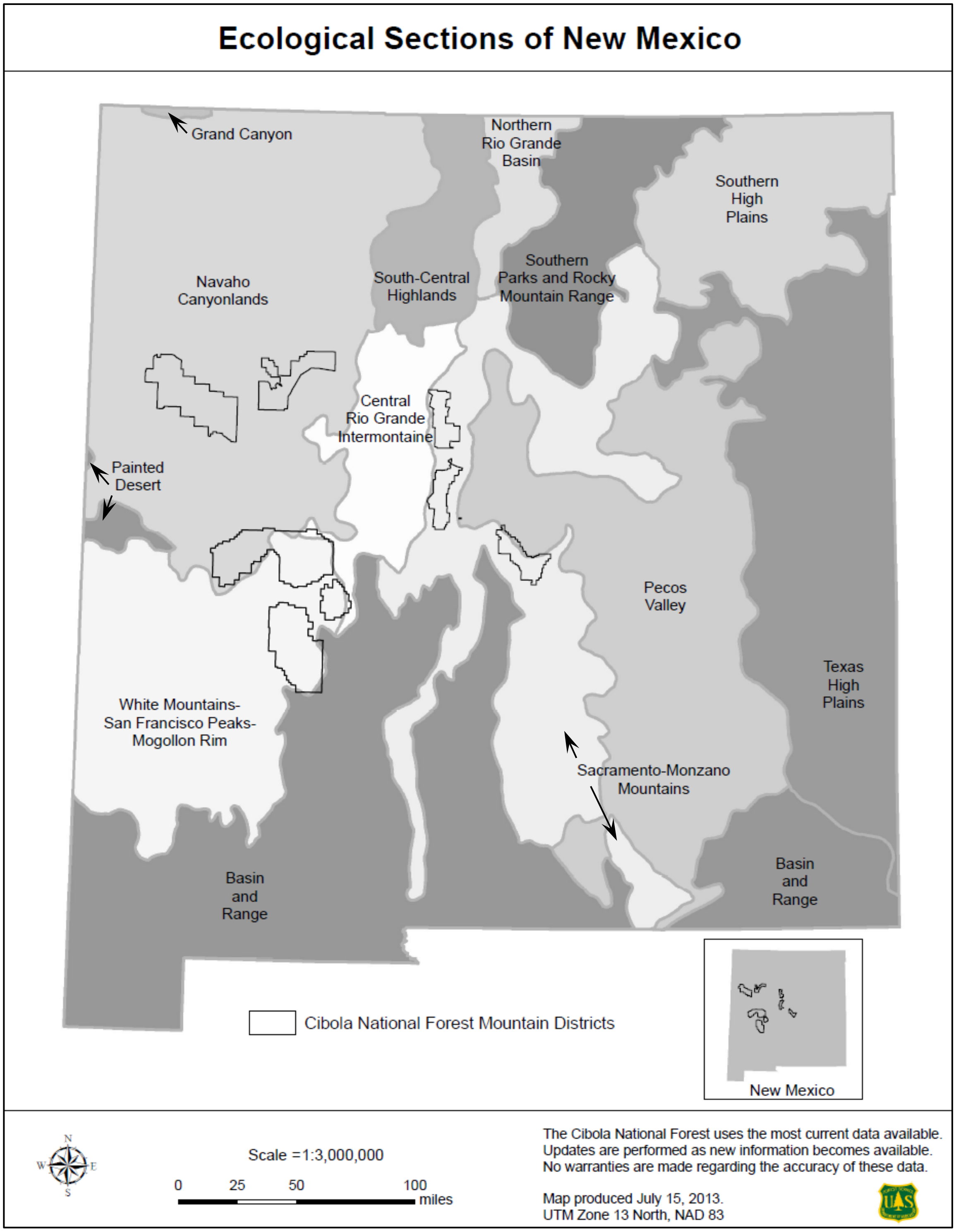

Figure 5. Ecological sections of New Mexico.

Chapter 1. Key Concepts of Ecological Analysis

Ecosystem Characteristics

Ecological sustainability and diversity of plant and animal communities were assessed by analyzing the individual components of these resource areas:

- Terrestrial ecosystems, aquatic ecosystems, and watersheds;
- Air, soil, and water resources and quality;
- System drivers (including dominant ecological processes, disturbance regimes, and stressors) like natural succession, wildland fire, invasive species, and climate change;
- Baseline assessment of carbon stocks; and
- Threatened, endangered, proposed, and candidate species and potential species of conservation concern present in the plan area.

Specific system drivers are discussed in the context of their appropriate resource area section (below).

The process for evaluating terrestrial ecosystems, aquatic ecosystems, and watersheds was iterative throughout the assessment, and was influenced by information provided by public and by governmental participation.

Scales of Analysis

This assessment aims to reveal patterns in resource conditions and trends that will inform the development of plan components such as (1) desired conditions (the optimal status for each ecosystem characteristic), (2) objectives (actions that move us toward desired conditions), and (3) standards and guidelines ("sideboards" on the implementation of projects). This assessment does not serve as the primary analysis of individual sites or features—these will be analyzed in more detail when developing projects under the guidance of the plan.

Each ecosystem characteristic was analyzed at three scales:

- The **context scale** puts the forest condition in context of the greater area, including lands beyond the forest boundary.
- The **plan scale** showcases current condition and trends as an average of conditions across the forest.
- The **local scale** identifies particular areas within the forest that may warrant specific attention.

The "footprint" of each of these three scales varies by resource area and is defined in their respective sections.

System Drivers and Stressors

This section addresses major system drivers and stressors, including dominant ecological processes (succession), and disturbance regimes (wildland fire, invasive species) and climate change. Forest insects and diseases are addressed in the Vegetation section in this volume.

Succession

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

The shade tolerance and competitive ability of the "highest seral" ("latest seral" or "climax") species present on a site naturally tend to decrease with decreasing elevation (warmer, drier). For example, the latest-successional ("climax") plant communities on the highest-elevation (coldest, wettest) sites on the Cibola tend to be dominated by Engelmann spruce and corkbark fir—highly shade-tolerant tree species that are good competitors for limited soil nutrients. Descending in elevation (progressively warmer, drier), the highest seral species found on a site are mixed-conifer (Douglas fir, white fir), followed by ponderosa pine, then pinyon-juniper, then shrublands, and finally, desert scrub or grasslands at the lowest elevations. A relatively highly seral species on one site is likely to be present as a relatively mid-seral species on a site that is higher in elevation (colder, wetter). For example, Douglas fir may be a climax species in a mixed-conifer forest but may be present as a mid-seral species in a spruce-fir forest 1,000 feet uphill.

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

Climax category denotes the major controlling factors of species composition on a site. "Primary" climax categories are edaphic (soil), topographic, and topo-edaphic. A "disclimax" is a prolonged change of vegetation from the climax condition as the result of recurrent or sustained disturbance. Disclimax classes have compound names. The first part of the name is the climax class (where succession would result if disturbance ceased), and the second part of the name is the disclimax category. An example would be an edaphic climax that is maintained by successive fires and heavy grazing. This would be an edaphic-fire-zootic. The name (e.g., fire-zootic) suggests a combination of causes but not the exact mechanism of succession or adaptation to recurrent disturbances.

There may be more than one kind of reference condition climax for a given ERU, depending on the site, and a disclimax may occur under reference conditions. For example, communities dominated by the forb, alpine avens (*Geum rossii*), are maintained by the natural soil churning activity of native pocket gophers on an otherwise grass-dominated tundra. Conversely, grazing by domestic livestock can create and maintain a forb-dominated community much different (departed) from the grassland of an ungrazed (reference) condition under otherwise similar site conditions.

Wildfire

Wildfire played a key role in shaping and maintaining historic conditions, and it greatly influences the composition, structure, and function of vegetation across the landscape today. Wildfire frequency and effect vary from short return intervals with low severity to long return intervals with stand-replacing severity.

Wildfire reverses succession by establishing an earlier seral state. A low-severity ground fire in a stand of mature timber will reverse succession slightly by removing ground vegetation while maintaining large trees, while a stand-replacing fire greatly reverses succession by creating an early seral community dominated by herbaceous species. The historically treeless character of grassland and shrubland vegetation types was maintained by frequent wildfire.

Laterally continuous fuels like a dense understory or interlocking tree crowns promote fire movement across a landscape. Vertically continuous fuels (understory-midstory-upper canopy) are conducive to stand-replacing fire, for example, where small and medium-sized trees (ladder fuels) wick the flames of a ground fire into the upper canopy. Tree mortality caused by insects and disease contributes to fuel accumulation. Unnaturally high woody fuel accumulation caused by wildfire suppression and overgrazing (lack of fine fuels) leads to fewer (longer return interval), but larger and more severe fires, and a subsequent increase in patch size.

Invasive Species

Invasive species have the potential to upset the ecological balance by displacing native species and altering the hydrologic and nutrient cycles and energy flow. For example, where invasive forbs displace native grasses, plant basal ground cover decreases and bare ground increases, thereby increasing soil erosion. Disturbed areas (trails, campsites, etc.) are especially vulnerable to invasion by invasive plants.

Invasive animals also have the potential to disrupt native species and ecological processes. Feral hogs are a recent invader in New Mexico and as of July 2013 had been reported in 22 counties, although to date none have been reported on the Cibola Mountain Districts. Other nonnative terrestrial animals including Barbary sheep and oryx have been occasionally reported on or near the Cibola but these sightings have been unconfirmed or sporadic and it is assumed that these species do not pose an invasive threat. A number of nonnative fish have been introduced to waterways adjacent to and on the Cibola over the years. This includes many species of game fish (tiger muskie, channel catfish) which have been and in some cases still are released in Bluewater Lake, as well as baitfish introductions (golden shiner). Additionally, both brown trout and rainbow trout have been released in Tajique and Las Huertas Creeks in the past although the lack of self-sustaining populations does not necessarily make them invasive. It is not known if other aquatic invasive species that have posed problems elsewhere such as nonnative crayfish and bullfrogs are present or problematic on the Cibola. Requisite surveys to determine this have not been conducted and this has been identified as a data gap.

Climate[3]

The earth is undergoing a warming trend, and human-caused elevations in atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs) are among the causes of global temperature increases (IPCC 2007). If GHG concentrations increase as expected, so may the vulnerability of ecosystem structure, function, and productivity. For example, as higher temperatures increase evapotranspiration, water-stressed trees are less able to withstand insect attack—trees need water to produce the resin exuded to “pitch out” bark-boring beetles. To compound matters, the combination of higher temperatures and lower plant water content may increase the frequency and severity of wildfire, which in turn, may leave exposed sites more prone to soil erosion and invasion by nonnative species.

[3] Adapted from USFS SRCCFPWG 2010.

Assessing Risk to Ecological Integrity

An ecological assessment of each resource area was done to understand current conditions and trends and to identify characteristics at risk for a loss of ecological integrity. The ecological assessment culminates in a risk assessment and determination of ecological need-for-change. There is an ecological need for change for those characteristics that show a potential or likelihood for risk or a legacy of past management or deviation due to ongoing activities.

The ecological assessment included characterizations of the reference condition and current condition for specific ecosystem characteristics. For each characteristic, the following information was to be evaluated:

- Reference condition
- Current condition and trend
- Deviation of current condition from reference condition (departure)

A risk can be mitigated if the departure is due to ongoing activities, the characteristic is within agency authority and control, and the trend and condition can be improved (reversible).

The risk to ecological integrity was assessed for each ecosystem characteristic by weighing the current deviation from reference condition against the trend for that resource as conceptualized in a decision matrix (Table 2).

It is important to consider if the response to an influence is within agency authority and control to address (Table 3). If it is, the risk may be mitigated by a change in management. If it is not, the circumstances are outside the jurisdiction or control of agency management; no further risk analysis is performed.

Our focus was to identify patterns at the plan level. If there is a problem in one characteristic or one location, it does not necessarily indicate a plan-level concern. The risk assessment results are reported under each resource area's respective section (below).

Table 2. Decision matrix to assess risk to ecological integrity.

Deviation from Reference Condition	Major Stressor*	Trend: Toward Reference Condition	Trend: Stable	Trend: Away from Reference Condition
Significant Deviation	NO	Risk Addressed	Legacy of Past Mgmt. OR Deviation due to Current Mgmt.	Potential for High Risk
	YES	Potential Risk	Potential for High Risk	Likely High Risk
No Significant Deviation	NO		No Risk	Potential Risk
	YES		Potential Risk	Potential for High Risk

*A major stressor is a stressor or combination of stressors that would likely lead to a significant deviation from reference condition.

Table 3. Agency control and authority over influences on the Cibola.*

Influence	Agency Control	Agency Authority
Fire suppression; prescribed fire	Yes	Yes
Wildfire	No	Yes—appropriate response to all wildfires. Continue mitigation efforts through prescribed fire, mechanical treatments, and wildfire.
Managed grazing	Yes	Yes
Unmanaged wildlife herbivory	No	Maybe—can mitigate in very limited areas with fence exclosures or jackstraw cuts
Invasive plants	No	Yes
Motorized recreation, off-highway vehicle use, and non-motorized dispersed recreation	Yes	Yes through Travel Management Rule and Forest orders
Regeneration cutting, thinning, and fuelwood cutting. Gathering of forest products.	Yes	Yes
Insects/disease	No	Yes—FS can manage stand density and resiliency
Illegal woodcutting	No	Yes
Drought	No	Yes—FS can manage stand structure and density
Climate change	No	No—distinguished from drought by long time frame. Effect may shift, increase, decrease, or eliminate ERU from forest
Roads	No	Yes
Minerals[4]	No—locatable Yes—common	Yes
Developed recreation	Yes	Yes
Dams/impoundments	No—private lands Yes—national forest	Yes
Water withdrawal (wells)	No—private lands Yes—national forest	No—private lands Yes—national forest
Solid waste dumping	No	Yes

*Adapted from USFS 2008.

[4] In general, locatable minerals are hardrock minerals mined and processed for metals (e.g., gold, silver, copper, uranium) and some types of non-metallic minerals; common minerals are low value per volume (e.g., sand, gravel, cinders, flagstone). See Volume II, Chapter 9 for more.

Chapter 2. Vegetation

This chapter assesses vegetation-related ecosystem characteristics, drivers, and stressors, first individually, then collectively in an integrated discussion of risk assessment at the end of the chapter.

Vegetation provides many ecosystem services on which other life forms (including humans) depend. At the most basic level, vegetation provides *supporting* ecosystem services by converting sunlight and carbon dioxide into oxygen and carbohydrates (primary production). Vegetation also provides *regulating* ecosystem services, as it is key to soil formation and stability, thermoregulation (shading and evaporative cooling), nutrient and hydrologic cycling, and energy flow. Vegetation contributes to *provisioning* ecosystem services by providing wildlife habitat (cover, nest sites), food (forage for grazing and browsing animals), and fiber (lumber, paper, fuel). Especially important to humans are the *cultural* ecosystem services that vegetation provides to society (Christmas trees, botanical remedies, aesthetics).

Scales of Analysis. The **context scale** of analysis for vegetation-related ecosystem characteristics is the cluster of all ecological subsections (McNab et al. 2005) that intersect at least 1% of the Cibola Mountain Districts (shaded/textured areas in Figure 6). Context-scale analysis may identify disparate proportions of a vegetation type on- versus off the Forest and may shed light on how differences in management reflect differences in current condition. Context-scale analysis may also highlight the relative importance of a particular vegetation type, making sound management by the Cibola key to the overall condition of a vegetation type that occurs predominately on the Forest. The **plan scale** of analysis is the Forest Service-owned portion of the Cibola (all Mountain Districts)—the portion the Forest Service can actively manage. The **local scale** of analysis is the Geographic Area (individual sky island mountain range). Local-scale analysis for an individual ecological response unit (ERU) is generally precluded in this assessment because it reduces sample size, decreasing confidence to unacceptable levels. Unless otherwise noted, ERU-specific condition and trend[5] is assumed to be uniform across all Geographic Areas.

Ten vegetation-related ecosystem characteristics and drivers/stressors were analyzed:

Overall structure	Snags
Understory structure	Fire regime
Species composition[6]	Invasive plant species
Patch size[7]	Climate
Coarse woody material	Forest insects and disease

[5] For those ecosystem characteristics without recent or projected trend assessments (understory structure, species compostion, patch size, coarse woody material, snags, fire regime), departure from reference conditions indicates long-term negative trend.
[6] Analysis may be updated at a future date.
[7] Analysis may be updated at a future date.

Ecological Response Units (ERUs) of the Cibola[8]

Concepts and Descriptions of Major Ecosystem Types

The ERU system (formerly Potential Natural Vegetation Type or PNVT) is a stratification of units that are each similar in plant indicator species, succession patterns, and disturbance regimes, that in concept and resolution, are most useful to management. In the Southwest, the U.S. Forest Service uses ERUs to facilitate landscape analysis and strategic planning.

The ERU framework represents all major ecosystem types of the region and a coarse stratification of biophysical themes. The ERUs are map unit constructs, technical groupings of finer vegetation classes with similar site potential and disturbance history; that is, the range of plant associations (USFS SW Region 1997a, USFS SW Region 1997b), along with structure and process characteristics, that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006). Similar to LANDFIRE *biophysical settings* conceptualized in the Interagency Fire Regime Condition Class Guidebook (Hann et al. 2008), ERUs combine themes of site potential and historic fire regime:

Ecological Response Unit = Site Potential + Historic Disturbance Regime

The Fire Regime Condition Class guidebook describes how biophysical settings are delimited: "Vegetation includes the area's native species and associated successional stages, determined according to our best understanding of the historical or natural range of variation. Physical characteristics include climate, geology, geomorphology, and soils..." (i.e., site potential), and "…characteristic ecological processes of fire frequency and severity" (historic fire regime).

Map Unit Construct

Ecological Response Units (ERUs) are map unit constructs, technical groupings of finer vegetation classes. To date, ERUs have been built from plant associations recognized with the National Vegetation Classification (NVC), and from coarser *subseries* of ecological units that have been identified through Terrestrial Ecological Unit Inventory (Winthers et al. 2005). The Terrestrial Ecological Unit Inventory (TEUI) data are an ideal source of classification and line work from which to build ERUs. During TEUI projects, plot data are collected, along with climate and soils information, to form ecological units. For purposes of ERU mapping, vegetation classes can be derived from TEUI data.

Some vegetation classes that are used in constructing ERUs span more than one unit and require careful interpretation of historic circumstances for a given geography, particularly where they occur in ecotonal zones. For example, the *Oneseed juniper-Blue grama* subseries would initially indicate a woodland ERU—*Juniper Grass*. However, a closer look at the vegetation type as it occurs in central New Mexico, shows that the type usually exists in plant communities of low tree cover contiguous to grassland systems—potential inferences of high fire frequency. The TEUI map unit description also indicates a soil classification of mollisol, a signature of grassland ecosystems. The collective evidence suggests that the subseries would be best placed in the *Colorado Plateau/Great Basin Grassland* ERU.

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[8] Adapted from Wahlberg et al. 2013a (including reference conditions for structure and fire regime based on LANDFIRE 2010 and TNC 2006).

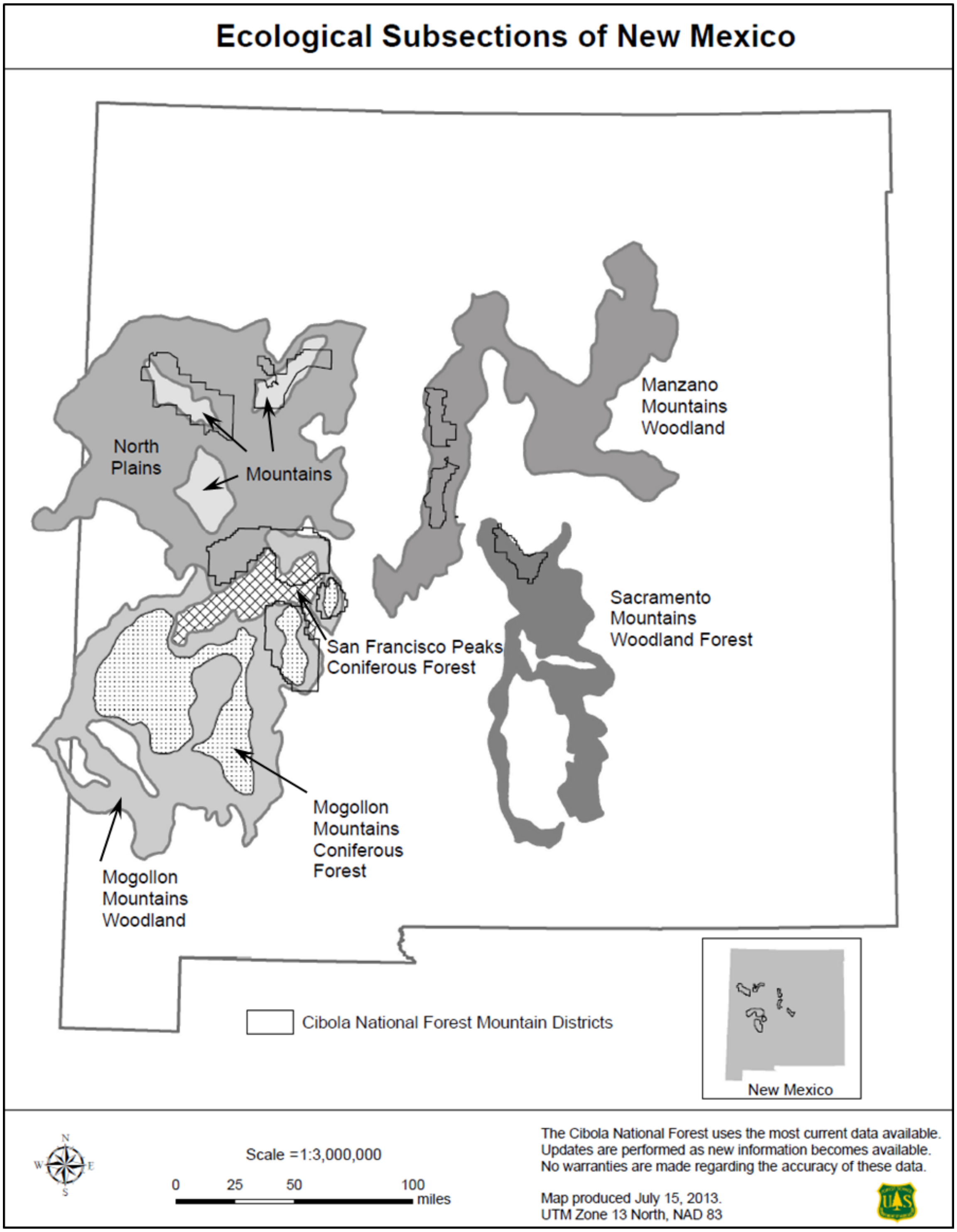


Figure 6. Ecological subsections that intersect at least 1% of the Cibola. This is the context scale of analysis for the vegetation resource. Each subsection contains multiple vegetation types.

Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)

Major Cibola ERUs are listed in Table 4, and all ERUs are listed by Geographic Area in Table 5. Only one ERU (RMAP[9] Fremont Cottonwood – Conifer) has more than one-third of its context-scale acreage on the Cibola.

Table 4. Major ERUs, ERU subclasses, and system types of the Cibola.

ERU	ERU Subclass	Code	System Type	% of Cibola
Spruce-Fir Forest		SFF	Forest	
	Spruce-Fir-Lower	SFM	Forest	0.40
	Spruce-Fir-Upper	SFP	Forest	0.08
Mixed Conifer with Aspen		MCW	Forest	2.04
Mixed Conifer–Frequent Fire		MCD	Forest	9.74
Ponderosa Pine Forest		PPF	Forest	
	Ponderosa Pine/Bunchgrass	PPG	Forest	2.10
	Ponderosa Pine/Evergreen Oak	PPE	Forest	26.1
PJ Evergreen Shrub		PJC	Woodland	1.40
PJ Woodland		PJO	Woodland	
	PJ Woodland–Cold	PJOc	Woodland	13.5
	PJ Woodland–Mild	PJOm	Woodland	2.98
PJ Grass		PJG	Woodland	
	PJ Grass–Cold	PJGc	Woodland	7.73
	PJ Grass–Mild	PJGm	Woodland	10.4
Juniper Grass		JUG	Woodland	
	Juniper Grass–Cold	JUGc	Woodland	1.18
	Juniper Grass–Mild	JUGm	Woodland	4.56
Madrean Pinyon-Oak Woodland		MPO	Woodland	1.82
Montane/Subalpine Grassland		MSG	Grassland	2.57
Colorado Plateau/Great Basin Grassland		CPGB	Grassland	1.49
Semi-Desert Grassland		SDG	Grassland	
	Piedmont Grassland	PFG	Grassland	6.64
	Sandy Plains Grassland	SPG	Grassland	0.42
Mountain Mahogany Mixed Shrubland		MMS	Shrubland	1.12
Gambel Oak Shrubland		GAMB	Shrubland	2.30
Sagebrush Shrubland		SAGE	Shrubland	0.16
Intermountain Salt Scrub		ISS	Shrubland	0.20
Chihuahuan Salt Desert Scrub		CSDS	Shrubland	0.18
Chihuahuan Desert Scrub		CDS	Shrubland	0.04
Sandsage		SAND	Shrubland	0.32

Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)

[9] Regional Riparian Mapping Project (RMAP; USFS 2012).

Table 5. Cibola ERU acreage as percentage of context-scale ERU acreage, Cibola ERU acreage as percentage of total Cibola acreage, and ERU acreage by Geographic Area as percentage of Cibola ERU acreage. The context scale area includes the Cibola and is about 10 times larger than the Cibola.

			Geographic Area*								
ERU	Cibola % of Context	ERU % of Cibola	Mt	Zu	Br	Dt	Mg	Sm	Ga	Mz	Sd
Chihuahuan Desert Scrub	3	<0.1						100			
Chihuahuan Salt Desert Scrub	28	0.2			100						
Colorado Plateau / Great Basin Grassland	1	1	49		0.1	34		<0.1	13	0.1	3
Gambel Oak Shrubland	32	2	14			6	15	32		11	23
Intermountain Salt Scrub	2	0.2	100								
Juniper Grass	3	6	<0.1	6	53	<0.1	0.2	11	12	13	4
Madrean Pinyon-Oak Woodland	9	2			7		15	45		11	22
Mixed Conifer - Frequent Fire	29	10	6	13		6	14	40	3	12	7
Mixed Conifer w/ Aspen	27	2					0.2	53		23	24
Montane / Subalpine Grassland	24	3	37	42		18	1			2	
Mountain Mahogany Mixed Shrubland	7	1					10	54		29	8
PJ Evergreen Shrub	3	1			5		6	62	27		
PJ Grass	11	18	11	6	24	5	11	22	15	3	3
PJ Woodland	22	17	15	16		29	1	16	4	5	13
Ponderosa Pine Forest	27	28	13	49	2	8	2	14	3	7	2
RMAP Arizona Alder - Willow	1	<0.1					0.1			99.9	
RMAP Arizona Walnut	0.2	<0.1						100			
RMAP Desert Willow	0.3	<0.1								100	

ERU	Cibola % of Context	ERU % of Cibola	Geographic Area* Mt	Zu	Br	Dt	Mg	Sm	Ga	Mz	Sd
RMAP Fremont Cottonwood - Conifer	81	<0.1					100				
RMAP Fremont Cottonwood - Oak	14	<0.1						100			
RMAP Fremont Cottonwood / Shrub	0.4	<0.1						100			
RMAP Herbaceous	28	0.2	9	91						0.4	0.1
RMAP Narrowleaf Cottonwood / Shrub	4	0.1	1	0.4			6	84		3	5
RMAP Ponderosa Pine / Willow	26	<0.1	28	3			12	18	2	33	4
RMAP Rio Grande Cottonwood / Shrub	11	0.1	0.2	3	3	81					13
RMAP Upper Montane Conifer / Willow	24	<0.1	4					62		34	
RMAP Willow - Thinleaf Alder	20	<0.1	25	18						39	18
Sagebrush Shrubland	1	0.2		99.9	0.1						
Sandsage	26	0.3	24						76		
Semi-Desert Grassland	10	7			12		7	70	0.4	4	7
Spruce-Fir Forest	30	0.5	82	3			5				11

Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)
*Geographic Area abbreviations: Br (Bear Mtns), Dt (Datil Mtns), Ga (Gallinas Mtns), Mg (Magdalena Mtns), Mz (Manzano Mtns), Mt (Mt Taylor), Sm (San Mateo Mtns), Sd (Sandia Mtns), Zu (Zuni Mtns).

ERU Descriptions[10]

Grassland and Shrubland Systems

Montane/Subalpine Grassland (MSG) – Also referred to as montane grasslands, this system occurs at elevations ranging from 8,000-11,000 feet, and often harbors several plant associations with varying dominant grasses and herbaceous species. Trees may occur along the periphery of the meadows, and some shrubs may also be present. These meadows are seasonally wet, which is closely tied to snowmelt. They typically do not experience flooding events. Historically, tree and shrub canopy cover were each less than 10% and stand-replacing fires occurred every 0–35 years.

[10] ERU descriptions are SW Region-wide (not Cibola-specific).

Gambel Oak Shrubland (GAMB) – This ERU is dominated by long-lived Gambel oak clones that form largely monotypic overstories (Simonin 2000). It occurs between 6,000 and 9,000 feet on all aspects in this ERU, and at higher elevations, it occurs predominantly on southern exposures. Gambel oak occurs as the dominant species ranging from dense thickets to clumps associated with other shrub species such as snowberry or sagebrush. Depending on site potential, ponderosa pine, juniper, and pinyon pine can encroach on older plant communities. The primary disturbance mechanism is mixed-severity to stand-replacing fire resulting in top-kill and rare mortality. Gambel oak responds to fire with vigorous sprouting from the root crown. Larger forms may survive low-intensity surface fire. The historic average fire return interval was 35–200 years from stand-replacing fire.

Mountain Mahogany Mixed Shrubland (MMS) – This ERU occurs in the foothills, canyon slopes, and lower mountain slopes of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico extending north into Colorado. These shrublands are often associated with exposed sites, rocky substrates, dry conditions, and recurrent historic fire that limited tree growth. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs. Historically, tree canopy cover was less than 10%. The historic average fire return interval was 35–200 years from stand-replacing fire.

Sagebrush Shrubland (SAGE) – This ERU is dominated by big sagebrush and primarily occurs adjacent to Great Basin grassland and pinyon juniper (PJ) woodland ERUs. While big sagebrush is the dominant species, other shrubs and grasses and forbs are present. Historically, tree canopy cover exceeded 10%, with the exception of early, post-fire plant communities. Sagebrush shrubland sites are usually found on deep well-drained valley bottom soils between 4,800 and 5,800 feet with precipitation ranging between 10 to 18 inches per year. The historic average fire return interval was 35–200 years from mixed-severity fire.

Sandsage (SAND) – This treeless ERU occurs on well-drained sandy soils at elevations between 3,500 and 5,500 feet, receiving about 8–10 inches of annual precipitation. It is dominated by sand sagebrush (sandsage) and includes an understory of sand-loving perennial and annual forbs and grasses. The historic average fire return interval was 35–200+ years from mixed-severity fire.

Colorado Plateau/Great Basin Grassland (CPGB) – In general, this ERU is found at lower elevations with vegetation coverage consisting of mostly grasses and interspersed shrubs. This ERU may have had over 10% shrub cover historically, but had less than 10% tree cover. The historic average fire return interval was 0–35 years. Mixed-severity fire has been reported in this ERU to have occurred with a mean return interval of 37 years primarily top-killing herbaceous species. Fire occurred less frequently (mean fire return interval of 75 years) and consumed both shrub and herbaceous life forms.

Intermountain Salt Scrub (ISS) – This ERU is found in cold climate gradients and the Great Plains, and is not often found on Forest Service lands of the Southwest. The vegetation is characterized by a typically open to moderately dense shrubland dominated by saltbush. The historic average fire return interval was 35–200+ years from mixed-severity fire.

Semi-Desert Grassland (SDG) – Semi-desert grassland occurs throughout southern New Mexico at elevations ranging from 3,000 to 4,500 feet. These grasslands are bounded by Chihuahuan desert at the lowest elevations and woodlands or chaparral at the higher elevations. This ERU may have had over 10% shrub cover historically, but had less than 10% tree cover. There are currently two subclasses of this ERU occurring on the Cibola—Piedmont Grassland (occurring on piedmont slopes and foothills) and Sandy Plains Grassland (also known as Chihuahuan Sandy Plains Grassland) occurring on sandy plains. The historic average fire return interval was 0–35 years. Recurring fire is important in this type to maintain open conditions, prevent shrub and tree invasion, and retain species diversity.

Chihuahuan Desert Scrub (CDS) – Some areas within this ERU may be barren with an abundance of sand, rock, gravel, scree or talus. Other areas may have sparse to dense vegetation cover that includes succulent scrub-dominated communities (generally low in perennial grass cover) or thorn scrub-dominated communities (often occurring on limestone substrates). The historic average fire return interval was 200+ years from mixed-severity fire. The sparse nature of this ERU indicates that fires likely would have been limited in size to small areas of continuous fuels.

Chihuahuan Salt Desert Scrub (CSDS) – This ERU occurs in the mild climate gradient where most precipitation comes during the growing season and includes extensive open-canopied shrublands of typically saline basins in the Chihuahuan Desert. Stands often occur on alluvial flats and around playas. Substrates are generally fine-textured, saline soils. Vegetation is typically composed of halophytic ("salt-loving") shrubs and grasses. The historic average fire return interval was 100–200 years from mixed-severity fire.

Forest and Woodland Systems

Spruce-Fir Forest (SFF) – Also known as subalpine conifer forests, spruce-fir forests range in elevation from 9,000 to 11,500 feet along a variety of gradients including gentle to very steep mountain slopes. This ERU is comprised almost entirely of Engelmann spruce and corkbark fir (subalpine fir) associations. Engelmann spruce and corkbark fir dominate the higher-elevation subclass of this ERU (SFP or "spruce-fir pure"), while in the lower-elevation subclass (SFM or "spruce-fir mix") mixed conifer species, especially Douglas-fir and quaking aspen, occur as a seral component that may be codominant or dominant. Natural disturbances in this ERU are blow-downs, insect outbreaks and stand replacing fires. Historically, tree canopy cover exceeded 10%, with the exception of early, post-fire plant communities. The historic fire return interval was 100–200 years from mixed-severity fire and 200–400 years from stand-replacing fire.

Mixed Conifer with Aspen (MCW or "wet mixed conifer") – This ERU spans a variety of dominant and codominant species in mesic environments in the Rocky Mountain and Madrean Provinces. In the Rocky Mountains, mixed conifer forests may be found at elevations between 5,000 and 10,000 feet, situated between ponderosa pine forests below and spruce-fir forests above. Dominant and codominant vegetation varies in elevation and moisture availability. Ponderosa pine occurs incidentally or is absent, while Douglas-fir, Southwestern white pine, white fir, and Colorado blue spruce occur as dominant and or codominant conifer species. Other species that may be present in subdominant proportions include limber pine. Understory vegetation is comprised of a wide variety of shrubs, graminoids, and forbs depending on soil type, aspect, elevation, disturbance history, and other factors. The historic average fire return interval was 35–200 years from mixed-severity fire. Historically, tree canopy cover exceeded 10%, with the exception of early, post-fire plant communities.

Mixed Conifer–Frequent Fire (MCD or "dry mixed conifer") – This ERU spans a variety of semi-mesic environments in the Rocky Mountain and Madrean Provinces. In the southern Rocky Mountains, mixed conifer forests may be found at elevations between 5,000 and 10,000 feet, situated between ponderosa pine, pinyon-oak, or pinyon-juniper woodlands below and spruce-fir forests above. This ERU typically occupies the warmer and drier sites of the mixed conifer life zone and has a historic fire return interval of 9–22 years from low-severity surface fire and infrequent mixed-severity fire (Baisan and Swetnam 1990, Dietrich 1983, Grissino-Mayer et al. 1995, Heinlein et al. 2005). Typically these types were historically dominated by ponderosa pine in an open forest structure (<30% tree cover), with minor occurrence of aspen, Douglas-fir, and Southwestern white pine. Aspen in this ERU occurs within dissimilar inclusions and not as a seral stage forest type as with the Mixed Conifer with Aspen ERU. More shade-tolerant conifers, such as Douglas fir, white fir, and blue spruce tend to increase in cover in late succession, and would not typically achieve dominance under the characteristic fire regime. These species could achieve dominance in localized settings where aspect, soils, and other factors limited the spread of surface fire. Currently, much of this type is dominated by closed structure ($\geq$30% tree cover) and climax species as a result of fire suppression.

Ponderosa Pine Forest (PPF) – The ponderosa pine forest ecosystem is widespread in the Southwest occurring at elevations ranging from 6,000-7,500 feet on igneous, metamorphic, and sedimentary parent soils with good aeration and drainage, and across elevational and moisture gradients. This ERU comprises the “ponderosa pine bunchgrass” (PPG) and “ponderosa pine/Evergreen oak” (PPE) subclasses. The dominant species in this system is ponderosa pine. Other trees, such as Gambel oak, pinyon pine, oneseed juniper, and Rocky Mountain juniper may be present. There is typically a shrubby understory mixed with grasses and forbs, although 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 historic average fire return interval was 0–35 years from low-severity fire.

Pinyon-Juniper (PJ) ERUs – Mostly found on lower slopes of mountains and in upland rolling hills at approximately 4,500 to 7,500 feet in elevation, this ERU is most commonly dominated by pinyon pine and oneseed juniper. Grasses, forbs, and shrubs can be found beneath the woodland overstory. Tree canopy cover exceeded 10% in the later successional stages, but was usually sparse or low in early, post-fire plant communities. PJ ERUs include:

- **Juniper Grass (JUG) – (cold [JUGc] and mild [JUGm] subclasses)** – Although it is included here, the Juniper Grass ERU is conceptualized as a separate life zone, typically on warmer and drier settings beyond the environmental limits of pinyon pine, and just below and often intergrading with the pinyon-juniper zone. The Juniper Grass ecosystem is generally uneven aged and very open in appearance. Trees occur as individuals or in smaller groups and range from young to old. A dense herbaceous matrix of native grasses and forbs characterize this type. Typical disturbances (fire, insects, disease) are of low severity and high frequency with a historic average fire return interval of 0–35 years from low–moderate severity fire. These disturbance patterns create and maintain the uneven-aged, open-canopy nature of this type. Typically, native understory grasses are perennial species, while forbs consist of both annuals and perennials. Shrubs are characteristically absent or scattered. This type is typically found on sites with well-developed, loamy soil characteristics, generally at the drier edge of the woodland climatic zone. Generally these types are most extensive in geographic areas dominated by warm (summer) season or bi-modal precipitation regimes. Overall these sites are less productive for tree growth than the PJ Woodland Type.

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

- **PJ Evergreen Shrub (PJC)** – This ERU is typically found on lower slopes in transition zones, often between interior chaparral and montane forests, and is most extensive in geographic areas dominated by mild climate gradients and bi-modal precipitation regimes. Historically, tree canopy cover exceeded 10% in later successional stages. Pinyon pine is occasionally absent, but one or more juniper species are always present. Oak trees are subordinate, but have high constancy in mild climate zones. Trees occur as individuals or in smaller groups and range from young to old, but typically small stands or clumps are even-aged in structure as a consequence of mixed-severity fire. Typical disturbances (fire, insects, disease) are of mixed-severity and moderate frequency with a historic average fire return interval of 35–200 years from mixed-severity fire, although some evergreen shrub woodland types have a fire return interval of 35–200 years from stand-replacing fire. These disturbance patterns create and maintain tree-age diversity and low- to moderately closed canopy typical of this type. The understory is dominated by a low to moderate density shrub layer with herbaceous plants in the interspaces. This ERU is found on well-drained (frequently gravelly or rocky) soils.

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

- **PJ Woodland (PJO) – (cold [PJOc] and mild [PJOm] subclasses)** – PJ woodlands are a broad grouping of different plant associations for descriptive purposes. Trees may occur as individuals or in smaller groups and range from young to old, but more typically as large, even-aged structured patches. The site characteristically has a moderate to dense tree canopy and a sparse understory of perennial grasses, annual and perennial forbs, and shrubs. Typical disturbances (fire, insects, disease) are of high severity and occur infrequently with a historic fire return interval of 35–200 years from stand-replacing fire. These disturbance patterns create and maintain the even-aged nature of this type. Woodland development occurs in distinctive phases, ranging from open grass-forb, to mid-aged open canopy, to mature closed canopy. Some types on broken or rocky terrain exhibit little to no natural fire, and insects and disease may be the only disturbance agents.

- **PJ Grass (PJG) – (cold [PJGc] and mild [PJGm] subclasses)** – PJ Grass occurs in what was historically more open woodlands with grassy understories. Native understories were made up of perennial grasses, with both annual and perennial forbs, and shrubs that were absent or scattered. Contemporary understories often include invasive grasses and uncharacteristically high shrub cover. The PJ Grass type is typically found on sites with well-developed, loamy soil characteristics, within areas of warm summer seasons and a bi-modal precipitation regime.

  Historically, trees would have occurred as individuals or in smaller clumps and range from young to old. Scattered shrubs and a dense herbaceous understory of native perennial grasses and annual and perennial forbs characterize this type. Typical disturbances (fire, insects, disease) were of low severity and high frequency, creating and maintaining an uneven-aged open canopy. The historic fire return interval was 0–35 years from low–moderate severity fire.

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

Madrean Pinyon-Oak Woodland (MPO) – Found in the Madrean province,[11] this ERU is dominated by open to closed canopy of evergreen oaks and pines with a grassy understory. Madrean pinyon-oak woodlands usually occupy foothills and mountains ranging from approximately 4000 to 7000 feet in elevation. Climate generally consists of mild winters and wet summers with mean annual precipitation ranging from about 10 to 25 inches; half of the precipitation typically occurs in summer, with the remainder occurring during the winter and spring. Historically, tree canopy cover exceeded 10%, with the

[11] Semiarid woodland characterized by pines and evergreen oaks. On the Cibola, this province occurs in the Sandia, Manzano, Bear, Magdalena, and San Mateo Mountains.

exception of early, post-fire plant communities. The historic fire return interval was 35–200+ years from mixed-severity fire.

Riparian ERUs – Riparian ERUs collectively occupy less than one-half of one percent of the Cibola (for full description of individual Riparian ERUs, see Triepke et al. 2013). Because the condition of riparian ERUs is so dependent on—and responsive to—physical setting (hydrology, bank structure, etc.), status and trend of individual riparian ERUs are best assessed in a spatially explicit context (see Water Resources section in this volume).

Overall Vegetation Structure: Assessment of Current Status and Trend

Overall vegetation structure was analyzed using two similar approaches and two data sources. First, structure was analyzed using mapping and ecosystem modeling for current conditions and future (15, 100, 1000 year) trends for major Cibola ERUs at the plan scale[12] based on data sources of the USFS Southwestern Region. Second, overall structure was analyzed for current conditions and past (2001–2008) trends for all Cibola ERUs at the context, plan, and local scales, expressed as Vegetation Condition Class (VCC), using LANDFIRE data. Even though overall vegetation structure and VCC are represented by two separate characteristics in this assessment, they reflect the same type of analysis of vegetation structure departure. While data of the Southwestern Region are improved over LANDFIRE (Triepke and Moreland 2013), it was important to develop structure analyses from both sources: (1) to help corroborate trends in vegetation structure, given the importance of this particular analysis and (2) to satisfy the current trends in agency accomplishments reporting, which relies on VCC with the aim of reducing departure through fuels treatments. For most ERUs, the two analyses provided similar results, corroborating ecosystem trends on the Cibola NF—the underlying cause of any dissimilar results cannot be attributed to any specific attribute of vegetation structure without site-specific data collection.

USFS Southwestern Region — Current Status/Analysis Method. The current condition of an ERU is compared to its respective reference condition under the natural range of variation (NRV).[13] This comparison examines the proportion of each seral stage ("state") under current conditions relative to its respective proportion under reference conditions. Reference conditions in this assessment (based on Wahlberg et al. 2013a) were derived from multiple sources including research (dendrochronology, stand reconstruction, etc.), empirical data, and state-and-transition models.

In order to determine the percentage of departure from reference condition for an ERU, the vegetation structural class within each ERU is placed into a Successional Class Structure category (state) based on the information in the reference condition model being used for the evaluation (Weisz et al. 2009). A comparison is then made of the current percentage to the reference percentage for each state within the model. The lesser of these two values for each state represents the "amount in common" between current conditions and reference conditions for each state. The sum of these lesser values is subtracted from 100% to classify overall ERU departure: 0–33% = low departure, 34–66% = moderate departure, and 67–100% = high departure. For example, the Mixed Conifer with Aspen (MCW) ERU has seven model states[14] identified (Table 6). The sum of the lesser values for the seven states is 38%. Therefore, the

[12] The analysis was limited to major ERUs and the plan scale due to lack of off-Cibola data and sample size limitations of on-Cibola data, respectively.

[13] NRV refers to the spatial and temporal variation in ecosystem characteristics under historic disturbance regimes during a reference period. The reference period considered typically includes the full range of variation produced by dominant natural disturbance regimes, often several centuries, for such disturbances as fire and flooding and also includes short-term variation and cycles in climate.

[14] Seedlings and saplings are trees <5 inches DBH (diameter at breast height), small trees are 5–9.9 inches DBH, medium trees are 10–19.9 inches DBH, and large trees are > 20 inches DBH. The terms "open" and "closed"

departure rating is 100% − 38% = 62% (moderate departure). Using this method for each ERU modeled in VDDT, current departures were calculated at the context scale and current and projected departures were calculated at the plan scale (Table 7).

Table 6. Calculation of vegetation structure departure. This example uses model states under reference and current conditions for the Mixed Conifer with Aspen ERU. The lesser of the two values from each model state are used to calculate departure.

	Reference	Current	Lesser Value
Grass/ Forb/ Shrub	1%	6%	1%
Aspen/ Mixed-deciduous (all sizes, open & closed)	21%	8%	8%
Seedling/ Sapling/ Small (intolerant, open)	0%	1%	0%
Seedling/ Sapling/ Small (intolerant, closed)	0%	35%	0%
Seedling/ Sapling/Small (tolerant/ mixed-tolerant) & Medium (closed)	29%	47%	29%
Medium (intolerant, open)	0%	2%	0%
Large (tolerant & intolerant, closed, single- & multi-storied)	49%	0%	0%
Sum of lesser values (departure %)			38%
Departure category			Moderate

Projected Trend/Analysis Method. Trends were assessed based on the difference between current or future conditions and the reference condition. Forest Service mid-scale mapping was used to depict current condition (Mellin et al. 2008). The Forest Vegetation Simulator (FVS) (Dixon 2002) was used to characterize the effects of natural growth on the ecosystem structure. For the forest and woodland ERUs where data and adequate models existed, the Vegetation Dynamics Development Tool (VDDT) (ESSA 2006) was then used to simulate stand structure 15, 100, and 1000 years into the future under current management[15] (Table 7). Trend was not calculated for ERUs whose Cibola acreages were too small to adequately assess.

For each major ERU, current departures were calculated at the context scale, and current and projected departures were calculated at the plan scale (Table 7). All ERUs at the plan (Cibola) scale are either moderately or highly departed except for Mountain Mahogany/Mixed Shrubland, and only PJ Woodland is projected to be in low departure in the near or distant future. (A departure rating of "Low" is considered to be within reference conditions and not at risk.) Stand structures for reference, context, and Cibola are graphically compared (Figure 7–Figure 15) to help visualize the nature of the departures; projected departures are not displayed, but projected stand structures tend to follow the same pattern as current stand structures, that is, the nature of the departure changes little.

describe canopy cover—under 30% and over 30%, respectively. The terms "tolerant" and "intolerant" refer to species that are tolerant (e.g., spruce, fir) or intolerant (e.g., ponderosa pine) of shade, respectively; "mixed-tolerant" refers to species intermediate in shade tolerance (e.g., Douglas-fir).

[15] Based on management activity from 1997–2012. The Cibola shifted emphasis from producing and selling timber products to wildlife habitat management and restoration in 1996. (See Volume II, Timber and Special Forest Products, Background.)

Table 7. Departure rating (%) and departure category (shading) for major Cibola ERUs at the context scale and plan (Cibola) scale.

LEGEND	High departure	Moderate departure	Low departure	Not assessed/Unknown

ERU	Current Context	Current Cibola	Projected Cibola (+years) +15	+100	+1000
Juniper Grass	38	57	41	80	89
Mixed Conifer–Frequent Fire	71	69	65	63	61
Mixed Conifer with Aspen	49	62	53	44	41
Madrean Pinyon-Oak Woodland	47	75	67	89	92
PJ Evergreen Shrub	44	75	76	82	85
PJ Grass	30	50	53	72	74
PJ Woodland	29	55	30	20	27
Ponderosa Pine/ Bunchgrass	95*	97	95	88	87
Ponderosa Pine/ Evergreen Oak		98	96	93	93
Spruce-Fir Forest	39	45	**	**	**
Colorado Plateau/ Great Basin Grassland	53†	45	**	**	**
Gambel Oak Shrubland	42	47	**	**	**
Mountain Mahogany/ Mixed Shrubland	54	8	**	**	**
Montane/Subalpine Grassland	55†	28	**	**	**
Semi-Desert Grassland	59†	31	**	**	**

* Calculated as overall PPF departure (subclass-level data not available off-Forest).
** Insufficient sampling intensity of this ERU for modeling projected departure.
† LANDFIRE data (http://www.landfire.gov/NationalProductDescriptions11.php data); USFS data not available.

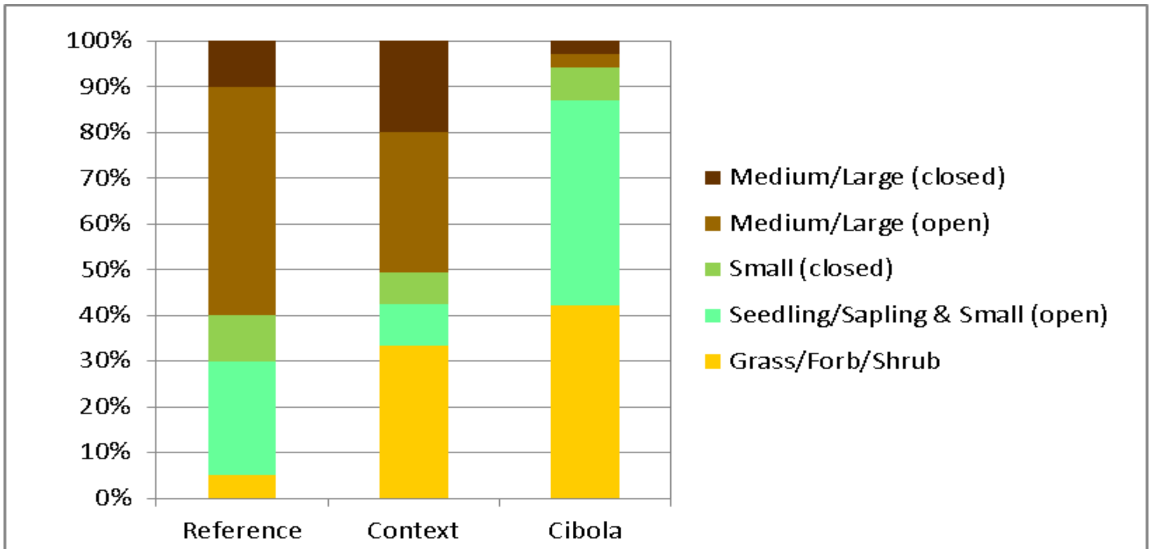
Regional Corporate Spatial Database: gdb04a_r03_default_(Region) unless otherwise noted.

Historical timber harvest has been largely responsible for the overall decrease in large trees across Rocky Mountain forests since the reference period, while active fire suppression (firefighting) and passive fire suppression (roads, excessive removal of fine fuels by improper grazing, community development, etc.) have been largely responsible for reduced fire frequency (Schoennagel et al. 2004). A reduced fire frequency allows fuels to accumulate and tree canopies to close, facilitating insect and disease outbreaks, uncharacteristically severe fires, and increases in the early seral (grass/forb/shrub, seedling/sapling) states that follow fire. The effects of these phenomena are evident in the graphical representations of stand structure within and among ERUs (Figure 7–Figure 15).[16, 17]

[16] Model state distributions for ERUs at the context scale do not include Cibola NF area.

[17] Model states dominated by medium and large trees were combined ("Medium/Large") for Context and Cibola scales where reference condition data are not sufficient to distinguish whether medium or large trees were dominant in a particular ERU state.

Juniper Grass. Under reference conditions, 60% of the Juniper Grass ERU was in the states characterized by medium/large trees (light brown and dark brown bars, Figure 7) and only 5% was in the grass/forb/shrub state. At the context scale, one-third is in the grass/forb/shrub state, and slightly over half is in the medium/large states with an increase in closed canopies relative to reference conditions. On the Cibola, 42% of this ERU is in the grass/forb/shrub state while only 6% is in medium/large states.

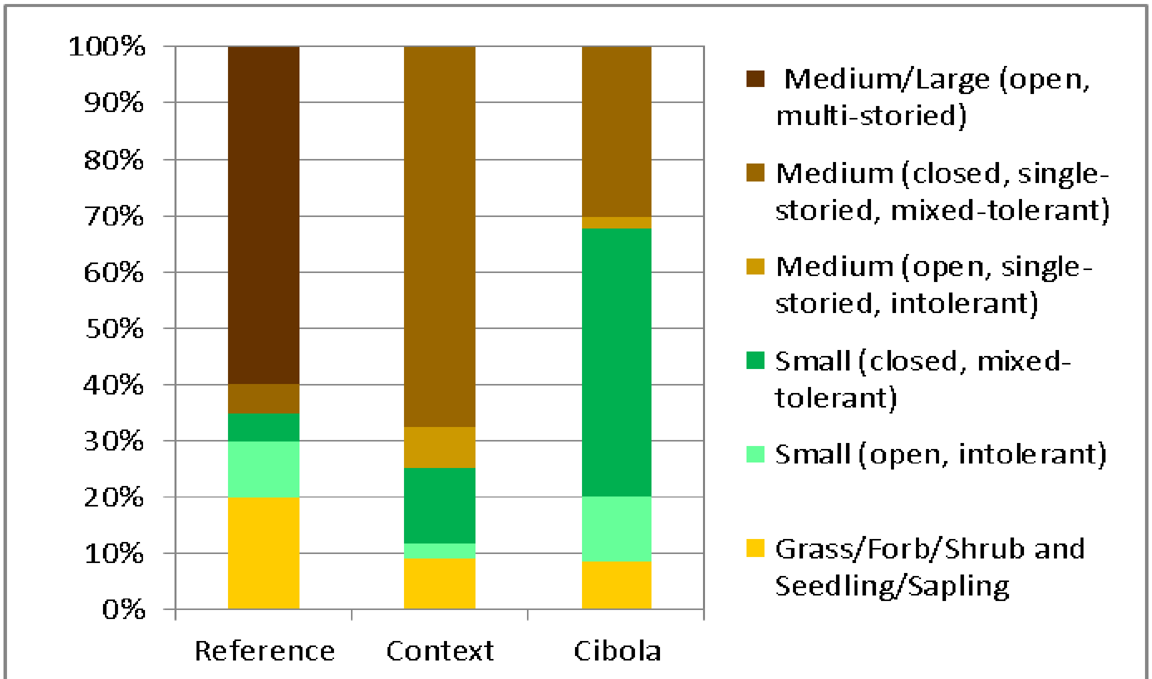


	Reference	Context	Cibola
Medium/Large (closed)	**10%**	**20%**	**3%**
Medium/Large (open)	**50%**	**31%**	**3%**
Small (closed)	**10%**	**7%**	**7%**
Seedling/Sapling & Small (open)	**25%**	**9%**	**45%**
Grass/Forb/Shrub	**5%**	**33%**	**42%**

Figure 7. Proportions of model states for Juniper Grass ERU under reference conditions and current proportions at context and plan scales.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

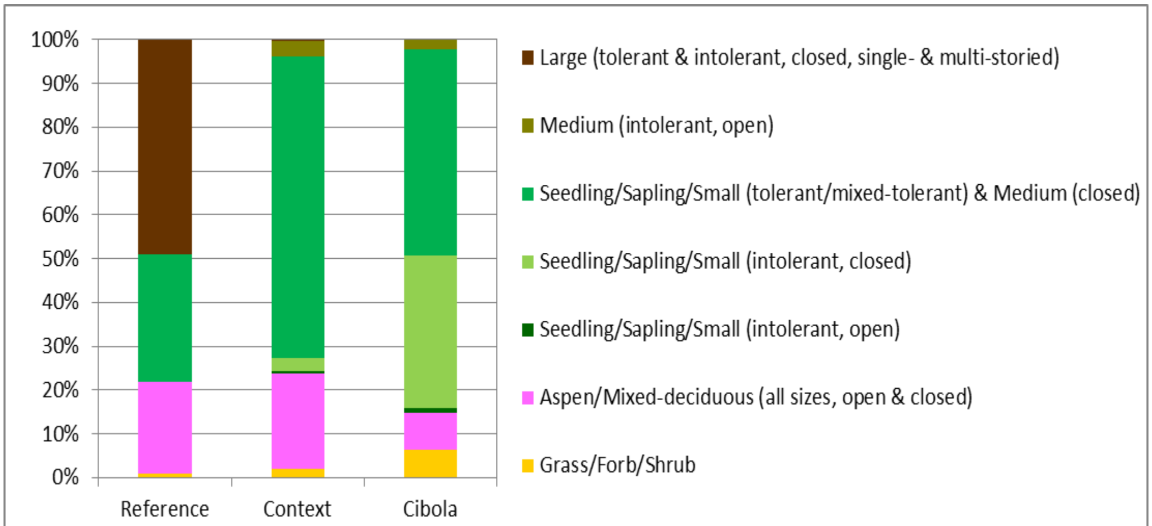
Mixed Conifer–Frequent Fire. The amount of the small, closed state has increased from 5% during the reference period to 13% outside the plan area and to 48% on the Cibola (Figure 8). During this same period, the grass/forb/shrub state has decreased from 20% under reference conditions to 9% at both context and plan scales. Meanwhile, the states characterized by medium and large trees have shifted in canopy closure from a ratio of 1:12 (closed:open) under reference conditions to 10:1 and 15:1 at context and plan scales, respectively.



	Reference	Context	Cibola
Medium/Large (open, multi-storied)	60%	0%	0%
Medium (closed, single-storied, mixed-tolerant)	5%	67%	30%
Medium (open, single-storied, intolerant)	0%	7%	2%
Small (closed, mixed-tolerant)	5%	13%	48%
Small (open, intolerant)	10%	3%	12%
Grass/Forb/Shrub and Seedling/Sapling	20%	9%	9%

Figure 8. Proportions of model states for Mixed Conifer–Frequent Fire ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Mixed Conifer with Aspen. The most profound change since reference conditions is the loss of states characterized by large trees—from nearly one-half during the reference period to almost none today (Figure 9); however, large trees may be present in states currently dominated by medium-sized trees.

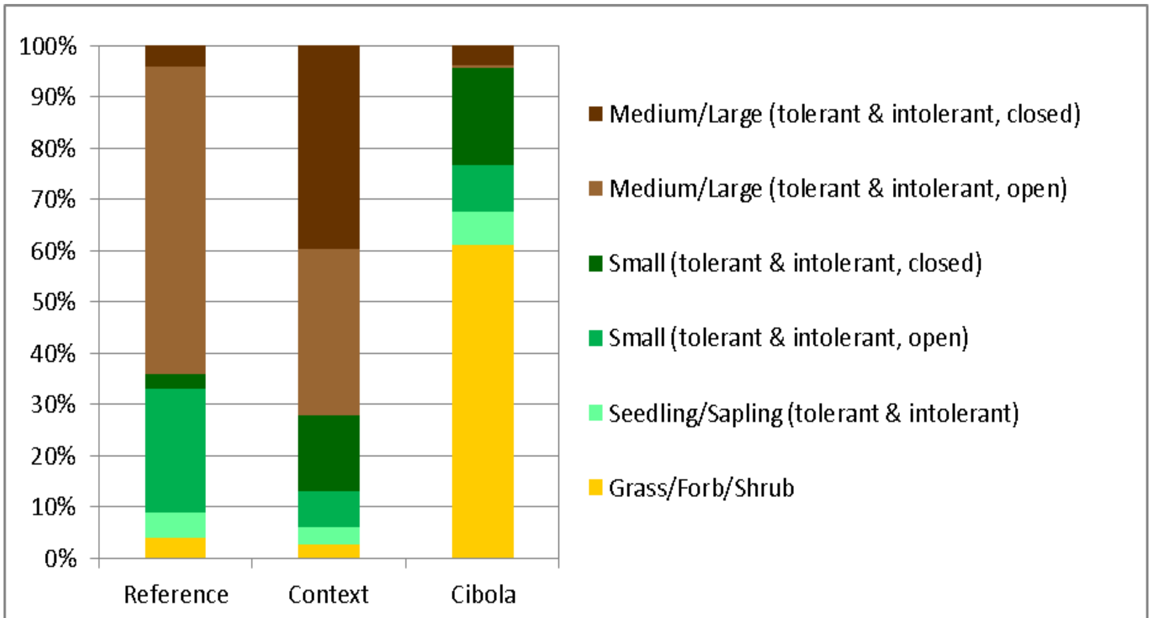


	Reference	Context	Cibola
Large (tolerant & intolerant, closed, single- & multi-storied)	49%	0%	0%
Medium (intolerant, open)	0%	3%	2%
Seedling/Sapling/Small (tolerant/mixed-tolerant) & Medium (closed)	29%	69%	47%
Seedling/Sapling/Small (intolerant, closed)	0%	3%	35%
Seedling/Sapling/Small (intolerant, open)	0%	0.5%	1.1%
Aspen/Mixed-deciduous (all sizes, open & closed)	21%	22%	8%
Grass/Forb/Shrub	1%	2%	6%

Figure 9. Proportions of model states for Mixed Conifer with Aspen ERU under reference conditions and current proportions at context and plan scales.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

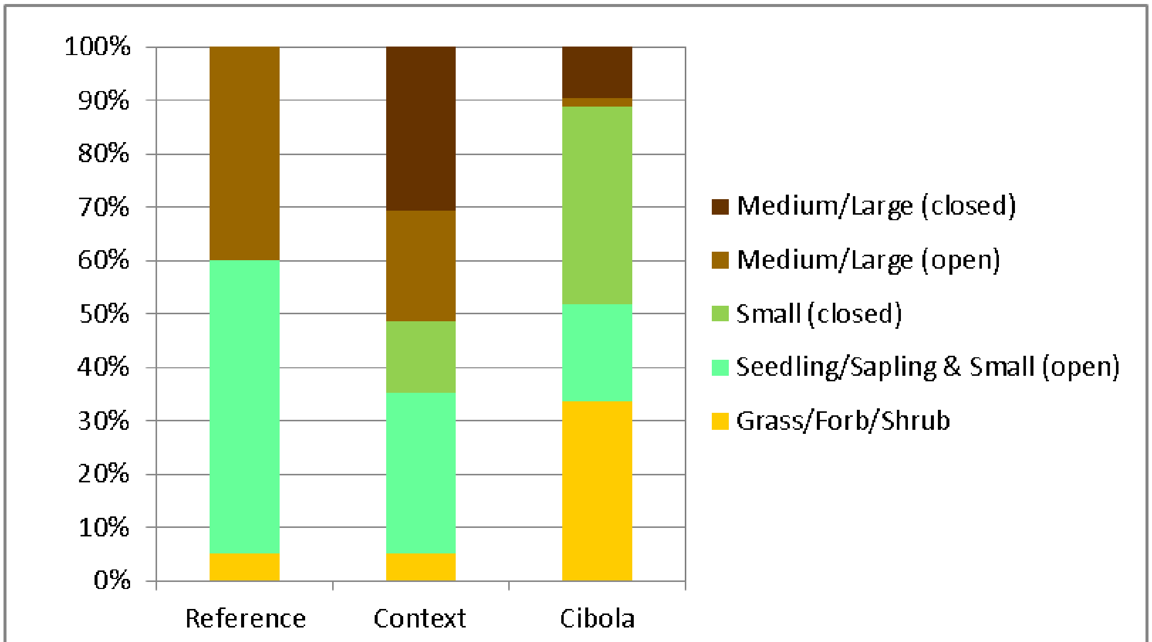
Madrean Pinyon-Oak Woodland. The proportion of open to closed canopy in the states characterized by medium and large trees has shifted from almost exclusively open (reference) to mostly closed at the context scale and almost exclusively closed on the Cibola (Figure 10). While the collective proportion of states characterized by medium and large trees (light brown and dark brown bars) has increased slightly since the reference period at the context scale, it has decreased more than 12-fold on the Cibola. Additionally, more than 60% of this ERU is now in the grass/forb/shrub state on the Cibola.



	Reference	Context	Cibola
Medium/Large (tolerant & intolerant, closed)	4%	40%	4%
Medium/Large (tolerant & intolerant, open)	60%	32%	0.5%
Small (tolerant & intolerant, closed)	3%	15%	19%
Small (tolerant & intolerant, open)	24%	7%	9%
Seedling/Sapling (tolerant & intolerant)	5%	3%	7%
Grass/Forb/Shrub	4%	3%	61%

Figure 10. Proportions of model states for Madrean Pinyon-Oak Woodland ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

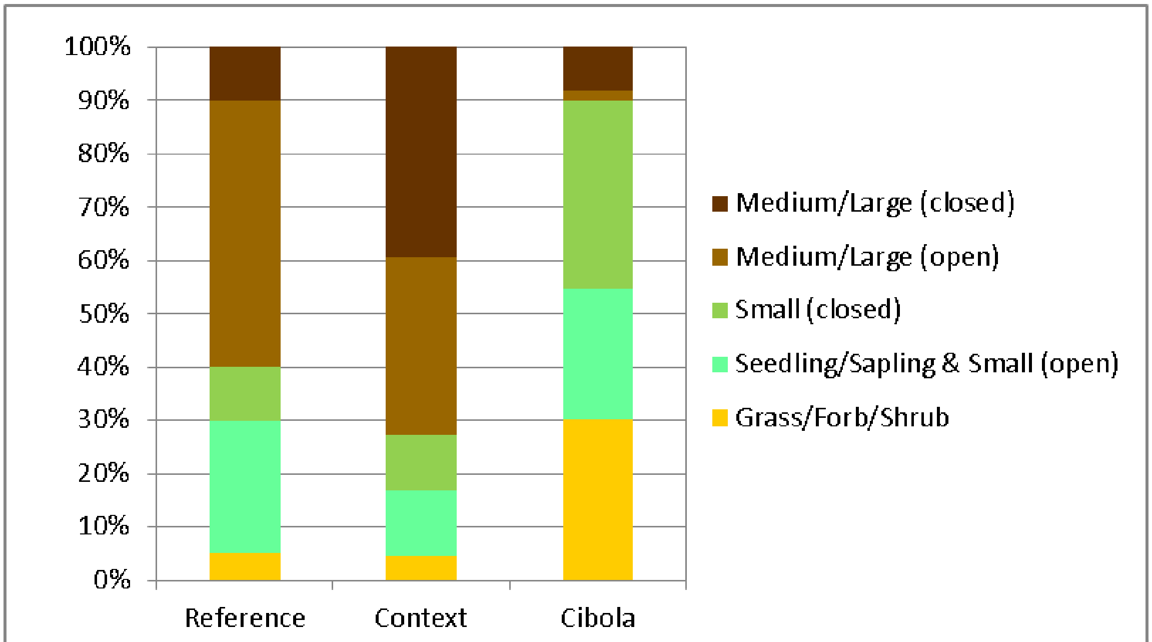
PJ Evergreen Shrub. Note the shift in canopy structure from exclusively open (reference) to mostly closed (context and plan scales) in states characterized by medium and large trees. Also note the increases in the grass/forb/shrub and small (closed) states on the Cibola (Figure 11).



	Reference	Context	Cibola
Medium/Large (closed)	0%	31%	9%
Medium/Large (open)	40%	21%	2%
Small (closed)	0%	13%	37%
Seedling/Sapling & Small (open)	55%	30%	18%
Grass/Forb/Shrub	5%	5%	34%

Figure 11. Proportions of model states for PJ Evergreen Shrub ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

PJ Grass. Note the shift in canopy structure from mostly open (reference) to mostly closed (context and plan scales) in states characterized by medium and large trees. Also note the increases in the grass/forb/shrub and small (closed) states on the Cibola (Figure 12).

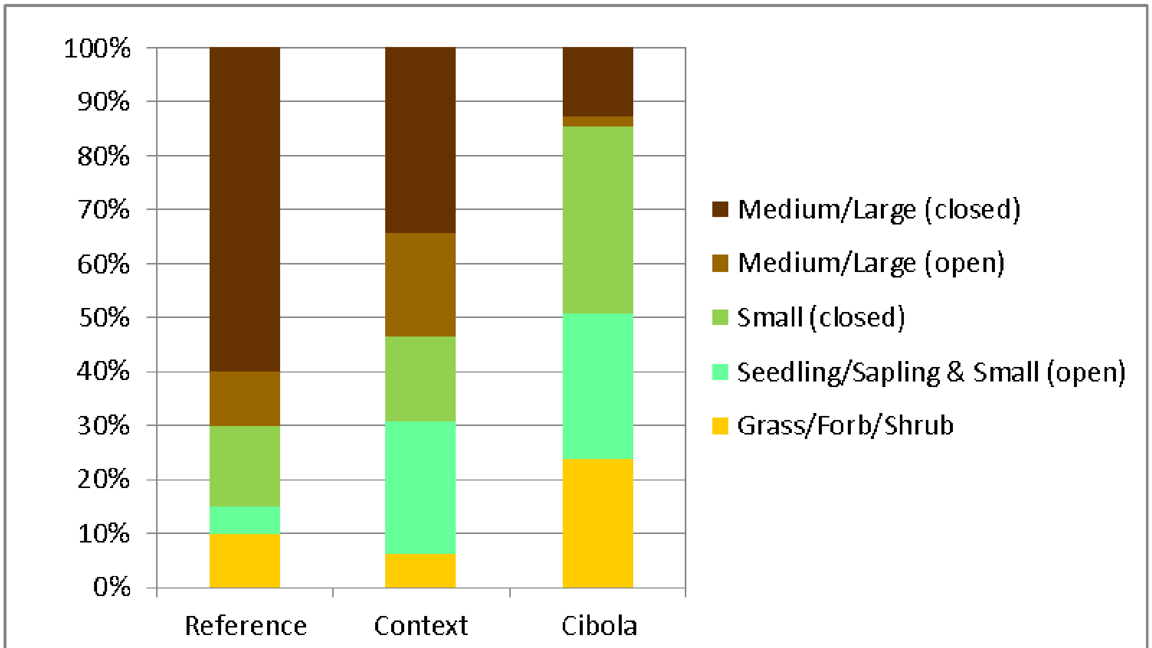


	Reference	Context	Cibola
Medium/Large (closed)	10%	39%	8%
Medium/Large (open)	50%	33%	2%
Small (closed)	10%	11%	35%
Seedling/Sapling & Small (open)	25%	12%	25%
Grass/Forb/Shrub	5%	5%	30%

Figure 12. Proportions of model states for PJ Grass ERU under reference conditions and current proportions at context and plan scales.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

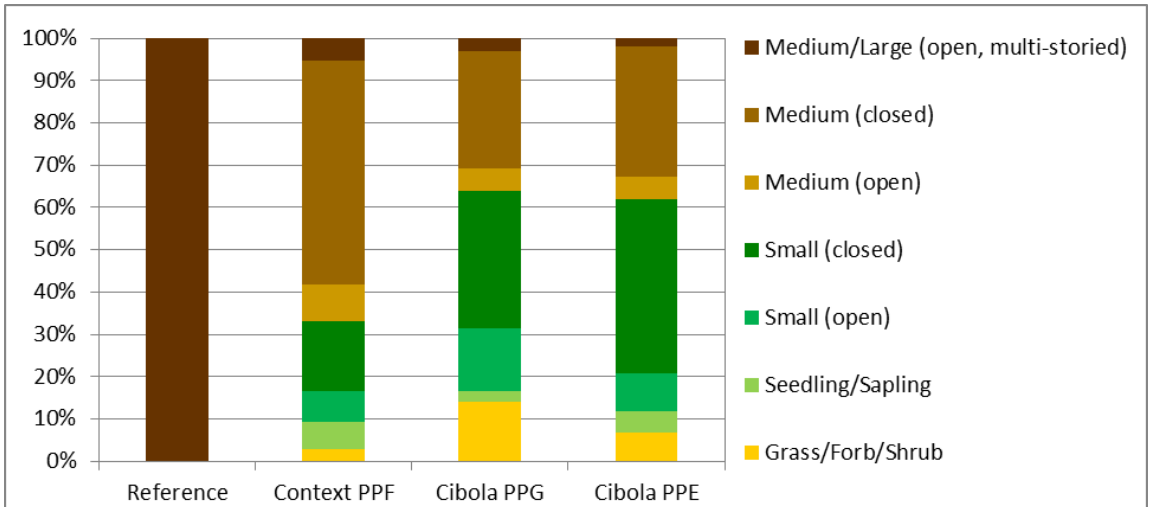
PJ Woodland. Since the reference period, there has been an overall shift away from states characterized by medium and large trees (context and plan scales). This is especially true for the Cibola where there have been large, concomitant increases in the grass/forb/shrub and small (closed) states (Figure 13).



	Reference	Context	Cibola
Medium/Large (closed)	60%	34%	13%
Medium/Large (open)	10%	19%	2%
Small (closed)	15%	16%	35%
Seedling/Sapling & Small (open)	5%	25%	27%
Grass/Forb/Shrub	10%	6%	24%

Figure 13. Proportions of model states for PJ Woodland ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

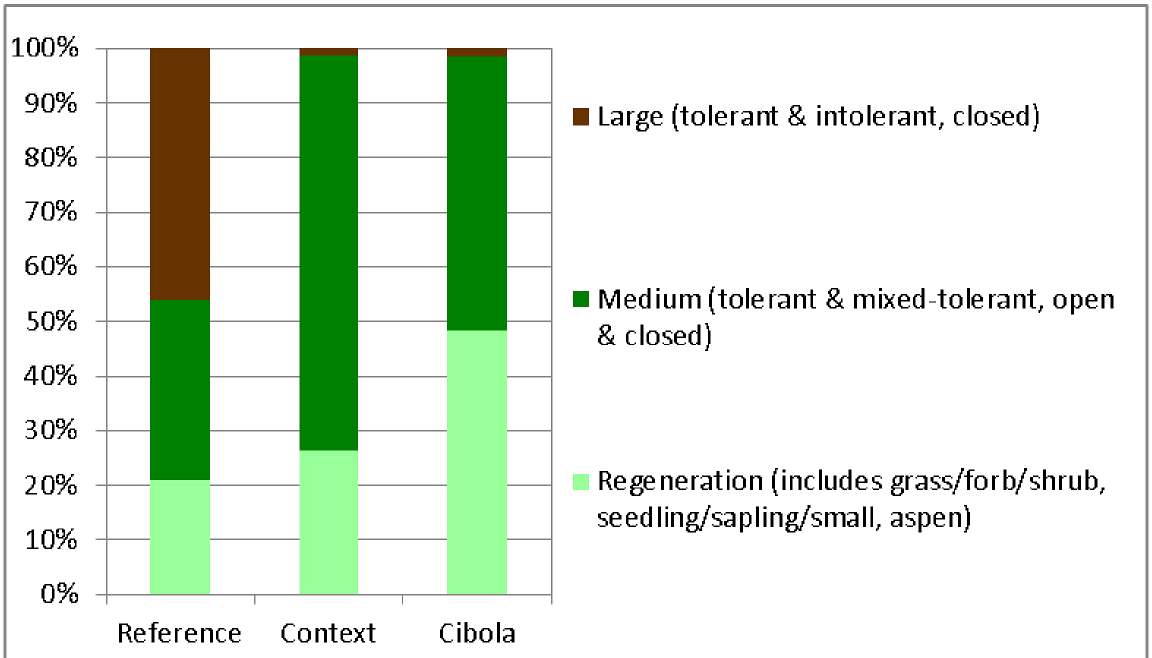
Ponderosa Pine Forest. Under reference conditions, 100% of both the Ponderosa Pine/ Bunchgrass (PPG) and Ponderosa Pine/Evergreen Oak (PPE) ERU subclasses were in a state characterized as uneven-aged forests, represented by trees of all size classes, from seedlings to very large (old) trees (represented by a single bar in Figure 14) where all structural stages were present in small patches in open, multiple-aged, multiple-storied stands. At the context scale, data are only available at the Ponderosa Pine Forest (PPF) ERU class level (shown collectively as PPF in Figure 14). The proportion of stands characterized by medium or large trees with open canopies has decreased from 100% (reference) to 14% (context), 8% (Cibola PPG), and 7% (Cibola PPE).



	Reference	Context	Cibola PPG	Cibola PPE
Medium/Large (open, multi-storied)	100%	5%	3%	2%
Medium (closed)	0%	53%	28%	31%
Medium (open)	0%	9%	5%	5%
Small (closed)	0%	17%	32%	41%
Small (open)	0%	7%	15%	9%
Seedling/Sapling	0%	7%	2%	5%
Grass/Forb/Shrub	0%	3%	14%	7%

Figure 14. Proportions of model states for Ponderosa Pine Forest ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Spruce-Fir. The most profound change since reference conditions is the loss of states characterized by large trees—from nearly one-half during reference conditions to almost none now (Figure 15); however, large trees may be present in states currently dominated by medium-sized trees.

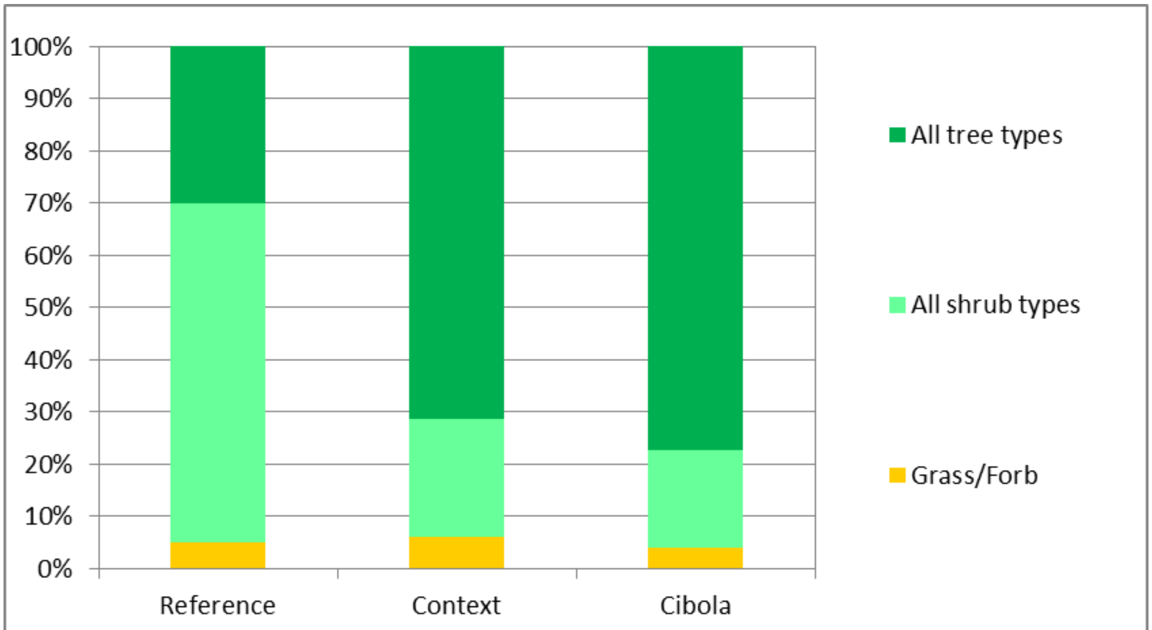


	Reference	Context	Cibola
Large (tolerant & intolerant, closed)	46%	1.3%	1.5%
Medium (tolerant & mixed-tolerant, open & closed)	33%	72%	50%
Regeneration (includes grass/forb/shrub, seedling/sapling/small, aspen)	21%	26%	48%

Figure 15. Proportions of model states for Spruce-Fir Forest ERU under reference conditions and current proportions at context and plan scales.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

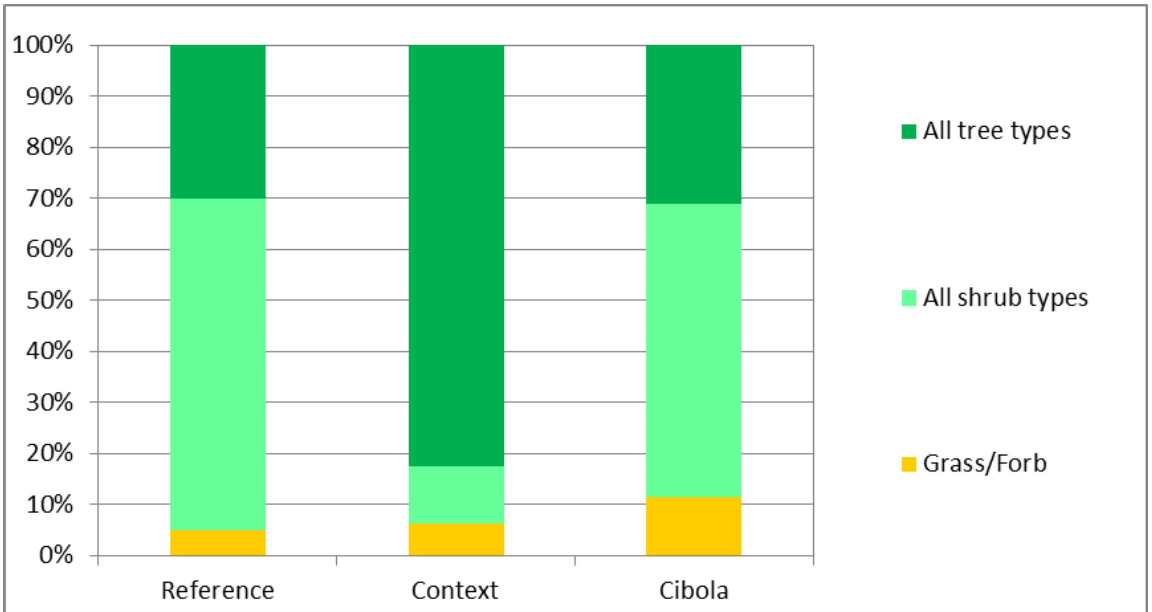
Gambel Oak Shrubland. The most profound changes since reference conditions are the increase in proportion of the tree-type states and decrease in proportion of the shrub-type states at both context and plan scales (Figure 16).



	Reference	Context	Cibola
All tree types	30%	71%	77%
All shrub types	65%	23%	19%
Grass/Forb	5%	6%	4%

Figure 16. Proportions of model states for Gambel Oak Shrubland ERU under reference conditions and current proportions at context and plan scales.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Mountain Mahogany / Mixed Shrubland. Current seral stage proportions on the Cibola are very similar to reference conditions (Figure 17); however, at the context scale, there has been a large increase in tree types and a correspondingly large decrease in shrub types.

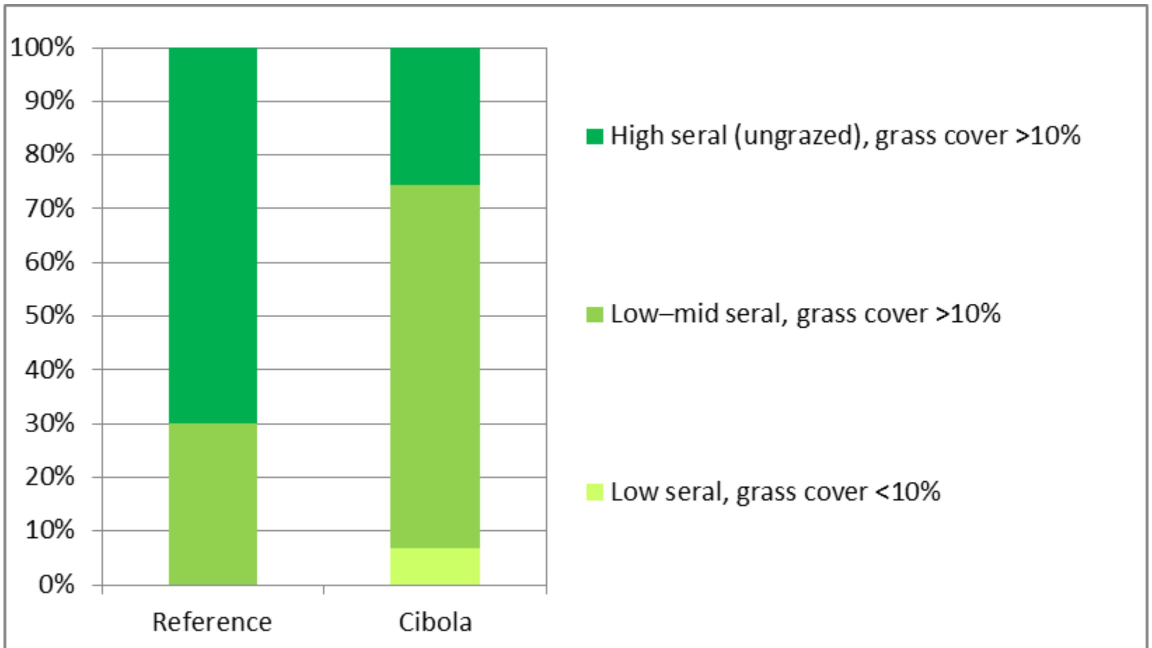


	Reference	Context	Cibola
All tree types	30%	83%	31%
All shrub types	65%	11%	57%
Grass/Forb	5%	6%	12%

Figure 17. Proportions of model states for Mountain Mahogany / Mixed Shrubland ERU under reference conditions and current proportions at context and plan scales.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Colorado Plateau / Great Basin Grassland. The most profound changes since reference conditions are the decrease in proportion of the high-seral state, the increase in proportion of low–mid seral states (with >10% grass cover), and the appearance of a low-seral state with <10% grass cover (Figure 18).

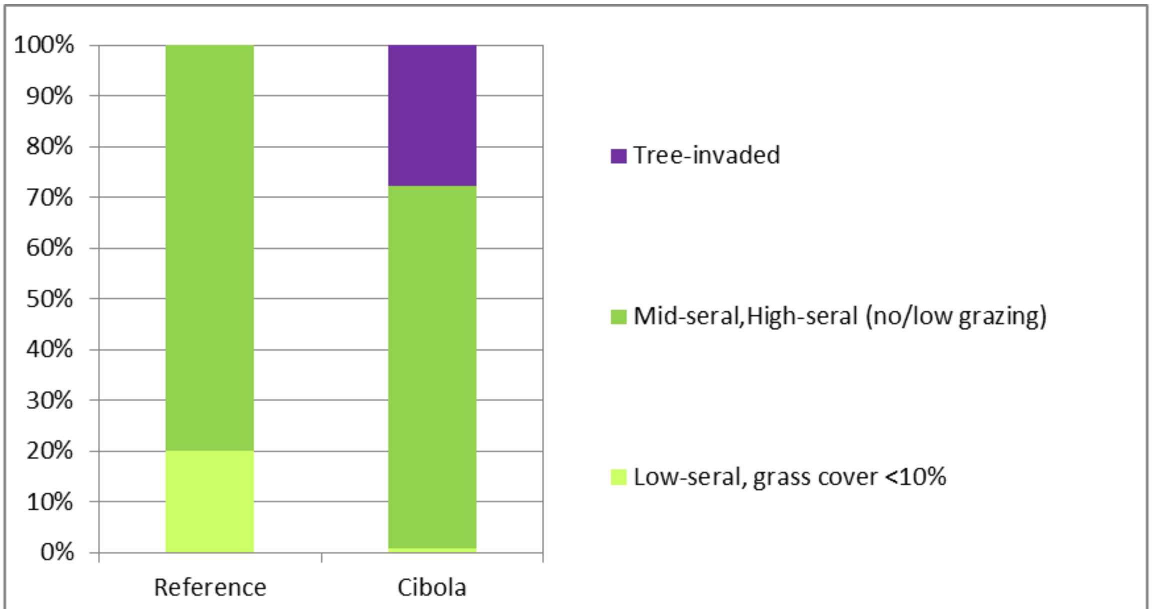


	Reference	Cibola
High seral (ungrazed), grass cover >10%	**70%**	**25%**
Low–mid seral, grass cover >10%	**30%**	**68%**
Low seral, grass cover <10%	**0%**	**7%**

Figure 18. Proportions of model states for Colorado Plateau / Great Basin Grassland ERU under reference conditions and current proportions at the plan scale.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

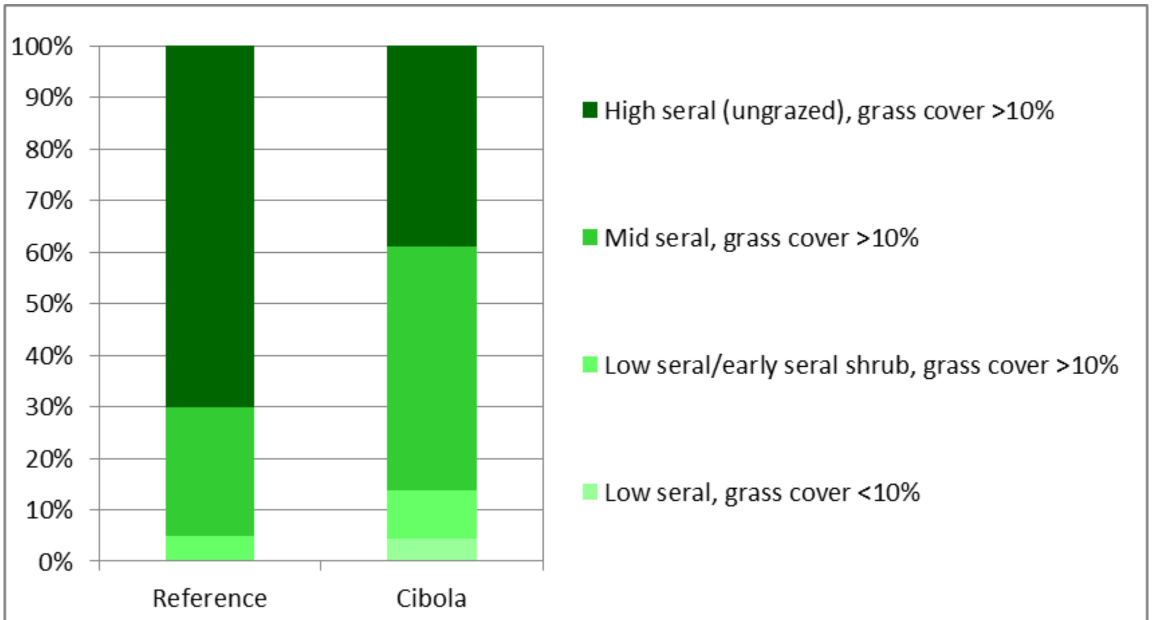
Montane / Subalpine Grassland. The most profound changes since reference conditions are the large decrease in the low-seral state and the appearance of a tree-invaded state (Figure 19).



	Reference	Cibola
Tree-invaded	0%	28%
Mid-seral, High-seral (no/low grazing)	80%	71%
Low-seral, grass cover <10%	20%	1%

Figure 19. Proportions of model states for Montane / Subalpine Grassland ERU under reference conditions and current proportions at the plan scale.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Semi-Desert Grassland. The most profound changes since reference conditions are the decrease in proportion of the high-seral state, the increase in proportion of the mid-seral state, and the appearance of a low-seral state with <10% grass cover (Figure 20).



	Reference	Cibola
High seral (ungrazed), grass cover >10%	70%	39%
Mid seral, grass cover >10%	25%	47%
Low seral/early seral shrub, grass cover >10%	5%	9%
Low seral, grass cover <10%	0%	4%

Figure 20. Proportions of model states for Semi-Desert Grassland ERU under reference conditions and current proportions at the plan scale.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Vegetation Condition Class (VCC) — Current Condition. All Cibola ERUs were categorized by VCC (formerly called Fire Regime Condition Class)—a measure of departure of current conditions from reference conditions (Hann and Bunnell 2001) in overall structure using the most recent data available (2008). The three VCC classes (Table 8) are based on low, moderate, and high departure from the natural range of variation (NRV). (A departure rating of “Low” is considered to be within reference conditions and not at risk.) The Cibola overall is mostly (53%) in VCC 2 with 23% in VCC 3 and 24 % in VCC 1 (Figure 21).

Table 8. Vegetation condition classes.

Class	Description
1 (Low)	Fire regimes are within the natural or historical range; risk of losing key ecosystem components is low. Vegetation composition and structure are intact and functioning.
2 (Moderate)	Fire regimes have been moderately altered. Risk of losing key ecosystem components is moderate. Fire frequencies may have departed by one or more return intervals (either increased or decreased). This departure may result in moderate changes in fire and vegetation attributes.
3 (High)	Fire regimes have been substantially altered. Risk of losing key ecosystem components is high. Fire frequencies may have departed by multiple return intervals. This may result in dramatic changes in fire size, fire intensity, fire severity, and landscape patterns. Vegetation attributes have been substantially altered.

Adapted from Barrett et al. 2010.

All Cibola ERUs have at least 25% of their acreage in VCC 2 or 3 and are considered to be at risk, including thirteen ERUs with at least 25% of their acreage in VCC 3 and considered to be at high risk (Figure 22). Overall risk is at least 75% at the context scale, plan (Cibola) scale, and local (GA) scale, except for the Zuni Mtns GA with just under half of its acreage at risk (Table 9). Most ERUs at the context and plan scales are over 75% at risk, and all but one ERU is over 50% at risk (PJ Evergreen Shrub is 48% at risk at context scale). The San Mateo Mtns Geographic Area (GA) is the only GA whose majority of ERUs predominately occur within a single GA (10 of its 19 ERUs have at least half of their acreage in the San Mateo Mtns GA), and all 10 of these ERUs are at risk in that GA.

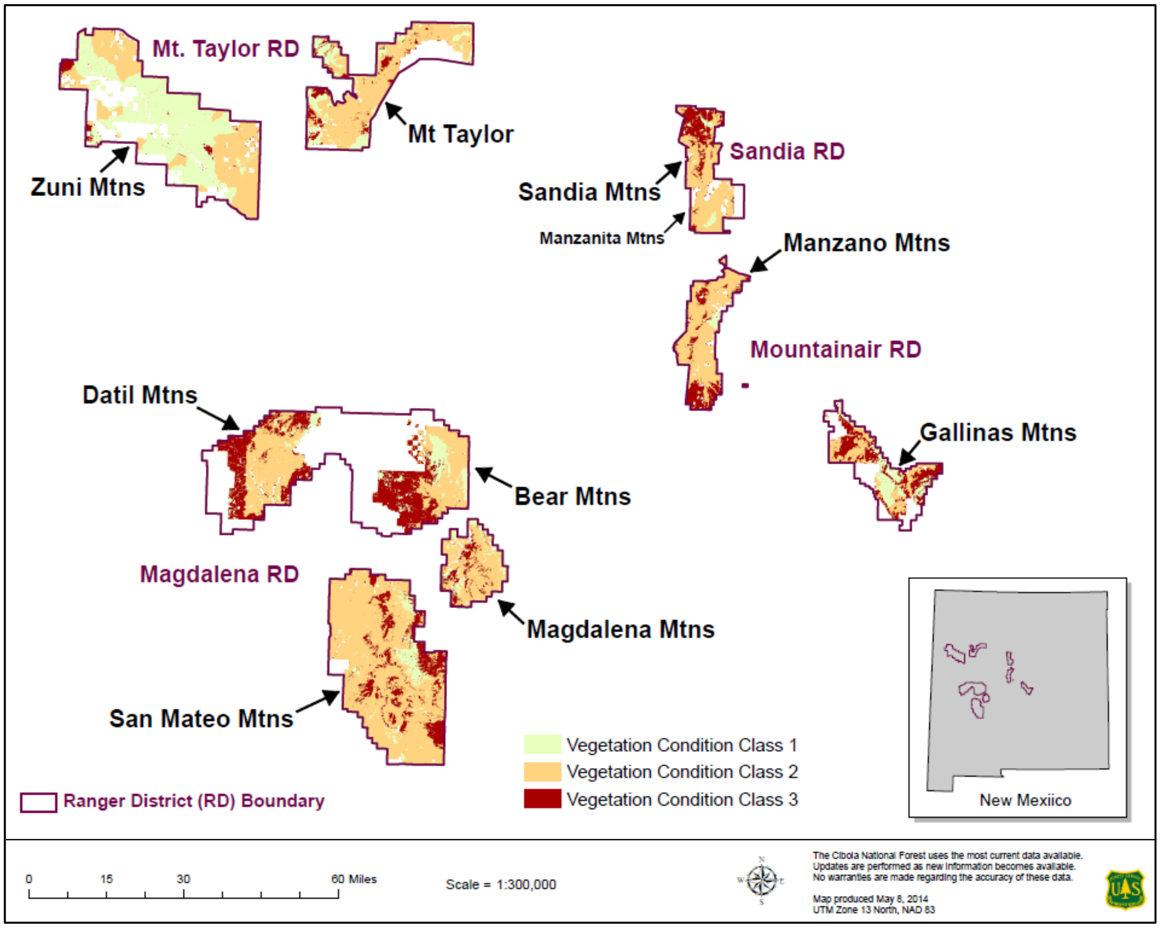


Figure 21. Vegetation condition class ratings for the Cibola. http://www.landfire.gov/
White areas within RD boundary is non-Forest Service-owned land.

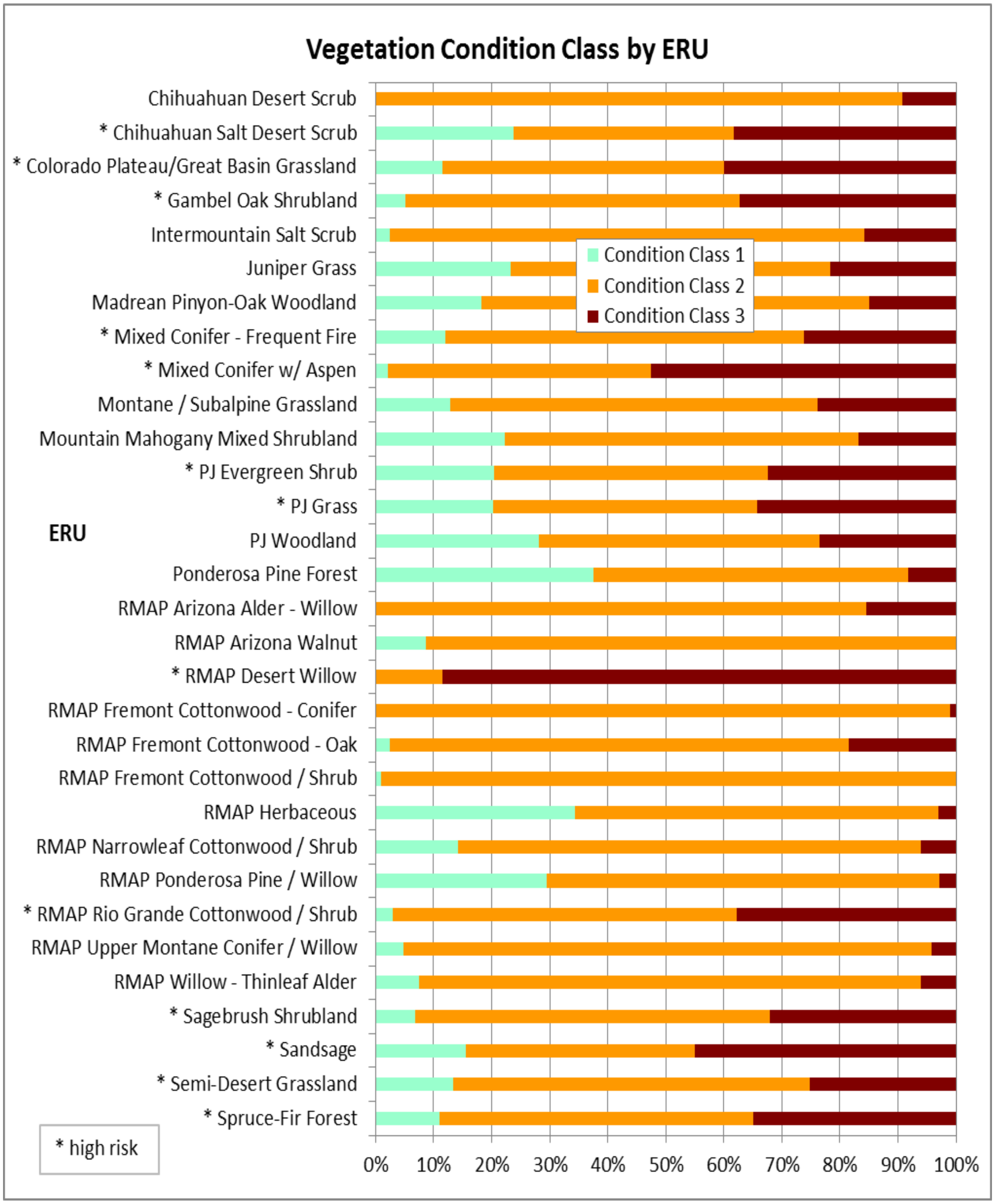


Figure 22. Vegetation condition class by ERU (% of ERU area) for the Cibola.
http://www.landfire.gov/

Table 9. Percentage of ERU area with VCC of 2 or 3 at context, plan (Cibola), and local (Geographic Area [GA]) scales. An ERU with at least 25% of its area with VCC of 2 or 3 is considered at risk. Values in parentheses denote GA representation (total ERU area in GA [regardless of risk] as percentage of Cibola ERU area). Colored cells call attention to GA-specific ERUs of particular concern based on combination of risk and representation.

LEGEND	>75% at risk and >75% of Cibola ERU area	>50% at risk and >50% of Cibola ERU area	ERU not present

			Geographic Area*								
ERU	Context	Cibola	Mt	Zu	Br	Dt	Mg	Sm	Ga	Mz	Sd
Chihuahuan Desert Scrub	95	100						100 (100)			
Chihuahuan Salt Desert Scrub	91	76			76 (100)						
Colorado Plateau / Great Basin Grassland	81	89	83 (49)		89 (<1)	98 (34)			83 (13)	100 (<1)	94 (3)
Gambel Oak Shrubland	90	95	93 (13)			98 (6)	92 (15)	95 (32)		99 (11)	94 (23)
Intermountain Salt Scrub	88	98	98 (100)								
Juniper Grass	79	76		97 (6)	69 (53)	100 (<1)	80 (<1)	84 (11)	57 (12)	100 (13)	98 (4)
Madrean Pinyon-Oak Woodland	73	82			72 (7)		57 (15)	81 (45)		91 (11)	99 (22)
Mixed Conifer - Frequent Fire	71	88	85 (6)	46 (13)		97 (6)	96 (14)	97 (40)	50 (3)	93 (12)	98 (7)
Mixed Conifer w/ Aspen	92	98					100 (<1)	98 (53)		96 (23)	99 (24)
Montane / Subalpine Grassland	82	87	96 (31)	74 (42)		97 (18)	84 (1)			95 (2)	
Mountain Mahogany Mixed Shrubland	67	78					83 (10)	65 (53)		95 (29)	95 (7)
PJ Evergreen Shrub	48	80			40 (5)		93 (6)	81 (62)	81 (27)		
PJ Grass	73	80	65 (11)	66 (6)	83 (24)	95 (5)	70 (11)	84 (22)	87 (15)	96 (3)	80 (3)
PJ Woodland	76	72	48 (15)	67 (16)		72 (29)	67 (1)	72 (16)	95 (4)	93 (5)	89 (13)
Ponderosa Pine Forest	59	63	85 (13)	37 (49)	80 (2)	89 (8)	89 (2)	91 (14)	55 (3)	92 (7)	89 (2)
RMAP Arizona Alder – Willow	78	100					100 (<1)			100 (99)	
RMAP Arizona Walnut	86	91						91 (100)			
RMAP Desert Willow	72	100								100 (100)	
RMAP Fremont Cottonwood – Conifer	100	100					100 (100)				
RMAP Fremont Cottonwood – Oak	86	98						98 (100)			
RMAP Fremont Cottonwood / Shrub	84	99						99 (100)			
RMAP Herbaceous	77	66	96 (9)	63 (91)						100 (<1)	100 (<1)
RMAP Narrowleaf Cottonwood / Shrub	80	86	98 (1)	84 (<1)			100 (6)	85 (84)		83 (3)	94 (5)
RMAP Ponderosa Pine / Willow	79	70	99 (28)	98 (3)			22 (12)	16 (16)	100 (2)	88 (33)	95 (4)
RMAP Rio Grande Cottonwood / Shrub	97	97	89 (<1)	84 (3)	69 (3)	99 (81)					95 (13)
RMAP Upper Montane Conifer / Willow	91	95	100 (4)					96 (62)		92 (34)	
RMAP Willow - Thinleaf Alder	90	93	96 (25)	85 (16)						92 (39)	97 (18)
Sagebrush Shrubland	91	93		93 (100)	100 (<1)						
Sandsage	76	84	36 (24)						100 (76)		
Semi-Desert Grassland	80	87			57 (12)		70 (7)	92 (70)	61 (<1)	99 (4)	97 (6)
Spruce-Fir Forest	95	89	89 (82)	61 (2)			98 (5)				91 (11)
Overall risk (acres at risk/total acres)	75	76	75	47	75	83	80	88	77	94	92

*Geographic Area abbreviations: Mt (Mt Taylor), Zu (Zuni Mtns), Br (Bear Mtns), Dt (Datil Mtns), Mg (Magdalena Mtns), Sm (San Mateo Mtns), Ga (Gallinas Mtns), Mz (Manzano Mtns), Sd (Sandia Mtns).

Vegetation Condition Class (VCC) — Trend. Vegetation Condition Class ratings from 2001 and 2008 were analyzed to estimate trend in vegetation structure. While this spans the oldest and newest comparable data sets, this is a short time period from an ecological perspective. Hence, this trend analysis is more sensitive to changes that take place quickly like vegetation reductions (lower VCC) from wildfire and silvicultural treatment (thinning and prescribed burning) than to changes that occur gradually over long periods of time like increases (higher VCC) in vegetation (tree growth).

Change in overall acreage at risk was less than 1% at the context, plan (Cibola), and local (GA) scales, except for the Gallinas Mtns and Manzano Mtns GAs where risk decreased by 8.3% and 3.5%, respectively (Table 10). At the context and plan scales, the largest change in acreage at risk for any individual ERU was 1.72% and 6.66%, respectively. Trend by ERU was more pronounced at the local scale.

To help explain trend at the local scale, wildfire and silviculture data (available by ranger district but not GA) from 2001–2008 were analyzed. The most notable changes at the local scale were risk declines in the Gallinas Mtns GA of about 42% and 38% for the Mixed Conifer-Frequent Fire and Ponderosa Pine Forest ERUs, respectively. These same two ERUs also declined in risk by about 5% and 7%, respectively, in the Manzano Mtns GA. The Mountainair ranger district comprises the Gallinas Mtns and Manzano Mtns GAs, which were the only two GAs with noticeable overall change in VCC—this change is likely due to the high concentration of silvicultural activity in the Mixed Conifer-Frequent Fire and Ponderosa Pine Forest ERUs and wildfire on that ranger district (Figure 23). Other noticeable changes occurred in riparian ERUs, where all but the Ponderosa Pine/Willow ERU increased in risk. (Changes in riparian ERUs have little influence on overall trends because of their small acreages.) These risk increases may be related to structural conditions that resulted in a generally poor watershed condition indicator for fire regime (see Figure 43 in Chapter 4-Water Resources).

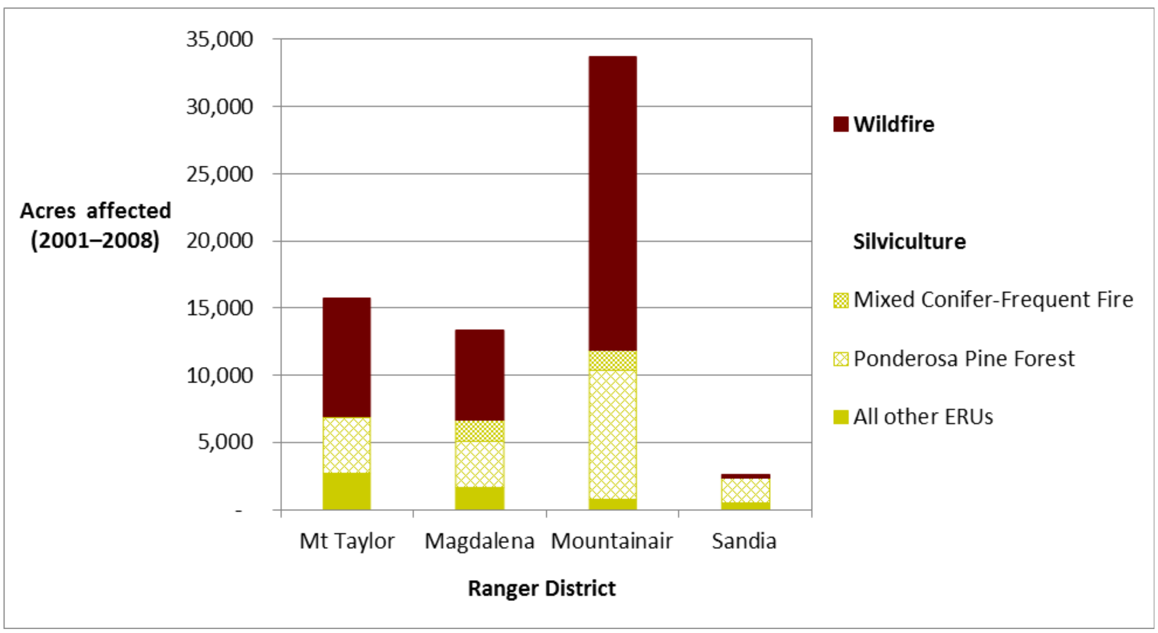


Figure 23. Acres affected by wildfire and silviculture on the Cibola from 2001–2008. Silviculture data from Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola). Wildfire data from https://fam.nwcg.gov/fam-web/

Table 10. Trend in vegetation structure from 2001–2008 at context, plan (Cibola), and local (Geographic Area) scales. Values represent percent change in ERU acreage at risk (Vegetation Condition Class = 2 or 3).

LEGEND	Decreased risk (negative value)	No change (*change of less than 1%)	Increased risk (positive value)	ERU not present

ERU	Context	Cibola	Geographic Area[†]								
			Mt	Zu	Br	Dt	Mg	Sm	Ga	Mz	Sd
Chihuahuan Desert Scrub	*	*						*			
Chihuahuan Salt Desert Scrub	*	*			*						
Colorado Plateau / Great Basin Grassland	*	*	*	-1.14	2.93	*			*	*	*
Gambel Oak Shrubland	*	*	*			*	*	*		*	*
Intermountain Salt Scrub	*	*	*								
Juniper Grass	*	*		*	*	*	*	*	*	*	*
Madrean Pinyon-Oak Woodland	*	*			*		*	*		*	*
Mixed Conifer - Frequent Fire	-1.39	-1.74	*	*		*	*	*	-41.79	-4.89	*
Mixed Conifer w/ Aspen	-1.47	*					*	*		-1.73	*
Montane / Subalpine Grassland	1.72	*	*	*		*	*			-1.66	
Mountain Mahogany Mixed Shrubland	-1.60	*					*	*		*	*
PJ Evergreen Shrub	*	-2.02			*		*	*	-7.37		
PJ Grass	*	*	*	*	*	*	*	*	*	-4.33	*
PJ Woodland	*	*	*	*		*	*	*	-3.82	-1.12	*
Ponderosa Pine Forest	-1.20	-1.57	*	*	*	*	*	*	-38.15	-7.27	*
RMAP Arizona Alder – Willow	-1.41	*					*			*	
RMAP Arizona Walnut	*	6.66						6.66			
RMAP Desert Willow	*	*								*	
RMAP Fremont Cottonwood – Conifer	*	*					*				
RMAP Fremont Cottonwood – Oak	*	1.43						1.43			
RMAP Fremont Cottonwood / Shrub	*	*						*			
RMAP Herbaceous	*	*	*	*						*	*
RMAP Narrowleaf Cottonwood / Shrub	*	*	1.17	15.16			*	*		1.63	*
RMAP Ponderosa Pine / Willow	*	-4.49	*	3.80			-8.91	-1.24	*	-10.28	1.05
RMAP Rio Grande Cottonwood / Shrub	*	*	13.71	*	3.70	*					*
RMAP Upper Montane Conifer / Willow	*	4.12	*					2.64		8.37	
RMAP Willow - Thinleaf Alder	*	*	*	4.49						-1.50	*
Sagebrush Shrubland	*	*		*	*						
Sandsage	*	*	*						*		
Semi-Desert Grassland	*	*			*		*	*	*	*	*
Spruce-Fir Forest	*	*	*	*			*				*
Overall trend (change in acres at risk/total acres)	*	*	*	*	*	*	*	*	-8.3	-3.5	*

[†]Geographic Area abbreviations: Mt (Mt Taylor), Zu (Zuni Mtns), Br (Bear Mtns), Dt (Datil Mtns), Mg (Magdalena Mtns), Sm (San Mateo Mtns), Ga (Gallinas Mtns), Mz (Manzano Mtns), Sd (Sandia Mtns).

Understory Structure

While the tree overstory tends to be the dominant characteristic of overall stand structure of forests and woodlands, understory structure is an especially important characteristic of shrublands and grasslands. Litter cover and plant basal cover (TEUI data) were used in this assessment to indicate departure of understory structure from reference conditions.[18] While understory structure is not departed for forest or woodland ERUs, most grassland and shrubland ERUs are either moderately or highly departed (Table 11).

Table 11. Departure rating (%) and departure category (shading) for understory structure of Cibola ERUs.

LEGEND	High departure	Moderate departure	Low departure

ERU	System Type	Departure
Chihuahuan Desert Scrub	Shrubland	0
Chihuahuan Salt Desert Scrub	Shrubland	100
Colorado Plateau / Great Basin Grassland	Grassland	34
Gambel Oak Shrubland	Shrubland	38
Intermountain Salt Scrub	Shrubland	98
Juniper Grass	Woodland	17
Madrean Pinyon-Oak Woodland	Woodland	11
Mixed Conifer - Frequent Fire	Forest	8
Mixed Conifer w/ Aspen	Forest	10
Montane / Subalpine Grassland	Grassland	48
Mountain Mahogany Mixed Shrubland	Shrubland	28
PJ Evergreen Shrub	Woodland	32
PJ Grass	Woodland	17
PJ Woodland	Woodland	29
Ponderosa Pine Forest	Forest	29
Sagebrush Shrubland	Shrubland	93
Sandsage	Shrubland	0
Semi-Desert Grassland	Grassland	17
Spruce-Fir Forest	Forest	21

[18] For grassland and shrubland ERUs with unassessed (USFS) overall structure. Data unavailable for riparian ERUs.

Species Composition

The understory species composition of grassland and shrubland ERUs is used to determine seral condition (USFS TESH 1986) and is used in this assessment to indicate current species composition (TEUI data) departure from reference condition[19] (Table 12). About half of the ERUs assessed (Colorado Plateau/Great Basin Grassland, Intermountain Salt Scrub, Montane/Subalpine Grassland, Riparian,[20] Sagebrush Shrubland) are moderately or highly departed and considered to be at risk.

Table 12. Seral condition for grassland and shrubland ERUs on the Cibola.

ERU	Climax category	Seral Condition	ERU acres on Cibola	% of ERU	Total in low departure	Total in moderate–high departure
Chihuahuan Desert Scrub	Primary-Edaphic	Reference	595	100		
			595		**100%**	**0%**
Colorado Plateau/Great Basin Grassland	Disclimax-Topo-Edaphic-Zootic	Departed	23,417	89		
	Primary-Edaphic	Reference	2,813	11		
			26,230		**11%**	**89%**
Chihuahuan Salt Desert Scrub	Primary-Topo-edaphic	Reference	3,726	100		
			3,726		**100%**	**0%**
Gambel Oak Shrubland	Disclimax-Edaphic-Fire	Reference	463	1		
	Disclimax-Topo-Edaphic-Fire	Reference	46,653	99		
			47,115		**100%**	**0%**
Intermountain Salt Scrub	Disclimax-Topo-Edaphic-Zootic	Departed	3,702	100		
			3,702		**0%**	**100%**
Mountain Mahogany Mixed Shrubland	Disclimax-Topo-Edaphic-Fire	Reference	11,716	64		
	Primary-Edaphic	Reference	6,584	36		
			18,300		**100%**	**0%**
Montane / Subalpine Grassland	Disclimax-Edaphic-Fire	Reference	927	1		
	Disclimax-Topo-Edaphic-Fire	Reference	2,587	4		
	Disclimax-Topo-Edaphic-Zootic	Departed	65,670	95		
			69,184		**5%**	**95%**
Riparian	Disclimax-Topo-Edaphic-Zootic	Departed	3,082	64		
	Primary-Topo-edaphic	Reference	1,741	36		
			4,823		**36%**	**64%**
Sagebrush Shrubland	Disclimax-Topo-Edaphic-Zootic	Departed	5,544	100		
			5,544		**0%**	**100%**
Sandsage	Primary-Edaphic	Reference	5,100	100		
			5,100		**100%**	**0%**
Semi-Desert Grassland	Disclimax-Edaphic-Zootic	Departed	19,689	16		
	Disclimax-Topo-Edaphic-Zootic	Departed	21,272	17		
	Primary-Edaphic	Reference	64,498	51		
	Primary-Topo-edaphic	Reference	21,018	17		
			126,477		**68%**	**32%**

[19] Not appropriate indicator of species composition for tree-dominated ERUs (woodlands and forests).
[20] Riparian ERUs were grouped to increase sample size.

Patch Size

A “patch” is a contiguous area of the same system type in the same structural state. Patch size plays a significant role in wildfire behavior. As previously mentioned, historical timber harvest and fire suppression are largely responsible for decreased fire frequency, increased fire severity, and an increase in closed canopies across Rocky Mountain forests (Schoennagel et al. 2004). These changes, where combined with uncharacteristically large patches of contiguous tree canopies, set the stage for insect and disease outbreaks and uncharacteristically large, severe wildfires.

Patch size is also an important element of wildlife habitat. Each wildlife species has its own patch size preference, and these preferences vary by species. For these reasons, and also for reasons of wildfire behavior, current landscape distribution of patches should resemble the distribution under reference conditions—the conditions to which wildlife species adapted—so as to best accommodate the varying preferences of all wildlife species and simultaneously mimic historic fire behavior.

All major[21] Cibola ERUs were analyzed for mean patch size.[22] All Cibola forest and woodland types are currently highly departed from reference conditions because of uncharacteristically large patch size and are considered to be at high risk (Table 13). In contrast, all grassland and most shrubland system types are highly departed because of small patch size and considered to be at high risk (Gambel Oak Shrubland and Sandsage ERUs are at moderate risk).

The same phenomena responsible increasing patch size of forests and woodlands (removal of fine fuels, fire suppression) are responsible for decreasing patch size of shrublands and grasslands due to tree encroachment. Under historic fire regimes, trees establishing in a shrubland or grassland would have been periodically killed by wildfire, maintaining these historically treeless system types.

[21] Patch size analysis procedure precludes analysis of riparian ERUs because of their limited spatial extent.
[22] Reference condtions from Wahlberg et al. 2013a (including reference conditions for structure based on LANDFIRE 2010 and TNC 2006). Current conditions from Regional Corporate Spatial Database: gdb04a_r03_default_(Region).

Table 13. Mean patch size of Cibola ERUs. Arrows indicate if patch size increased (↑) or decreased (↓) since the reference period.

LEGEND*	Low departure	Moderate departure	High departure

ERU	System Type	Average Patch Size (acres)	
		Reference	Current
Mixed Conifer with Aspen	Forest	150	5,560 ↑
Mixed Conifer–Frequent Fire	Forest	0.6	2,017 ↑
Ponderosa Pine Forest	Forest	0.3	4,062 ↑
Spruce-Fir Forest	Forest	300	38,541 ↑
Juniper Grass	Woodland	0.3	440 ↑
Madrean Pinyon-Oak Woodland	Woodland	5	697 ↑
PJ Evergreen Shrub	Woodland	5	552 ↑
PJ Grass	Woodland	0.6	181 ↑
PJ Woodland	Woodland	100	212 ↑
Chihuahuan Desert Scrub	Shrubland	38,810	30 ↓
Chihuahuan Salt Desert Scrub	Shrubland	124	40 ↓
Gambel Oak Shrubland	Shrubland	144	223 ↑
Intermountain Salt Scrub	Shrubland	308	50 ↓
Mountain Mahogany Mixed Shrubland	Shrubland	167	388 ↑
Sagebrush Shrubland	Shrubland	277	28 ↓
Sandsage	Shrubland	134	47 ↓
Colorado Plateau/Great Basin Grassland	Grassland	12,664	485 ↓
Montane/Subalpine Grassland	Grassland	16,614	246 ↓
Semi-Desert Grassland	Grassland	837,674	14,823 ↓

*Low departure = <33.3% of mean reference conditions; Moderate departure = 33.3–66.6% of mean reference conditions; High departure = >66.6% from mean reference conditions.

Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Snags and Coarse Woody Material

Snags (standing dead trees) and coarse woody material (downed wood) serve important ecological functions. Both provide wildlife habitat and contribute to the formation of soil organic matter. Coarse woody material (CWM) also helps to reduce soil erosion by shielding the soil surface from raindrop impact and interrupting rill and sheet erosion. The boxes below summarize reference[23] and current conditions[24] for snags and CWM[25] for all forest and woodland ERUs. The upper portion of each box compares current conditions to reference conditions for each seral stage *independent of seral stage proportion*—useful when considering seral-stage-specific habitat requirements of wildlife species. The lower portion of each box is *weighted by seral stage proportion* for an ERU-wide summary relevant to plan-scale analysis (general wildlife habitat requirements, soil condition). Because this analysis is primarily concerned with the benefits of CWM and snags to wildlife and soil health, amounts in excess of reference condition are not considered to be in departure.

Spruce-Fir Forest

By Seral Stage

Seral Stage Proportions	Early	Mid	Late
Reference Conditions	21%	33%	46%
Current Conditions	49%	50%	1%
CWM (tons/acre)			
Reference Conditions	20	34	54
Current Conditions	40	50	75
Departure*	201%	147%	139%
Departure class†	low	low	low

By ERU (weighted by seral stage proportion)

	CWM (tons/acre)				Snags per acre (total)	
	Early	Mid	Late	Total	≥8 in. DBH	≥18 in. DBH
Reference Conditions	4	11	25	40	28	11
Current Conditions	20	25	1	46	31	5
Departure*‡	465%	223%	4%	338%	110%	47%
Departure class†	low	low	high	low	low	moderate

* Current as % of Reference. Value of 100% = no departure.

† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).

‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

[23] Reference conditions for Arizona and New Mexico; based on Weisz et al. (2011) unless noted otherwise.
[24] Current Southwestern Region-wide FIA data modeled in FVS.
[25] Values rounded to nearest integer or significant digit.

Mixed Conifer with Aspen

By Seral Stage						
Seral Stage Proportions	**Early**	**Mid**	**Late**			
Reference Conditions	1%	50%	49%			
Current Conditions	6%	94%	0%			
CWM (tons/acre)						
Reference Conditions	9	32	38			
Current Conditions	11	53	*			
Departure**	119%	165%	*			
Departure class†	low	low	*			
By ERU (weighted by seral stage proportion)						
	CWM (tons/acre)				**Snags per acre (total)**	
	Early	**Mid**	**Late**	**Total**	**≥8 in. DBH**	**≥18 in. DBH**
Reference Conditions	0.1	16	19	17	14	4
Current Conditions	1	49	0	50	22	7
Departure**‡	768%	309%	0%	338%	155%	178%
Departure class†	low	low	high	low	low	Low

* No Current late seral. Departure calculation does not apply here; does apply below (weighted by seral stage proportion).
** Current as % of Reference. Value of 100% = no departure.
† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).
‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Mixed Conifer–Frequent Fire

By Seral Stage						
Seral Stage Proportions	**Early**	**Mid**	**Late**			
Reference Conditions	20%	15%	65%			
Current Conditions	9%	59%	32%			
CWM (tons/acre)						
Reference Conditions	2	12	20			
Current Conditions	8	27	37			
Departure*	418%	226%	183%			
Departure class†	low	low	low			
By ERU (weighted by seral stage proportion)						
	CWM (tons/acre)				**Snags per acre (total)**	
	Early	**Mid**	**Late**	**Total**	**≥8 in. DBH**	**≥18 in. DBH**
Reference Conditions	0.4	1.8	13.0	8.8	9	4
Current Conditions	0.7	16.1	11.8	28.6	19	3
Departure*‡	180%	892%	91%	573%	208%	85%
Departure class†	low	low	low	low	low	low

* Current as % of Reference. Value of 100% = no departure.
† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).
‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Ponderosa Pine Forest

By Seral Stage

Seral Stage Proportions	Early	Mid	Late
Reference Conditions	0%	0%	100%
Current Conditions	62%	38%	0.08%
CWM (tons/acre)			
Reference Conditions	*	*	9
Current Conditions	7	10	18
Departure**	*	*	197%
Departure class†	*	*	low

By ERU (weighted by seral stage proportion)

	CWM (tons/acre)				Snags per acre (total)	
	Early	Mid	Late	Total	≥8 in. DBH	≥18 in. DBH
Reference Conditions	0	0	9.0	9.0	0.65	0.65
Current Conditions	4.4	3.7	0.01	8.1	7	1
Departure*‡	∞	∞	0.2%	∞	1032%	132%
Departure class†	low	low	high	low	low	low

* All Reference characterized by large trees; hence, no purely early and mid-seral for comparison.
** Current as % of Reference. Value of 100% = no departure.
† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).
‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Note: For Reference Conditions, CWM value of 9 is the midpoint of the range of standard deviation (5-13 tons/acre) reported by Sánchez-Meador et al. (2008). Snag density value of 0.65 is the midpoint of the range (0.2-1.1 snags/acre) from Graham et al. (1994) and does not represent NRV, rather it reflects calculations by the authors for maximizing ecological sustainability.

PJ Evergreen Shrub

By Seral Stage

Seral Stage Proportions	Early	Mid	Late
Reference Conditions	5%	55%	40%
Current Conditions	34%	55%	11%
CWM (tons/acre)			
Reference Conditions	4	2	3
Current Conditions	1	6	7
Departure*	21%	282%	247%
Departure class†	high	low	low

By ERU (weighted by seral stage proportion)

	CWM (tons/acre)				Snags per acre (total)	
	Early	Mid	Late	Total	≥8 in. DBH	≥18 in. DBH
Reference Conditions	0.2	1.1	1.2	1.1	3	1
Current Conditions	0.3	3.1	0.8	4.2	5	1
Departure*‡	140%	284%	68%	212%	153%	124%
Departure class†	low	low	low	low	low	low

* Current as % of Reference. Value of 100% = no departure.
† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).
‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

PJ Woodland

By Seral Stage

Seral Stage Proportions	Early	Mid	Late
Reference Conditions	10%	20%	70%
Current Conditions	24%	61%	15%
CWM (tons/acre)			
Reference Conditions	2	2	5
Current Conditions	3	6	9
Departure*	152%	290%	183%
Departure class†	low	low	low

By ERU (weighted by seral stage proportion)

	CWM (tons/acre)				Snags per acre (total)	
	Early	Mid	Late	Total	≥8 in. DBH	≥18 in. DBH
Reference Conditions	0.2	0.4	3.5	2.6	2	1
Current Conditions	0.7	3.6	1.3	5.6	7	2
Departure*‡	361%	891%	38%	640%	330%	168%
Departure class†	low	low	moderate	low	low	low

* Current as % of Reference. Value of 100% = no departure.

† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).

‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

PJ Grass

By Seral Stage

Seral Stage Proportions	Early	Mid	Late
Reference Conditions	5%	35%	60%
Current Conditions	30%	60%	10%
CWM (tons/acre)			
Reference Conditions	1	2	5
Current Conditions	0.4	4	9
Departure*	35%	191%	187%
Departure class†	moderate	low	low

By ERU (weighted by seral stage proportion)

	CWM (tons/acre)				Snags per acre (total)	
	Early	Mid	Late	Total	≥8 in. DBH	≥18 in. DBH
Reference Conditions	0.1	0.7	3.0	2.0	5	1
Current Conditions	0.1	2.3	0.9	3.3	4	0.5
Departure*‡	211%	327%	31%	262%	83%	50%
Departure class†	low	low	high	low	low	moderate

* Current as % of Reference. Value of 100% = no departure.

† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).

‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Juniper Grass

By Seral Stage			
Seral Stage Proportions	**Early**	**Mid**	**Late**
Reference Conditions	5%	35%	60%
Current Conditions	32%	32%	36%
CWM (tons/acre)			
Reference Conditions	3	3	3
Current Conditions	2	6	6
Departure*	79%	188%	206%
Departure class†	low	low	low

By ERU (weighted by seral stage proportion)						
	CWM (tons/acre)				Snags per acre (total)	
	Early	**Mid**	**Late**	**Total**	**≥8 in. DBH**	**≥18 in. DBH**
Reference Conditions	0.2	1.1	1.8	1.5	3	1
Current Conditions	0.8	1.8	2.2	4.8	4	1
Departure*‡	505%	170%	125%	261%	120%	72%
Departure class†	low	low	low	low	low	low

* Current as % of Reference. Value of 100% = no departure.

† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).

‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Madrean Pinyon-Oak

By Seral Stage			
Seral Stage Proportions	**Early**	**Mid**	**Late**
Reference Conditions	4%	32%	64%
Current Conditions	61%	34%	4%
CWM (tons/acre)			
Reference Conditions	2	2	3
Current Conditions	1	7	13
Departure*	62%	326%	439%
Departure class†	moderate	low	low

By ERU (weighted by seral stage proportion)						
	CWM (tons/acre)				Snags per acre (total)	
	Early	**Mid**	**Late**	**Total**	**≥8 in. DBH**	**≥18 in. DBH**
Reference Conditions	0.1	0.6	1.9	1.4	4	1
Current Conditions	0.8	2.2	0.6	3.6	3	0.5
Departure*‡	948%	351%	30%	702%	70%	46%
Departure class†	low	low	high	low	low	moderate

* Current as % of Reference. Value of 100% = no departure.

† Difference between Current and Reference (Reference=100%): Low (>66.6%), Moderate (33.3–66.6%), High (<33.3%).

‡ Total departure is weighted by Current seral stage proportion for both CWM and snags.

Fire Regime

Cibola Wildfire History. From 1970–2012, there were 4,245 wildfires that burned 115,494 acres within the Cibola fire protection area (Figure 24). (The fire protection area includes all land within one mile of the forest administrative boundary.) Except for the heavily visited Sandia ranger district, most wildfires within the Cibola fire protection area have been ignited by lightning (Figure 25).

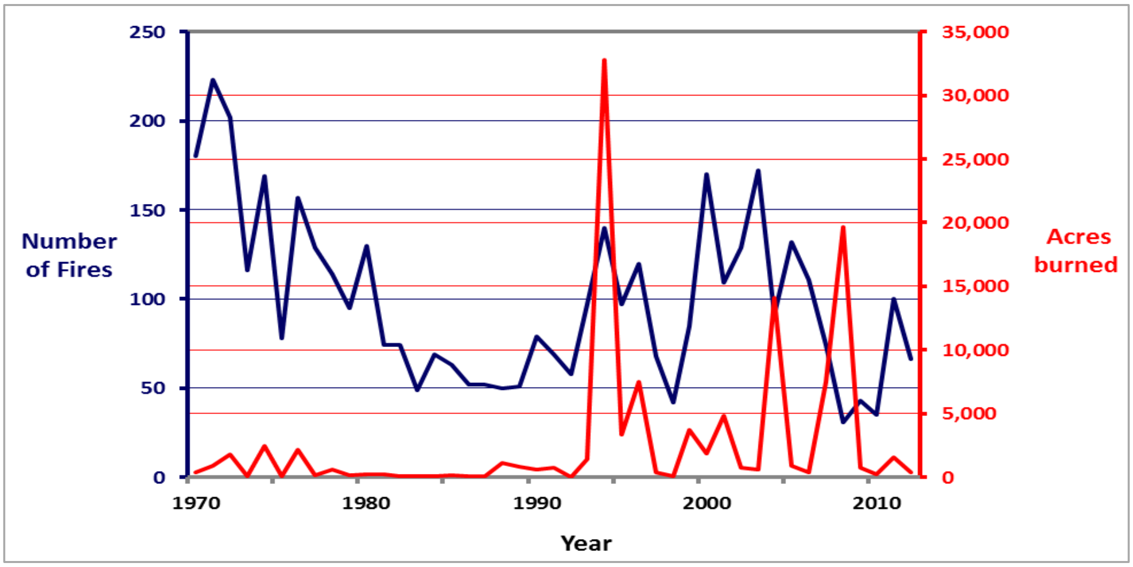


Figure 24. Wildfire occurrence within the Cibola fire protection area from 1970–2012. (FAMWEB 2013)

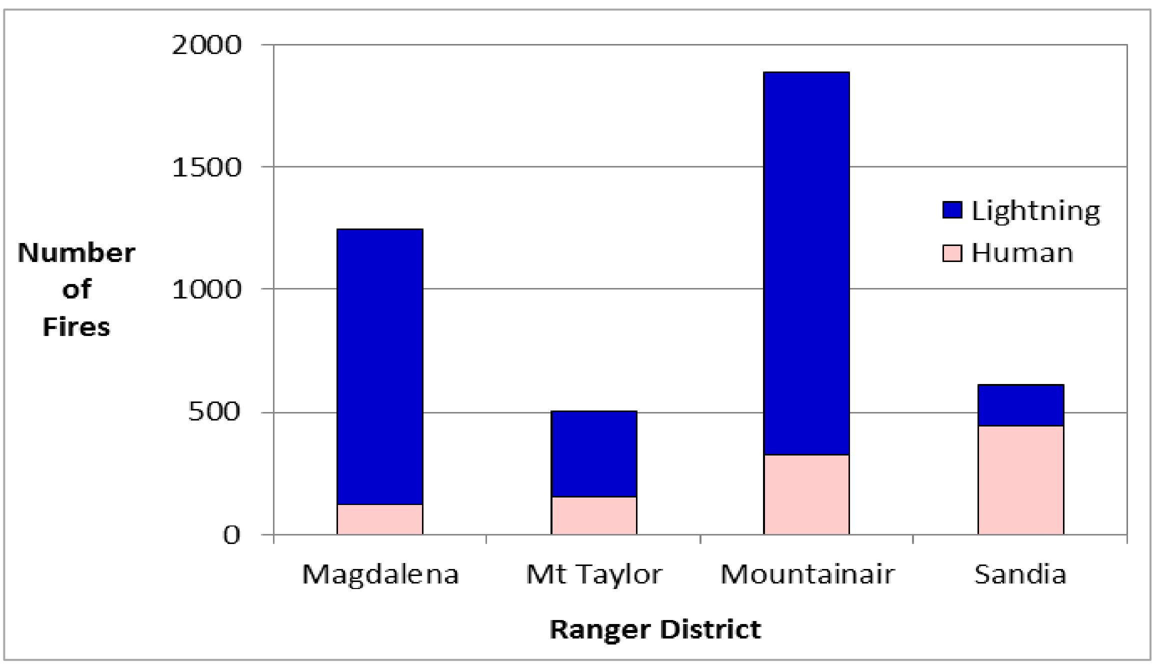


Figure 25. Ignition source of wildfires within the Cibola fire protection area from 1970–2012. (FAMWEB 2013)

Cibola Fire Regimes. Fire regime comprises fire return interval and fire severity type. On the Cibola, fire return interval has increased dramatically for most ERUs, and in many cases, fire severity type has changed as well (Table 14). All ERUs (except for those not listed or with unknown fire history) are considered to be highly departed from reference conditions and at high risk except for Mixed Conifer with Aspen and PJ Evergreen Shrub which are considered to be moderately departed from reference conditions (overall fire return interval is similar to reference conditions, but severity class has shifted to mostly non-lethal) and at moderate risk.

Table 14. Fire return interval for Cibola ERUs.

		Fire Return Interval (years)*		
ERU	Severity class	Cibola (actual)	Reference (low)	Reference (high)
Chihuahuan Desert Scrub	Mixed Severity	Unknown		>200
Chihuahuan Salt Desert Scrub	Mixed Severity	Unknown	100	200
Colorado Plateau / Great Basin Grassland	Non-Lethal	6,298		
Colorado Plateau / Great Basin Grassland	Mixed Severity	73,613		
Colorado Plateau / Great Basin Grassland	Stand-Replacing		0	35
Colorado Plateau / Great Basin Grassland Total		5,801		
Gambel Oak Shrubland	Non-Lethal	414		
Gambel Oak Shrubland	Mixed Severity	3,646		
Gambel Oak Shrubland	Stand-Replacing	23,742	35	200
Gambel Oak Shrubland Total		366		
Intermountain Salt Scrub	Mixed Severity	Unknown	35	>200
Juniper Grass	Non-Lethal	147,515		
Juniper Grass Total		147,515	0	35
Mixed Conifer - Frequent Fire	Non-Lethal	169	9	22
Mixed Conifer - Frequent Fire	Mixed Severity	504		
Mixed Conifer - Frequent Fire	Stand-Replacing	856		
Mixed Conifer - Frequent Fire Total		110		
Mixed Conifer w/ Aspen	Non-Lethal	217		
Mixed Conifer w/ Aspen	Mixed Severity	354	50	100
Mixed Conifer w/ Aspen	Stand-Replacing	401		
Mixed Conifer w/ Aspen Total		101		
Mountain Mahogany Mixed Shrubland	Non-Lethal	759		
Mountain Mahogany Mixed Shrubland	Mixed Severity	10,093		
Mountain Mahogany Mixed Shrubland	Stand-Replacing	1,254,762	35	200
Mountain Mahogany Mixed Shrubland Total		705		
Madrean Pinyon-Oak Woodland	Mixed Severity		35	>200
Madrean Pinyon-Oak Woodland	Unknown	14,873		
Montane / Subalpine Grassland	Non-Lethal	7,037		
Montane / Subalpine Grassland	Mixed Severity	91,184		
Montane / Subalpine Grassland	Stand-Replacing	3,326,852	0	35
Montane / Subalpine Grassland Total		6,520		
PJ Evergreen Shrub	Non-Lethal	203		
PJ Evergreen Shrub	Mixed Severity	2,358	35	200

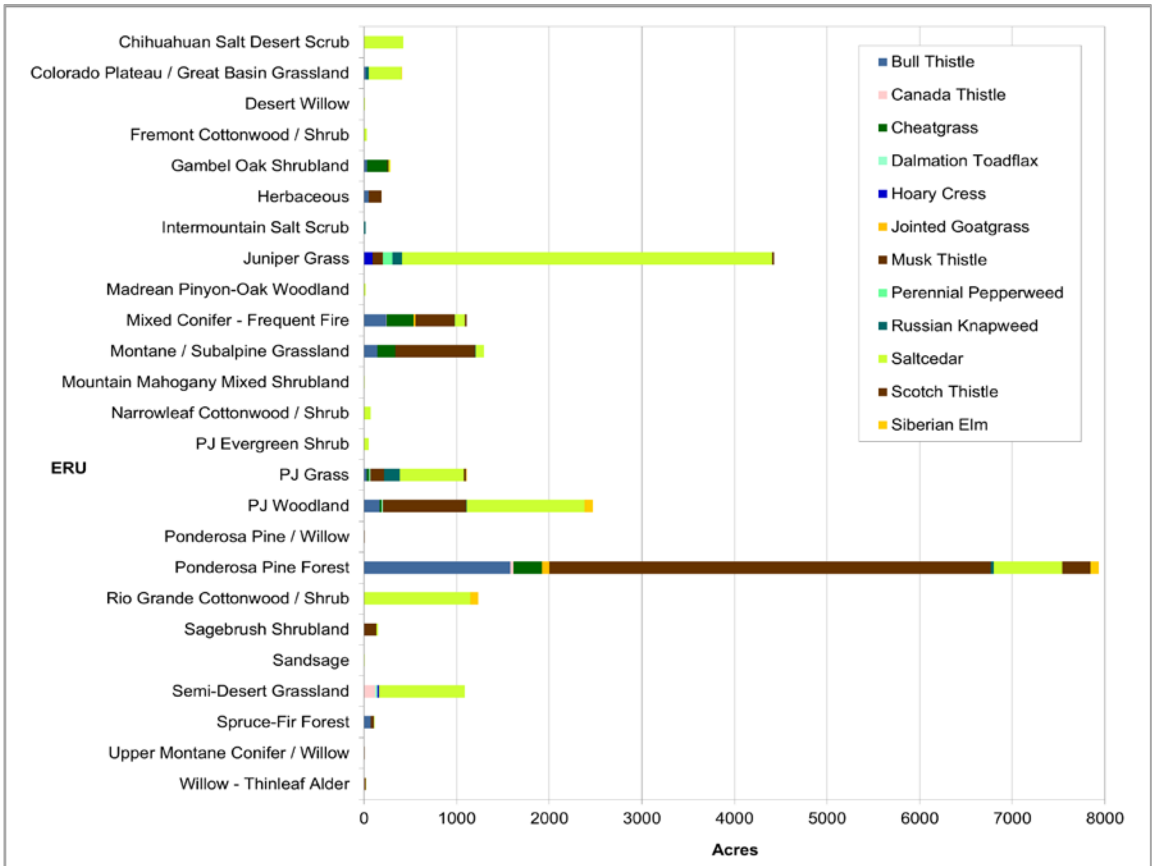
ERU	Severity class	Fire Return Interval (years)* Cibola (actual)	Reference (low)	Reference (high)
PJ Evergreen Shrub	Stand-Replacing	75,556		
PJ Evergreen Shrub Total		187		
PJ Grass	Non-Lethal	856	0	35
PJ Grass	Mixed Severity	8,852		
PJ Grass	Stand-Replacing	88,785		
PJ Grass Total		774		
PJ Woodland	Non-Lethal	3,585		
PJ Woodland	Mixed Severity	14,308		
PJ Woodland	Stand-Replacing	91,405	35	200
PJ Woodland Total		2,780		
Ponderosa Pine Forest	Non-Lethal	378	0	35
Ponderosa Pine Forest	Mixed Severity	1,743		
Ponderosa Pine Forest	Stand-Replacing	18,022		
Ponderosa Pine Forest Total		268		
Sagebrush Shrubland	Unknown	8,171		
Sagebrush Shrubland	Mixed Severity		35	>200
Semi-Desert Grassland	Non-Lethal	5,259		
Semi-Desert Grassland	Mixed Severity	12,003		
Semi-Desert Grassland	Stand-Replacing	570,569	0	35
Semi-Desert Grassland Total		3,634		
Spruce-Fir Forest	Non-Lethal	5,982		
Spruce-Fir Forest	Mixed Severity	30,957	100	200
Spruce-Fir Forest	Stand-Replacing	0	200	400
Spruce-Fir Forest Total		5,013		

* Cibola (actual) Fire Return Interval is the inverse of an ERU's proportional area that burned from 1984–2010 (annual average); data from Monitoring Trends in Burn Severity website <http://www.mtbs.gov>). Blank cells represent no fire occurrence. Reference conditions from LANDFIRE 2010 and TNC 2006 as adapted in Wahlberg et al. 2013a.

Invasive Plant Species

Invasive plant surveys were initiated on the forest in 1998 and have continued periodically, mostly conducted by range management specialists when they inspect range allotment conditions. Surveys have not been conducted systematically over the entire forest. Not all disturbed sites, such as burned areas or dispersed campsites, have been completely surveyed, so it is possible that some recent infestations have not been inventoried.

About 22,000 acres (about 1.4%) of the Cibola is infested with invasive plant species, almost half of which is saltcedar (Figure 26). Three ERUs on the Cibola are considered at risk from invasive species—all three are riparian ERUs infested with saltcedar. Two ERUs are at least 25% infested and considered at moderate risk: Desert Willow and Fremont Cottonwood/Shrub; Rio Grande Cottonwood/Shrub is over 50% infested and considered to be at high risk.



	Bull Thistle	Canada Thistle	Cheatgrass	Dalmation Toadflax	Hoary Cress	Jointed Goatgrass	Musk Thistle	Perennial Pepperweed	Russian Knapweed	Saltcedar	Scotch Thistle	Siberian Elm	Total	% of ERU
Chihuahuan Salt Desert Scrub							1			422			**422**	**14.2**
Colorado Plateau / Great Basin Grassland	21						2		26	354		1	**404**	**1.7**
Desert Willow										10			**10**	**29.2**
Fremont Cottonwood / Shrub										26			**26**	**48.5**
Gambel Oak Shrubland	31		220				15			12		5	**282**	**0.8**
Herbaceous	51						133				3		**187**	**7.3**
Intermountain Salt Scrub									12				**12**	**0.4**
Juniper Grass					88		111	106	105	4,000	18		**4,427**	**4.8**
Madrean Pinyon-Oak Woodland										16			**16**	**0.1**
Mixed Conifer - Frequent Fire	242	1	287			22	421		7	104	23		**1,107**	**0.7**
Montane / Subalpine Grassland	143		192				860		7	91			**1,294**	**3.1**
Mountain Mahogany Mixed Shrubland				0						7			**7**	**0.0**
Narrowleaf Cottonwood / Shrub										72			**72**	**5.5**
PJ Evergreen Shrub										51			**51**	**0.2**
PJ Grass	26		29	14			151		164	694	25	1	**1,104**	**0.4**
PJ Woodland	169		18	13			903		4	1,274		88	**2,468**	**0.9**
Ponderosa Pine / Willow							2						**2**	**0.5**
Ponderosa Pine Forest	1,578	34	310			80	4,764		31	740	302	91	**7,931**	**1.7**
Rio Grande Cottonwood / Shrub				3						1,142		84	**1,229**	**60.9**
Sagebrush Shrubland							135			17			**152**	**5.7**
Sandsage										1			**1**	**0.02**
Semi-Desert Grassland		118		26	17					925			**1,086**	**1.0**
Spruce-Fir Forest	71						36			0			**107**	**1.4**
Upper Montane Conifer / Willow							1						**1**	**0.4**
Willow - Thinleaf Alder	1	4					11			0			**17**	**2.4**
Total	**2,332**	**158**	**1,055**	**55**	**104**	**102**	**7,546**	**106**	**357**	**9,958**	**371**	**269**	**22,415**	**1.4**

Figure 26. Invasive species acreage by ERU on the Cibola. Blank cells represent no invasive species detected in surveys.

Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)

Climate [26]

The Climate Change Vulnerability Assessment (Triepke et al. 2014) was used to assess the potential vulnerability of Cibola ecosystems to climate change.

The Climate Change Vulnerability Assessment (CCVA) takes an ecosystems approach to predicting vulnerability resulting from projected climate change. This assessment provides a measure of vulnerability to anticipated climate change for each major Ecological Response Unit (ERU) in the plan area. (For more on ERUs, see Vegetation section in this volume.) Based on the anticipated effects by climate change on site potential, individual plant communities are assessed and scored as limited, moderate, high, and very high, according to the degree by which climate envelopes are exceeded with future climate projections.

Uncertainty reporting: Future climate projections based on different Global Circulation Models (GCMs) provide somewhat different values. As a result, there can be some uncertainty associated with a given vulnerability call for some ERUs in some areas. To address this concern, the CCVA provides a measure of uncertainty, which represents the degree of disagreement between different GCMs, within a given emission scenario.

The Cibola is projected to be more than 25% highly or very highly vulnerable to climate change overall and considered to be at high risk (Table 15; Figure 27) except for 6 ERU-specific[27] projections of moderate (≥25% moderately and <25% highly or very highly vulnerable) risk (Table 16): Juniper Grass, Mountain Mahogany Mixed Shrubland, Madrean Pinyon-Oak Woodland, PJ Evergreen Shrub, PJ Woodland, and Semi-Desert Grassland.

Table 15. Vulnerability to climate change for the Cibola (Triepke et al. 2014).

		Uncertainty Category			
	Vulnerability Category	**Low**	**Mod**	**High**	**Vulnerability Category Total**
Cibola National Forest – Plan Scale *FS ownership only*	Low	1%	5%	0%	**6%**
	Moderate	1%	30%	26%	**57%**
	High	5%	27%	0%	**32%**
	Very High	5%	0%	0%	**5%**
	Uncertainty Category Total	**12%**	**61%**	**27%**	

[26] Adapted from Trieple et al. 2014.

[27] To determine risk for ERUs that were analyzed by ERU subclass, the average vulnerability category total (weighted by ERU subclass acreage) of the respective subclasses was used.

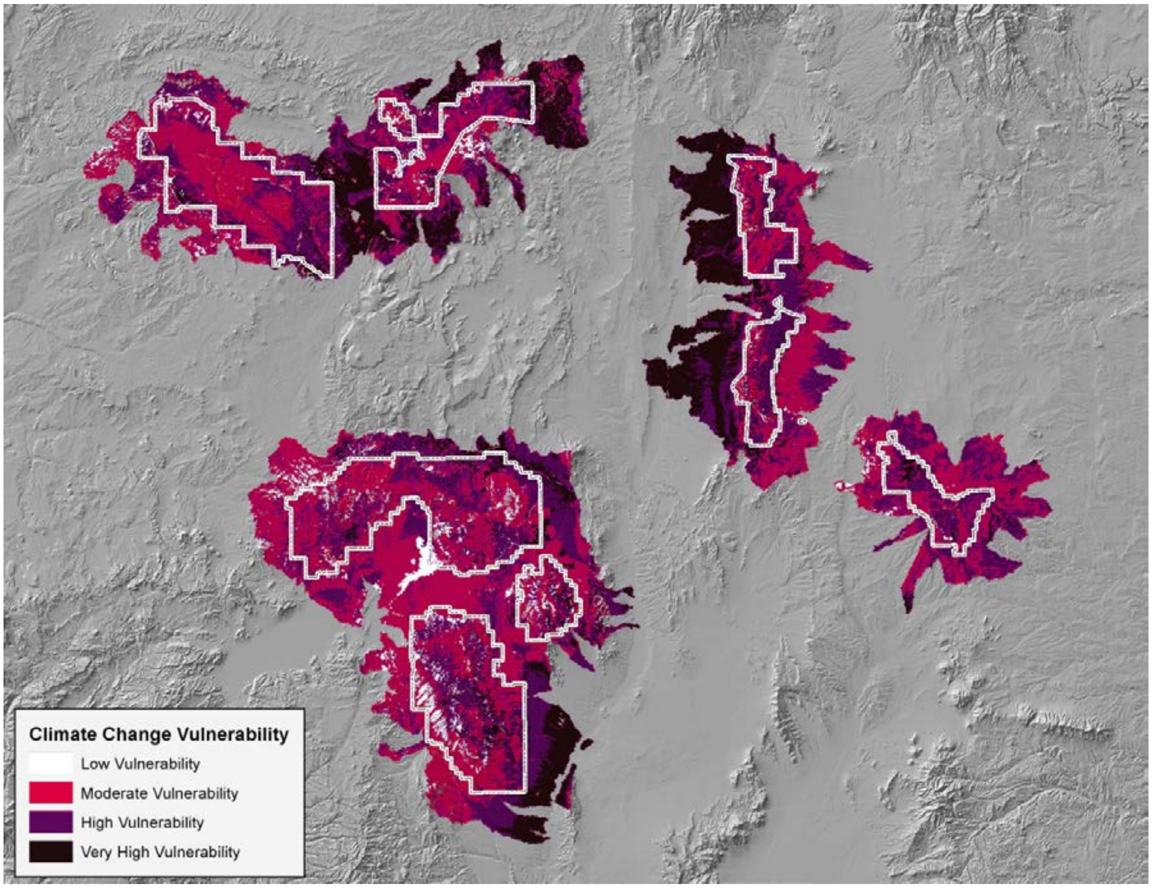


Figure 27. Vulnerability to climate change for the Cibola. (adapted from Triepke et al. 2014)

Table 16. Vulnerability to climate change for major ERUs of the Cibola (Triepke et al. 2014).

Ecological Response Unit	Vulnerability Category	Uncertainty Category			
		Low	Mod	High	Total
Colorado Plateau/ Great Basin Grassland	Low	0%	3%	0%	**3%**
	Moderate	0%	25%	25%	**50%**
	High	2%	40%	0%	**42%**
	Very High	5%	0%	0%	**5%**
	Total	**7%**	**68%**	**25%**	
Gambel Oak Shrubland	Low	0%	0%	0%	**0%**
	Moderate	1%	30%	14%	**44%**
	High	8%	30%	0%	**37%**
	Very High	18%	0%	0%	**18%**
	Total	**26%**	**60%**	**14%**	
Juniper Grass – Cold	Low	1%	0%	0%	**1%**
	Moderate	1%	48%	44%	**94%**
	High	0%	5%	0%	**5%**
	Very High	0%	0%	0%	**0%**
	Total	**2%**	**54%**	**44%**	

Ecological Response Unit	Vulnerability Category	Uncertainty Category			
		Low	Mod	High	Total
Juniper Grass – Mild	Low	0%	9%	0%	
	Moderate	0%	24%	40%	**64%**
	High	0%	25%	1%	**26%**
	Very High	1%	0%	0%	**1%**
	Total	**1%**	**58%**	**41%**	
Mixed Conifer – Frequent Fire	Low	0%	1%	0%	**2%**
	Moderate	0%	25%	23%	**48%**
	High	4%	41%	0%	**45%**
	Very High	5%	0%	0%	**5%**
	Total	**10%**	**67%**	**23%**	
Mixed Conifer with Aspen	Low	0%	0%	0%	**0%**
	Moderate	0%	24%	23%	**48%**
	High	8%	33%	0%	**41%**
	Very High	11%	0%	0%	**11%**
	Total	**19%**	**57%**	**23%**	
Mountain Mahogany Mixed Shrubland	Low	0%	15%	1%	**16%**
	Moderate	3%	52%	22%	**78%**
	High	0%	6%	1%	**7%**
	Very High	0%	0%	0%	**0%**
	Total	**3%**	**73%**	**24%**	
Madrean Pinyon-Oak Woodland	Low	0%	4%	1%	**5%**
	Moderate	8%	44%	30%	**82%**
	High	0%	10%	2%	**12%**
	Very High	0%	1%	0%	**1%**
	Total	**8%**	**59%**	**33%**	
Montane/Subalpine Grassland	Low	1%	5%	0%	**6%**
	Moderate	0%	22%	36%	**59%**
	High	0%	33%	0%	**34%**
	Very High	2%	0%	0%	**2%**
	Total	**3%**	**61%**	**36%**	
PJ Evergreen Shrub	Low	0%	19%	0%	**19%**
	Moderate	19%	62%	0%	**81%**
	High	0%	0%	0%	**0%**
	Very High	0%	0%	0%	**0%**
	Total	**19%**	**81%**	**0%**	

Ecological Response Unit	Vulnerability Category	Uncertainty Category Low	Mod	High	Total
PJ Grass–Cold	Low	0%	0%	0%	**0%**
	Moderate	0%	15%	24%	**38%**
	High	10%	40%	0%	**49%**
	Very High	12%	0%	0%	**12%**
	Total	**22%**	**55%**	**24%**	
PJ Grass–Mild	Low	0%	12%	1%	**13%**
	Moderate	0%	21%	37%	**58%**
	High	1%	24%	0%	**24%**
	Very High	5%	0%	0%	**5%**
	Total	**5%**	**57%**	**38%**	
PJ Woodland–Cold	Low	4%	7%	0%	**11%**
	Moderate	1%	54%	25%	**81%**
	High	0%	8%	0%	**9%**
	Very High	0%	0%	0%	**0%**
	Total	**6%**	**69%**	**25%**	
PJ Woodland–Mild	Low	0%	2%	1%	**3%**
	Moderate	1%	46%	31%	**77%**
	High	0%	15%	4%	**19%**
	Very High	0%	0%	0%	**0%**
	Total	**1%**	**64%**	**36%**	
Ponderosa Pine Forest	Low	0%	0%	0%	**0%**
	Moderate	0%	23%	21%	**43%**
	High	11%	38%	0%	**49%**
	Very High	8%	0%	0%	**8%**
	Total	**19%**	**61%**	**21%**	
Semi-Desert Grassland	Low	0%	14%	1%	**14%**
	Moderate	6%	35%	34%	**75%**
	High	0%	7%	3%	**11%**
	Very High	0%	0%	0%	**0%**
	Total	**6%**	**56%**	**38%**	
Spruce-Fir Forest	Low	0%	0%	0%	**0%**
	Moderate	0%	7%	2%	**9%**
	High	26%	27%	0%	**53%**
	Very High	38%	0%	0%	**38%**
	Total	**65%**	**34%**	**2%**	

Forest Insects and Disease[28]

Insects and diseases are integral components of forest and woodland ecosystems. Often there are numerous positive impacts of insects and disease on the forest ecosystem including creation of small openings, increasing biodiversity, enhancing nutrient cycling, as food sources for animals, creation of wildlife habitat, and many other ecologically significant benefits. However, under severe disease infection levels or episodic outbreaks of insects, their effects are more evident, sometimes negative, and cause greater forest change. With the exception of white pine blister rust, the insects and diseases on the Cibola that are often considered pests are native organisms that have long been part of the ecosystem and have evolved with their plant hosts. However, as patch size and stocking density have increased since reference conditions, so have the continuity and severity of infestations, and consequently, fire size and severity.

Forest and woodland distributions and characteristics are often viewed as static due to the difference in the human life span and the time scale of many ecological changes. Thus evaluation of ecological change or trends in insect and disease patterns depends upon the scale of the time period examined. Long-term paleoecological records provide insight into the presence, changes, and movements of vegetation communities over-long time scales. These records reveal that the communities observed today are not static; instead they are dynamically changing with the various influences upon them including climate changes, human impacts, and fire patterns. Human activities have affected and changed forest and woodland ecosystems through direct and indirect actions. In response to these altered environments, the extent and behavior of insects and diseases change. In turn, our view of the effects of insects and disease has also changed.

Beginning in the middle to late 1800s, particularly with the arrival of logging railroads, more widespread forest changes began. Grazing and later fire suppression efforts continued the change in forest and woodland structure. Today's pine and mixed conifer forests are at greater densities and therefore more susceptible to bark beetle outbreaks, as well as facilitating the spread of dwarf mistletoes. While mistletoe distribution has likely remained similar, harvest activities have probably decreased the abundance of large infected trees in many areas. Although, in some cases, past harvesting activities that left mistletoe-infected seed trees, likely increased infestation levels in many regenerating stands. Past harvesting preferences that reduced the pine component of mixed conifer stands have shifted forest composition to greater dominance by shade tolerant species favored by western spruce budworm, Douglas-fir tussock moth, and root disease. Outbreaks of western spruce budworm, in particular, are probably more extensive in the mixed conifer simply because of the greater abundance of host trees.

The relatively short length of most historical insect and disease records and their varying level of detail, however, often prevent quantitative identification of changes or trends in insect and disease activity from pre-settlement conditions to today. With the exception of unique paleoecological records, such as dendrochronological reconstructions, we are primarily restricted to records extending back to the middle or early portion of the 20th century, for our understanding of historical insect and disease activity. Thus, bark beetle activity in the open park-like stands of pre-settlement conditions typically cannot be directly compared to activity in a much denser stand today and likely occurred as isolated incidences. Instead, these types of evaluations are made by comparing contemporary insect and disease activity within stands of various conditions, including those similar to pre-settlement.

Overall, the available historical record shows no clear changes in insect or disease outbreak patterns on the Cibola. These records, however, are more recent and often concentrate on insect activity, particularly the larger events, such as bark beetle outbreaks. The bark beetle outbreaks on the Cibola have often been more climate induced and less influenced by specific stand conditions. While altered conditions may have

[28] Text, data, and map adapted from Ryerson 2013. Only forest and woodland types were assessed.

exacerbated the consequences of these events and led to greater mortality, it did not initiate the outbreaks. Thus evaluation of these records reveals more about the role of climate variability in triggering insect activity than changes in insect and disease activity resulting from altered forest and woodland structure.

Invasive insects and diseases pose new threats to forest and woodland ecosystems to which they are not adapted. The lack of adaptation by host species to invasive species can result in unprecedented changes. White pine blister rust is now established on the Cibola and expansion of the disease is expected over the next few decades. Blister rust will eventually impact several white pine populations on the Cibola. An introduced biological control tamarisk leaf beetle (Diorhabda spp.) has arrived in the region and has begun defoliating stands of the introduced invasive plant tamarisk. The lasting effect of this interaction is yet to be seen.

As has occurred in the past, changes in climate will affect forest and woodland communities. While climate models vary in their predictions, projections for New Mexico include continued increases in temperatures, warmer nighttime temperatures, and a longer frost-free period (summarized in ATWG 2005). The impact of climate change upon precipitation is less clear, however reduced snowpack levels and an increased potential for more extreme events, such as droughts, are predicted (ATWG 2005). Changes in climate are expected to considerably alter forest insect dynamics (numerous reviews available including Bale et al. 2002, Logan et al. 2003, Ryan et al. 2008).

Even in the presence of normal precipitation levels, warmer temperatures could increase the water stress of vegetation by stimulating higher evapotranspiration levels, leading to mortality (Adams et al. 2009). These stresses will add to the probability of increased bark beetle activity and could exacerbate the effects of root disease. Stress in general predisposes trees to various insects and diseases, but not all agents will respond in a similar way. Mistletoes are dependent upon their hosts for growth—weaker, stressed trees could actually result in reduced spread and intensification; however, mistletoe effects may become more damaging since mortality among infected trees will likely increase. Some defoliators, such as western spruce budworm, often have outbreaks during periods of increased moisture, so outbreaks might be less severe under a drier, warmer climate.

Risk Modeling

The 2012 National Insect and Disease Risk Map (NIDRM) is a strategic project to assess the potential risk of tree mortality from insects and diseases across the United States over a 15-year time period. While it started as a national strategic map to graphically represent risk of tree mortality, better data and models have improved the scale and potential uses of the assessment. The improved resolution (240 m) of the forest parameter data of the new 2012 NIDRM version (Krist et al. 2014) allows for more regional- and national forest-level analysis and summaries. These insect and disease risk models evaluate the potential loss of basal area[29] based upon current forest conditions.

While climate change scenarios are not included as part of the primary risk modeling effort, many of the risk models include climate variables that potentially could be modified to examine how predicted changes in climate could affect insect and disease risk. One scenario was analyzed in the 2012 NIDRM report and it predicted that future climate could further increase risk to the Cibola from pinyon ips, aspen decline, and fir engraver.

Basal area loss of 25% is considered to represent "an uncommon, rather extraordinarily high amount of mortality" (Krist et al. 2014). On the Cibola overall, approximately 148,000 acres are modeled as being at risk of losing at least 25% of the basal area over the next 15 years (Table 17, Figure 28). An ERU is

[29] Tree cross-sectional area (in^2) at breast height (4.5 ft).

considered at moderate risk if 15–25% of the basal area of one of its major tree species is at risk; an ERU is considered at high risk if >25% of the basal area of one of its major tree species is at risk (Table 18). On the Cibola, the Ponderosa Pine Forest ERU is at moderate risk; at high risk are the Spruce-Fir Forest, Mixed Conifer–Frequent Fire, Mixed Conifer with Aspen, Madrean Pinyon-Oak, PJ Evergreen Shrub, PJ Grass, and PJ Woodland ERUs. While insect- and disease-induced mortality could seemingly be interpreted as beneficial in overstocked stands, basal area loss would likely disproportionately come from mature trees—currently underrepresented relative to reference conditions.

Table 17. Summary of insect & disease risk for lands within the Cibola National Forest boundary.

% Basal Area Loss Class	Hazard	Acres
0–15%	low	1,258,400
15–25%	moderate	309,000
25–100%	high	147,600

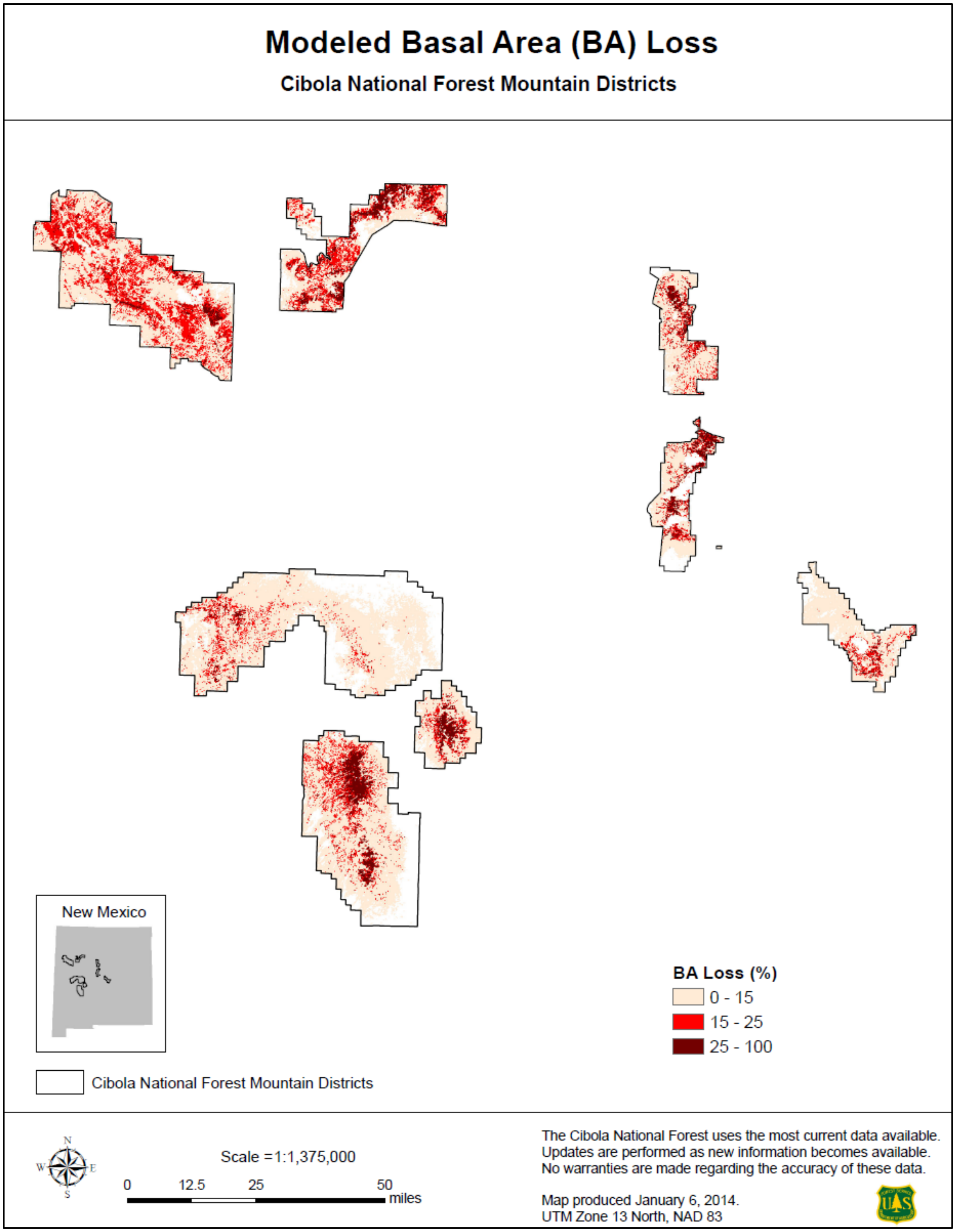


Figure 28. Modeled percent basal area at risk from insect and disease activity (white area within Cibola boundary is nonforested).

Table 18. Summary of risk to tree species by agent modeled for the Cibola.

Species	Basal Area (BA)	BA at Risk	% BA at Risk	Agent(s) Modeled	Associated ERUs*
Douglas-fir	367,208	200,891	54.7	Douglas-fir beetle Douglas-fir tussock moth dwarf mistletoe root diseases western spruce budworm	SFF MCW MCD
Pinyon pine	2,385,166	634,717	26.6	dwarf mistletoe pinyon Ips	MPO PJC PJO PJG
Ponderosa pine	2,413,660	545,118	22.6	dwarf mistletoe Ips spp. root diseases roundheaded pine beetle western pine beetle	PPF MCD
White fir	59,426	12,258	20.6	Douglas-fir tussock moth fir engraver beetle western spruce budworm	MCW
Quaking aspen	30,220	4,424	14.6	aspen decline	MCW
Spruce/Fir	68,328	8,645	12.7	root diseases	SFF
Limber pine	1,463	150	10.3	mountain pine beetle white pine blister rust	†
Southwestern white pine	17,064	1,289	7.6	mountain pine beetle white pine blister rust	†
Engelmann spruce	8,884	129	1.5	spruce beetle western spruce budworm	SFF

* ERU acronyms are defined in Table 4.
† Not a major component of an ERU on the Cibola.

Summary of Condition, Trend, and Risk

Plan-scale risk for each ecosystem characteristic analyzed in the Vegetation chapter is summarized in Table 19. A discussion on condition, trend, and need for ecological change for individual ERUs follows.

Table 19. Summary of risk by ERU and ecosystem characteristic or driver/stressor.

LEGEND	Assessed and not at risk	Moderate risk	High risk	Not assessed/Unknown	Not applicable

ERU	Structure		Species Compo-sition	Coarse Woody Material	Snags ≥8 in. DBH	Snags ≥18 in. DBH	Fire Regime	Patch Size[30]	Invasive Plant Species	Climate	Forest Insects & Disease
	USFS	VCC									
Chihuahuan Desert Scrub	Not at risk	Moderate	Not at risk	N/A	N/A	N/A	Not assessed	High ↓	Not at risk	High	N/A
Chihuahuan Salt Desert Scrub	High	High	Not at risk	N/A	N/A	N/A	Not assessed	High ↓	Not at risk	High	N/A
Colorado Plateau/Great Basin Grassland	Moderate	High	High	N/A	N/A	N/A	High	High ↓	Not at risk	High	N/A
Gambel Oak Shrubland	Moderate	High	Not at risk	N/A	N/A	N/A	High	Moderate ↑	Not at risk	High	N/A
Intermountain Salt Scrub	High	Moderate	High	N/A	N/A	N/A	Not assessed	High ↓	Not at risk	High	N/A
Juniper Grass	Moderate	Moderate	N/A	Not at risk	Not at risk	Not at risk	High	High ↑	Not at risk	Moderate	Not at risk
Madrean Pinyon-Oak Woodland	High	Moderate	N/A	Not at risk	Not at risk	Moderate	High	High ↑	Not at risk	Moderate	High
Mixed Conifer-Frequent Fire	High	High	N/A	Not at risk	Not at risk	Not at risk	High	High ↑	Not at risk	High	High
Mixed Conifer with Aspen	Moderate	High	N/A	Not at risk	Not at risk	Not at risk	Moderate	High ↑	Not at risk	High	High
Montane/Subalpine Grassland	Not at risk	Moderate	High	N/A	N/A	N/A	High	High ↓	Not at risk	High	N/A
Mountain Mahogany Mixed Shrubland	Not at risk	Moderate	Not at risk	N/A	N/A	N/A	High	High ↑	Not at risk	Moderate	N/A
PJ Evergreen Shrub	High	High	N/A	Not at risk	Not at risk	Not at risk	Moderate	High ↑	Not at risk	Moderate	High
PJ Grass	Moderate	High	N/A	Not at risk	Not at risk	Moderate	High	High ↑	Not at risk	High	High
PJ Woodland	Moderate	Moderate	N/A	Not at risk	Not at risk	Not at risk	High	High ↑	Not at risk	Moderate	High
Ponderosa Pine Forest	High	Moderate	N/A	Not at risk	Not at risk	Not at risk	High	High ↑	Not at risk	High	Moderate
RMAP Arizona Alder-Willow	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Arizona Walnut	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Desert Willow	Not assessed	High	High	N/A	N/A	N/A	Not assessed	Not assessed	Moderate	High	N/A
RMAP Fremont Cottonwood–Conifer	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Fremont Cottonwood-Oak	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Fremont Cottonwood/Shrub	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Moderate	High	N/A
RMAP Herbaceous	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Narrowleaf Cottonwood/Shrub	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Ponderosa Pine/Willow	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Rio Grande Cottonwood/Shrub	Not assessed	High	High	N/A	N/A	N/A	Not assessed	Not assessed	High	High	N/A
RMAP Upper Montane Conifer/Willow	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
RMAP Willow-Thinleaf Alder	Not assessed	Moderate	High	N/A	N/A	N/A	Not assessed	Not assessed	Not at risk	High	N/A
Sagebrush Shrubland	High	High	High	N/A	N/A	N/A	High	High ↓	Not at risk	High	N/A
Sandsage	Not at risk	High	Not at risk	N/A	N/A	N/A	Not assessed	Moderate ↓	Not at risk	High	N/A
Semi-Desert Grassland	Not at risk	High	Not at risk	N/A	N/A	N/A	High	High ↓	Not at risk	Moderate	N/A
Spruce-Fir Forest	Moderate	High	N/A	Not at risk	Not at risk	Moderate	High	High ↑	Not at risk	High	High

30 Arrows indicate if patch size increased (↑) or decreased (↓) since the reference period.

Influence of Climate Change on Risk. The Cibola overall and almost all individual ERUs are projected to be highly vulnerable to climate change. A changing climate can potentially compound all ERU-specific risks discussed below by reducing ecosystem health and the ability to withstand stresses like invasive species and insects and disease. Additionally, in a warmer, drier climate, wildfires may become increasingly frequent and severe, possibly bringing increased soil erosion and hydrologic degradation, further reducing ecosystem health and increasing risk.

Chihuahuan Desert Scrub, Chihuahuan Salt Desert Scrub, and Intermountain Salt Scrub. These ERUs are all at risk because of vegetation structure (USFS or VCC or both) and decreased patch size (and species composition in the case of Intermountain Salt Scrub). Identification of a need for ecological change hinges on identifying the specific reason(s) for their departures in structure. Once identified, future management may be able to increase patch size while restoring vegetation structure to reference conditions.

Colorado Plateau/Great Basin Grassland. The historic average fire return interval was 0–35 years from stand-replacing fire; however, most recent fires have been non-lethal. With moderate–high[31] risk from vegetation structure, high risk from altered fire regime, and high risk from decreased patch size, future management should strive to restore vegetation structure to reference conditions. In turn, this may simultaneously (either passively or actively) return fire regime and patch size to reference conditions.

Gambel Oak Shrubland. The historic average fire return interval was 35–200 years from stand-replacing fire; however, most recent fires have been non-lethal. With moderate–high risk from vegetation structure, high risk from altered fire regime, and moderate risk from increased patch size, future management should strive to restore vegetation structure to reference conditions In turn, this may simultaneously (either passively or actively) return fire regime and patch size to reference conditions.

Juniper Grass. The primary risks are a high proportion in the early seral stage (32% vs 5% for reference), severe lack of fire, and highly departed (too large) patch size. Although the projected 15-year trend is for a lower (still moderate) departure in structure, long-term trends show high departure. The ecological need for change is to increase the proportion of the open, late-seral state. This undoubtedly will take time (juniper grows slowly), but once accomplished, restoration of a fire regime characteristic of reference conditions may be used to maintain these open stands and decrease patch size.

Madrean Pinyon-Oak Woodland. Structure is departed (high–moderate) because of a severe lack of representation in the medium/large open state (with a corresponding reduction in large snags) and excess in the grass/forb/shrub state. Restoring seral stage proportions to reference conditions requires time—the amount of time it takes to grow a mature tree (roughly 100 years; much longer to restore large snag density)—and management (controlled burns, thinning) to maintain open canopies as these stands grow. Opening the canopies of existing mid-seral states would be a partial remedy that could be accomplished in the short term—open stands are conducive to mixed-severity fire, currently lacking in this ERU. Collateral benefits include reduced risk from insects and disease (currently at high risk) and decreased patch size (currently highly departed; too large).

Mixed Conifer-Frequent Fire. A negative synergy exists among the high-risk ecosystem characteristics—all related to a lack of mature, open stands, an abundance of young, closed stands prone to severe fire or outbreaks of insects and disease, and large patch size. At the context scale, the

[31] Where an ERU has differing vegetation structure departure ratings, both ratings are mentioned in this order: USFS Southwestern Region–LANDFIRE.

preponderance of medium, open stands (vs open stands under reference conditions) may self-correct over time. At the plan scale, reducing the proportion of early seral stands and increasing the proportion of open, late-seral stands requires time—the amount of time it takes to grow a mature tree (roughly 100 years)—and management (controlled burns, thinning) to maintain open canopies as these stands grow and to favor the return of frequent, non-lethal surface fires. Such management could simultaneously reduce the threat from insects and disease (currently at high risk) and reduce patch size (currently highly departed for patch size; too large). Such action is especially important as the Cibola accounts for 35% of the context scale acreage of this ERU.

Mixed Conifer with Aspen. Most risks are related to the moderate–high departure in structure: the complete loss of states dominated by large trees and the appearance of closed stands of seedling/sapling/small trees (over 1/3 of Cibola, none in reference). While the fire return interval is similar to reference conditions, most recent fires have been non-lethal (vs mostly mixed severity or stand-replacing under reference conditions), the risk from insects and disease is high, and patch size is highly departed (too large). The primary ecological need for change requires time (for medium-size trees to become large trees) and active management (thinning of young stands, reducing patch size). Such change is especially important as the Cibola accounts for about ¼ of the context scale acreage of this ERU.

Montane/Subalpine Grassland. The most substantial risks are from a lack of frequent stand-replacing fire and patch size (currently highly departed; too small). This ERU may be considered especially sensitive to climate change, as it occurs at the highest elevations and is therefore incapable of uphill migration as a climate change response. Future management should use stand-replacing fire to reduce tree encroachment, increase patch size, and potentially restore species composition.

Mountain Mahogany Mixed Shrubland. Vegetation structure departure is low–moderate, and patch size is highly departed (too large). However, reversing the shift from stand-replacing fire (historical) to non-lethal fire (current) may simultaneously decrease patch size and benefit yet unassessed ecosystem characteristics. For example, species composition data (when available) may reveal a root cause—for example, a shift in grass-shrub proportion—of the altered fire regime and thereby help identify an ecological need for change.

PJ Evergreen Shrub. The risk from structural departure (mostly closed vs exclusively open for reference) calls for thinning and prescribed burning to open the stands. Collateral benefits may be a restored fire regime (currently mostly non-lethal vs historically mixed-severity), decreased patch size (currently highly departed; too large), improved soil condition (currently at high risk, see Soil section below), and reduced threat from insects and disease (currently at high risk).

PJ Grass. Canopy structure shifted from being mostly open (reference) to currently being mostly closed. Current structural departure is high using the LANDFIRE method (VCC), and the improved USFS Southwestern Region method shows a currently (and projected 15 years) moderate departure; however, the projected trends (100 and 1000 years) are to be highly departed. The ecological needs for change are converting large (currently highly departed for patch size; too large) closed, early seral stands to smaller open, late-seral stands, restoring frequent non-lethal fire, and increasing the density of large snags (currently moderately departed). This requires time and management (controlled burns, thinning) to maintain open canopies as these stands grow. Such management may simultaneously reduce the threat from insects and disease (currently at high risk).

PJ Woodland. Since the reference period, there has been an overall shift away from states characterized by medium and large trees at both context and plan scales. This is especially true for the Cibola where there have been large, concomitant increases in the grass/forb/shrub and small (closed) states. While currently moderately departed for structure, the projected trends (15, 100, and 1000 years) are for the

Cibola to be within reference conditions—especially important as the Cibola accounts for about ¼ of the context scale acreage of this ERU. Ecological need for change rests with restoring frequent stand-replacing fire and reducing patch size (currently highly departed). This may simultaneously reduce the threat from insects and disease (currently at high risk) and improve soil condition (currently at high risk, see Soil section below).

Ponderosa Pine Forest. Under reference conditions, 100% of this ERU existed as open, multistoried, multi-aged stands that included medium and large trees. Currently highly departed at context and plan scales (USFS Southwestern Region method), the majority at the context scale is mid-seral (medium-sized trees), while the majority of Cibola is early seral (grass/forbs/shrubs and small trees). At the plan scale, converting early seral stands to smaller (currently highly departed for patch size; too large) open, late-seral stands requires time—the amount of time it takes to grow a mature tree (roughly 100 years)—and management (controlled burns, thinning) to maintain open canopies as these stands grow. Such management may help restore the frequent, non-lethal fire regime characteristic of reference conditions and reduce patch size. Collateral benefits include reduced risk from insects and disease (currently at moderate risk).

Riparian ERUs. All riparian (RMAP) ERUs are at risk due to vegetation structure (VCC of 2 or 3) with an overall negative recent VCC trend. While the VCC rating may be due to structural departure resulting from altered fire regimes, the risk from invasive species (currently 3 ERUs) is due solely to saltcedar invasion. Saltcedar is able to establish and persist primarily for physical reasons (channel downcutting, lowered water tables, reduced flooding) that preclude the establishment and growth of cottonwood and willow. To further complicate the issue, saltcedar offers habitat for the endangered Southwestern Willow Flycatcher, so its control should only occur where geomorphological and hydrological conditions are conducive to the reestablishment of cottonwood and willow, the flycatcher's preferred habitat. Future management should strive to restore the physical and biological ecosystem characteristics of the Riparian ERUs. This is especially important in the San Mateo Mtns Geographic Area (GA) where 5 riparian ERUs are primarily represented (over half of their Cibola acreage is in this GA; three of these ERUs have all of their Cibola acreage in this GA, including one at risk due to saltcedar).

Sagebrush Shrubland. Highly departed for vegetation structure, species composition, and patch size (too small), ecological need for change may hinge on restoring the historic mixed-severity fire regime. While the Cibola accounts for only about 1% of the context-scale acreage of this ERU, its Cibola acreage is almost exclusively in the Zuni Mtns GA.

Sandsage. Vegetation structure is highly departed and patch size is moderately departed (too small). The Cibola accounts for over ¼ of the context scale acreage with over ¾ of the Cibola acreage for this ERU in the Gallinas Mtns GA. Identification of a specific need for ecological change may hinge on identifying the specific reason(s) for its high departure in vegetation structure.

Semi-Desert Grassland. Vegetation structure is at high risk using LANDFIRE method and at low risk using the improved method from USFS Southwestern Region. With fire regime and patch size also at risk (currently highly departed; too small), the ecological need for change may hinge on restoring frequent, stand-replacing fire.

Spruce-Fir Forest. Vegetation structure is at high risk using LANDFIRE method and at moderate risk using the USFS Southwestern Region method. Despite the shift from historic stand-replacing fire to mostly non-lethal fire today, there is a paucity of states dominated by large trees (nearly one-half during reference conditions to almost none now) and a shortage of large snags. The seemingly contradictory ecological needs for change (stand-replacing fire, reestablishment of mature stands) may be achieved simultaneously over time as unburned stands grow to maturity while stand-replacing fires reduce fuel buildup in others. These changes may also reduce patch size (currently highly departed; too large) and reduce the threat from insects and disease (currently at high risk)—especially important as the Cibola accounts for about ¼ of the context scale acreage of this ERU. Furthermore, this ERU may be considered especially sensitive to climate change, as it occurs at the highest elevations and is therefore incapable of uphill migration as a climate change response.

Effect on ecosystem services. The ecosystem services that vegetation provides are at risk because (1) almost all ERUs are at least moderately departed for structure, (2) most forest and woodland ERUs are at risk from insects and disease, (3) all non-riparian ERUs are at least moderately departed for patch size, and (4) all ERUs are at least moderately vulnerable to climate change. If a warming climate induces change in site potential from forest to woodlands, and from woodlands to shrub- and grasslands, there may be an overall decrease in large trees (wildlife habitat, timber) and a shift in the amount or location of available firewood and other ecosystem services on which humans depend.

Key Message

Historical timber harvest, improper grazing, and fire suppression have led to larger and more severe wildfires and a shift from open stands with large trees to young, overstocked stands.

Chapter 3. Soils

Soil provides many ecosystem services on which other life forms (including humans) depend. Soil yields *supporting* ecosystem services by providing a substrate and nutrients for plants. Soil provides *regulating* ecosystem services through thermoregulation (daytime heat absorption, nighttime heat release), nutrient cycling, and water purification and storage. Soil contributes to *provisioning* ecosystem services by providing wildlife habitat (burrows, dens), plant-growth media (nurseries), and fill (construction). Especially important to humans are the *cultural* ecosystem services that soil provides to society (pottery clay, play sand).

The diverse and productive soils of the Cibola are described, characterized, and classified in Terrestrial Ecosystem Survey of the Cibola National Forest and National Grasslands (Strenger et al. 2007). The information regarding the kind of soils on the Cibola is intricately linked to the climate, vegetation, and geology of the forest. The Cibola occurs on scattered isolated mountain ranges that exhibit a variety of bedrock and mountain forming processes (Figure 2).

- **The Sandia and Manzano Mountains** are part of the Rio Grande Rift. They are upthrust tilt blocks with mainly sedimentary limestone and sandstone bedrock overlying granitic and rhyolitic igneous bedrock. Metamorphic schists and metarhyolites are more common in the Manzano Mountains.
- **Mount Taylor** is an extinct volcano comprised of andesite, basalt, and rhyolite with basalt-capped mesas around its base. Cinder cones commonly occur on these mesas.
- **The Zuni Mountains** consist of a structural dome with granite exposed at its center. Sedimentary sandstones, siltstones, and shales dip away in all directions from the core.
- **The Gallinas Mountains** consist of an igneous intrusion which pushed up through sedimentary limestone and sandstone formations.
- **The San Mateo, Magdalena, Datil, and Bear Mountains** are of volcanic origin with extensive faulting. They are mainly composed of rhyolite and tuff. Alluvial landforms such as alluvial fan remnants, alluvial fans, and ballenas[32] commonly occur along the base of mountains. Floodplains and stream terraces occur along stream channels.

Climate is highly variable as a consequence of the uneven topography and a wide range in elevation. Climate varies from semiarid, hot steppe with subhumid regimes across the alluvial fans and piedmont plains at lower elevations to cold, wet subalpine regimes at the highest elevations of mountain summits. Vegetation varies from desert scrub at elevations under 5,500 feet on the southern end of the Magdalena District, to spruce-fir and mountain grassland at elevations over 10,000 feet.

Plant communities follow an elevational-climatic gradient from low-elevation desert scrub, shrub, and grassland upward to pinyon-juniper, mid-elevation ponderosa pine, mixed conifer, and eventually up to high-elevation spruce-fir and montane and subalpine grasslands. The pinyon-juniper plant community in the Zuni Mountains, Mount Taylor, and the Datil Mountains is in the cold-winter climatic zone characterized by deciduous oaks. The evergreen oak, pinyon-juniper, desert grassland, and desert shrub communities in other areas of the Cibola National Forest are in the mild-winter climatic zone. Ponderosa pine, mixed conifer, and spruce-fir plant communities are in the cold-winter climatic zone.

[32] A ballena (“bye-Ā-nah”) is a major landform comprising distinctively round-topped ridgeline remnants of fan alluvium (adapted from Peterson [1981]).

Across the Cibola, soils vary from an aridic (dry) moisture regime and thermic (very warm) temperature regime at lower elevations to an udic (humid–subhumid) moisture regime and cryic (very cold winter, cold summer) temperature regime at the highest elevations.[33]

Soils tend to be shallow and skeletal (>35% rock fragments) on steeper slopes. Soils are less well developed on the more unstable steeper slopes. Moderately steep to flat slopes tend to have deeper, more developed soils; rock fragment content can be variable. Soil texture varies by parent material kind and origin. Soils developed in parent materials such as andesite and basalt tend to have more clay content, as these parent materials are high in clay-forming minerals. Soils formed from parent materials such as rhyolite and tuff are lower in clay content because these parent materials have a lower percentage of clay-forming minerals.

Ecosystem Characteristics for Assessment

Soil Erosion Hazard and Soil Condition are directly linked to the ability of the soil to withstand disturbances from management activities and natural events while maintaining site productivity and sustainability of the soil resource. These characteristics are used to analyze the reference and current conditions and future trends of the soil resource. The Soil Erosion Hazard rating reflects inherent site and soil characteristics. Soil Condition rates soils as they exist currently and reflects the effects of management and disturbance history—soils were generally assumed to be in satisfactory soil condition under reference conditions.

Soil Erosion Hazard

Soil erosion hazard is the probability of soil loss resulting from complete removal of vegetation and litter—an inherent soil property (not influenced by management). Slope, soil texture, and vegetation type greatly influence soil erosion hazard rating. It is an interpretation based on the relationship between the maximum soil loss and the tolerable (threshold) soil loss of a site. Soils are given a slight, moderate, or severe erosion hazard rating.

- A rating of **slight** indicates the maximum soil loss does not exceed the threshold, and therefore, the loss of the soil production potential is of low probability.
- A **moderate** erosion hazard indicates that the loss in soil production potential from erosion is probable and significant if unchecked.
- A **severe** erosion hazard rating indicates that the loss of soil production potential from erosion is inevitable and irreversible if unchecked.

These ratings provide land managers with an index for identifying three classes of land stability and are useful in determining areas with the greatest potential for response to seeding after wildfire or areas that should receive minimum exposure of mineral soil. Soil erosion hazard was calculated using the Hillslope Erosion Model (Lane et al. 1995) for all major soils within the ERUs.

[33] For a complete explanation of soil temperature and moisture regimes, see *Keys to Soil Taxonomy, 11th ed.* (Soil Survey Staff 2010).

Soil Condition

Soil condition is an evaluation of soil quality based on an interpretation of factors which affect vital soil functions. Soil quality is the capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin 1994). The interrelated functions of soil hydrology, soil stability, and nutrient cycling are evaluated to assess soil condition. Unlike soil erosion hazard, soil condition is influenced by management.

- **Soil Hydrology**. This function is assessed by evaluating or observing changes in surface structure, surface pore space, consistence, bulk density, infiltration, or penetration resistance using appropriate methods. Increases in bulk density or decreases in porosity result in reduced water infiltration, permeability, and plant-available moisture.
- **Soil Stability**. Erosion is the detachment, transport, and deposition of soil particles by water, wind, or gravity. Vascular plants, soil biotic crusts, and litter cover are the greatest deterrents to surface soil erosion. Visual evidence of surface erosion may include rills, gullies, pedestalling, soil deposition, erosion pavement, or loss of the “A” (surface) horizon. Erosion models are also used to predict on-site soil loss.
- **Nutrient Cycling**. This function is assessed by evaluating plant community composition, litter, coarse woody material, root distribution, and soil biotic crusts. These indicators are directly related to soil organic matter, which is essential in sustaining long-term soil productivity. Soil organic matter provides a carbon and energy source for soil microbes and provides nutrients needed for plant growth. Soil organic matter also provides nutrient storage and capacity for cation and anion exchange.

Soil Condition Categories

Ecological Response Units (ERUs) are assigned a soil condition category which is an indication of the status of soil functions. Soil condition categories reflect soil disturbances resulting from both planned and unplanned events. Current management activities provide opportunities to maintain or improve soil functions that are critical in sustaining soil productivity. The following is a brief description of each soil condition category:

- **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 or there exists an increased vulnerability to degradation. An “impaired” rating should signal to 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 results in the inability of soil to maintain resource values, sustain outputs, and recover from impacts. Soils with an “unsatisfactory” rating are candidates for improved management practices or restoration designed to recover soil functions.

Existing management activities need to be evaluated to determine if the current management activity is contributing to the loss of soil function. In some cases, current management activities may not have caused the loss of soil function but may be preventing recovery. Management activities that slow or prevent recovery of soil function should be avoided.

Reference Condition, Current Condition, and Trend

Erosion Hazard

The magnitude of natural disturbances under reference conditions was smaller than under current conditions, and the subsequent loss of vegetation and litter for a given site—and the likelihood of erosion—would have been smaller as well. However, it is probable that when soils with high erosion hazard were burned and farmed, accelerated erosion occurred after storms.

The range in erosion hazard classes within an ERU often reflect the various slope gradients, landforms, and associated thresholds on which they occur.

The "severe" erosion hazard class includes ERUs occurring primarily on steep landforms (mountain slopes, escarpments, hills) such as Mixed Conifer with Aspen, PJ Woodland, and PJ Evergreen Shrub (Figure 29). Where these systems occur within watersheds that have excessive fuel loadings and uncharacteristic disturbance regimes, the potential risk for accelerated erosion exceeding thresholds and subsequent runoff is high.

Conversely, the majority of sites with predominately slight erosion hazard ratings occur on moderately sloping to nearly level landforms including piedmont plains, alluvial fans, valley plains, stream terraces, and floodplains and support the Chihuahuan Desert Scrub, Chihuahuan Salt Desert Scrub, Intermountain Salt Scrub, Sagebrush Shrubland, and Sandsage ERUs. Although these ERUs have low erosion hazard potentials, soil loss from lack of vegetative ground cover is contributing to unsatisfactory and impaired soil conditions.

Sites that predominantly have moderate erosion hazard on moderately sloping landforms support the Mixed Conifer-Frequent Fire, Mountain Mahogany Mixed Shrubland, Madrean Pinyon-Oak Woodland, Montane/Subalpine Grassland, and Spruce-Fir ERUs.

Soil Condition

Satisfactory soil condition (soil quality) is important in maintaining long-term soil productivity—key to sustaining ecological diversity. Unsatisfactory and impaired soil conditions have resulted in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation.

Very little quantitative data exist to measure historical soil condition. However, some qualitative and quantitative inferences can be made, providing insight into historical soil condition by using knowledge about present disturbances and their effect on soil stability, soil compaction, and nutrient cycling. Reference conditions generally estimate Pre-European settlement conditions.

Historically (without anthropogenic disturbance), soil loss, soil compaction, and nutrient cycling would probably have been within functional limits to sustain soil function and maintain soil productivity for most soils that are not inherently unstable—the exception being during cyclic periods of drought and possibly local areas impacted through non-domestic herbivory. Natural flood disturbance would have had a limited effect on the extent of soil loss, only causing accelerated erosion adjacent to stream channels or floodplains. Drought may have reduced the amount of protective vegetative ground cover resulting in accelerated erosion during prolonged rainstorms.

The most productive soils (satisfactory soil condition) historically and currently are within the Gambel Oak Shrubland, Mixed Conifer with Aspen, Mixed Conifer-Frequent Fire, and Spruce-Fir ERUs (Figure 30). These ERUs produce high amounts of organic matter to ensure stability of the soil and support nutrient cycling.

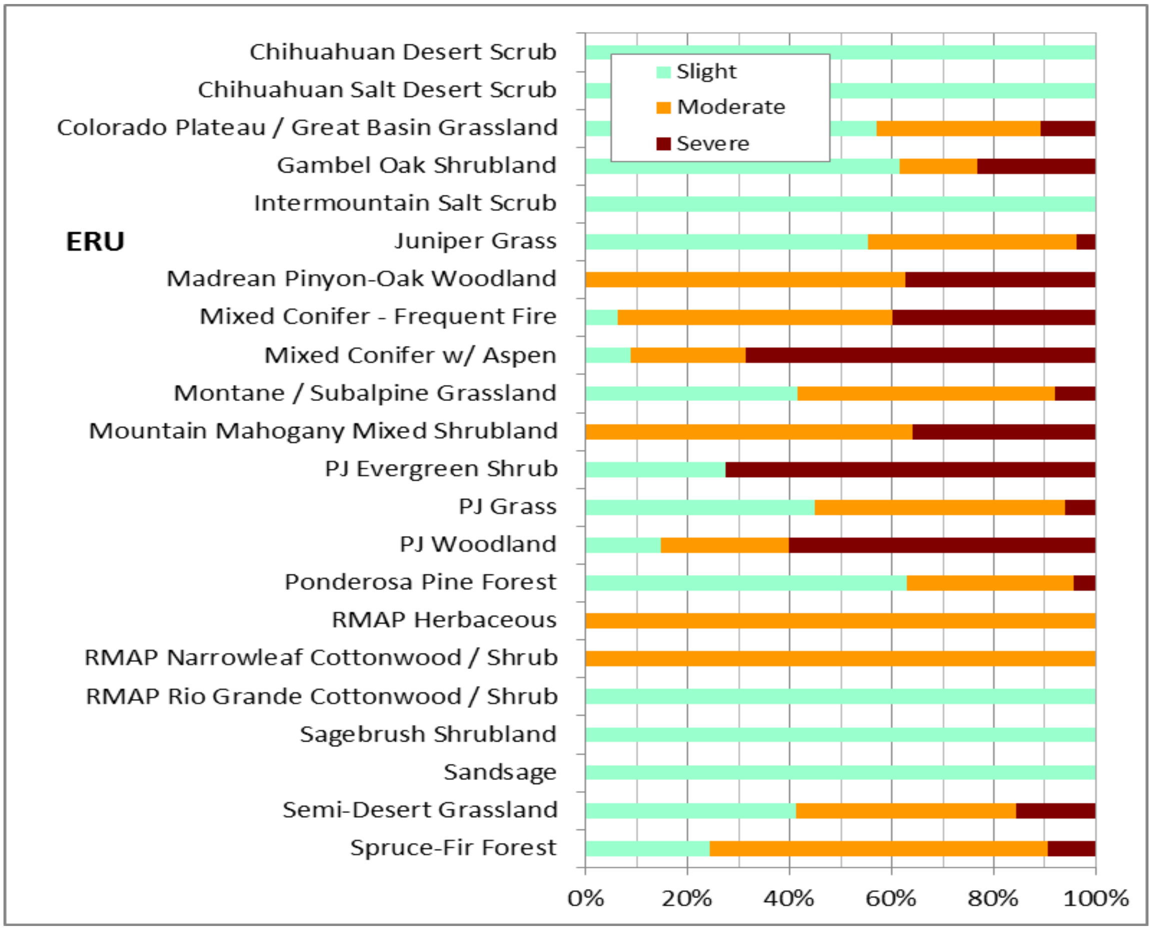


Figure 29. Erosion hazard of Cibola ERUs. (Data not available for all riparian ERUs.) Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)

Other ERUs that historically were very productive and assumed to have satisfactory soil condition but are now impaired through a reduction in soil function include: the Montane and Subalpine Grassland, Colorado Plateau/Great Basin Grassland, Chihuahuan Desert Scrub, Chihuahuan Salt Desert Scrub, Intermountain Salt Scrub, Mountain Mahogany Mixed Shrubland, PJ Grass, Ponderosa Pine Forest, Sandsage, and Sagebrush Shrubland. The lack of effective vegetative ground cover and organic matter has resulted in unstable soils with reduced nutrient cycling in these ERUs.

The PJ Evergreen Shrub and PJ Woodland ERUs are at least 40% unsatisfactory; however, all other ERUs are predominately satisfactory or impaired (Figure 30). Additionally, some soils are considered inherently unstable. Inherently unstable soils are those in which their geologic formation and geomorphic properties are naturally active, and soil erosion has existed historically and will continue. Inherently unstable soils are dispersed across the landscape and occur primarily in the PJ ERUs. Soil erosion hazard influences soil condition—an inherently unstable soil is more vulnerable to soil condition impairment than an inherently stable soil.

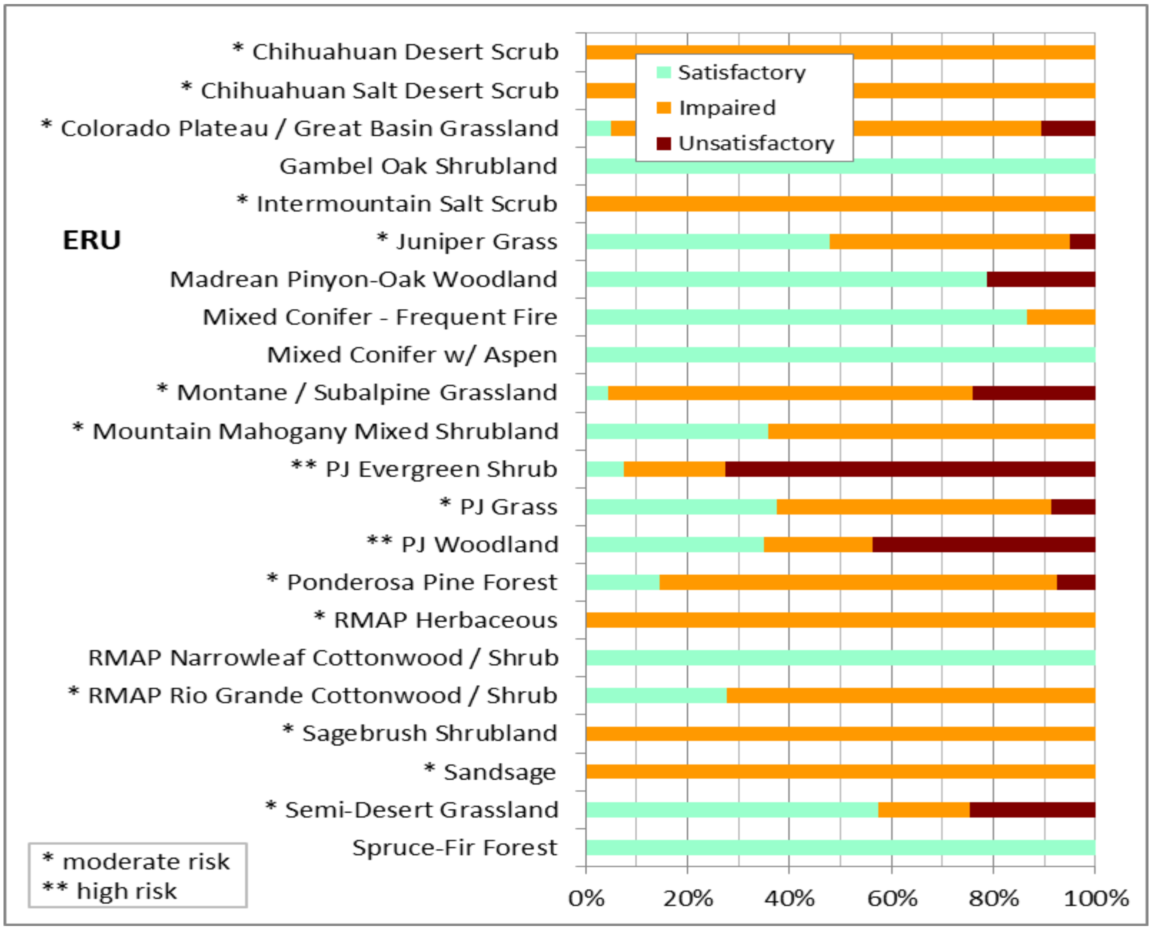


Figure 30. Current soil condition of Cibola ERUs. (Data not available for all riparian ERUs.) Forest Corporate Spatial Database: gdb04a_r03_cib_default_(Cibola)

Current estimates of soil trend are not available; however, stressors such as altered fire regimes, nonnative species, and drought—coupled with historical unmanaged grazing and fuelwood gathering—have produced unnaturally dense overstories and sparse vegetative ground cover. Soil erosion may be occurring beyond its threshold due to high amounts of bare soil and larger, more intense wildfires; and many soils may be trending toward conditions of accelerated erosion and declining site productivity. Current management practices strive to restore ecosystem health and improve soil condition as budgets allow.

Risk Assessment

While soil erosion hazard is an inherent soil property and not influenced by management, soil condition is influenced by management and is the sole criterion used in this risk assessment. Most of the Cibola ERUs are considered to be at moderate risk for soil condition (at least 25% impaired); the PJ Evergreen Shrub and PJ Woodland ERUs are at least 25% unsatisfactory and considered to be at high risk (Figure 30). Ecological need for change should address the site-specific characteristics (plant basal cover, canopy cover, litter, coarse woody material, etc.) that are in need of improvement.

Soil condition and overall risk was assessed by Geographic Area (Table 20). Five of the Cibola's 9 Geographic Areas (GAs) are considered to be at moderate risk for soil condition (at least 25% of the GA acreage is impaired), and one GA (San Mateo Mtns) is at least 25% unsatisfactory and considered to be at high risk.

Table 20. Soil condition and overall risk by Geographic Area.

LEGEND	Low risk	Moderate risk	High risk

	Geographic Area*								
Soil Condition	**Mt**	**Zu**	**Br**	**Dt**	**Mg**	**Sm**	**Ga**	**Mz**	**Sd**
Satisfactory	27	15	68	34	68	45	20	55	67
Impaired	66	72	24	46	19	23	78	31	21
Unsatisfactory	7	14	8	20	13	32	3	14	12
Overall Risk									

*Geographic Area abbreviations: Mt (Mt Taylor), Zu (Zuni Mtns), Br (Bear Mtns), Dt (Datil Mtns), Mg (Magdalena Mtns), Sm (San Mateo Mtns), Ga (Gallinas Mtns), Mz (Manzano Mtns), Sd (Sandia Mtns).

Effect on ecosystem services. With most ERUs at risk for soil condition, ecosystem services provided by soil are also at risk. Some aspects of soil condition, like canopy cover, may improve quickly. Other aspects take a long time to improve (recovery of lost topsoil) and could impact ecosystem services for quite some time.

Key Message

Most of the soils on the Cibola are in poor condition because of a combination of historic disturbance and current management.

Chapter 4. Water Resources

Water resources on the Cibola provide many ecosystem services from which society derives enjoyment or benefit. Watersheds and riparian areas, and water from streams, springs, and seeps provide *supporting* ecosystem services to society in that they contribute to nutrient cycling and primary production, and water is a catalyst in soil formation. Watersheds and riparian areas also provide *regulating* ecosystem services as they contribute to erosion control, flood regulation, and water purification. Watersheds and their component streams, springs, seeps, and groundwater resources, provide fresh water for people and all other life forms, satisfying thirst for all, and water is critical in production of forage, livestock, fruits and nuts, and game animals taken for meat and other animal products, and as such, contribute to *provisioning* ecosystem services. Mining and other industries related to fuel and energy also depend on water as a *provisioning* service for their operations. And finally, watersheds and their component parts provide *cultural* ecosystem services to society in a multitude of ways: for example, in providing research opportunities and educational study areas; in providing recreational (e.g., fishing, wildlife viewing, boating, swimming) opportunities to the public such as those partaken at McGaffey Lake on the Mt. Taylor RD, which depends on stream flow, or in providing places of quiet solitude and personal enrichment next to a stream or spring.

All of these ecosystem services related to watersheds and water are becoming more valuable in the context of the larger landscape, where many watersheds off the plan area are facing increased development pressure and degrading influences. However, conversely, the quantity of these same ecosystem services on the Cibola may be declining in the face of drier and hotter climatic conditions and increased demand of water resources.

This assessment of water resources characterizes and evaluates the status of watersheds and water resources (surface and ground water) and their role in sustaining the structure and function of terrestrial, riparian, and aquatic ecosystems within the plan area (forest-wide) and upon the larger area of analysis (contextual), assuming management consistent with current plan direction. In addition, the potential role of the larger area of analysis upon the status of watersheds and water resources within the plan area is considered. Watersheds relevant to the plan area include those non-NFS lands that contribute surface or subsurface water flows to the plan area, and those non-NFS lands that receive surface or subsurface water flows from the plan area.

Table 21 presents key ecosystem characteristics of water features present on the Cibola and in the contextual (broader) landscape.

Table 21. Water features and key ecosystem characteristics assessed.

Water Resource Feature	Ecosystem characteristic
Streams	• Water quality • Water quantity • Condition
Springs/seeps	• Water quality • Water quantity • Condition/development
Groundwater	• Recharge and discharge
Water rights/uses	• Location
Riparian areas, wetlands	• Condition

Water Resource Feature	Ecosystem characteristic
Watershed	• HUCs/scales • condition

Data

Data used for analysis of water features such as streams and springs is from the Cibola National Forest GIS dataset and the National Hydrography Data (NHD). Additional data was used as indicated by references throughout this report, including sources from the state of New Mexico. The attributes for stream flow, perennial, intermittent, and ephemeral, are not completed within this dataset. As a result, many smaller perennial portions and intermittent streams are not well represented in this data. There is little data regarding the existing condition of streams or springs in the analysis area. An ongoing inventory is currently occurring for springs but it has not been completed. Water quality and quantity data is also limited for water resources.

Streams

Timing of stream flow – stream types

Streams are classified by their flow characteristics into perennial, intermittent, and ephemeral types. These flow types provide information about the timing of water within the streams.

- **Perennial streams** flow year round because they get water from water storage in the ground. However, these streams may dry up during extreme droughts.
- **Ephemeral streams** only flow in direct response to precipitation or snow melt.
- **Intermittent streams** fall between ephemeral and perennial. These types of streams get water from the ground seasonally and usually dry up in the summer.

Perennial and intermittent streams support riparian vegetation. Intermittent and ephemeral streams provide many of the same ecosystem goods and services as perennial streams (Levick et al. 2008). All streams are pathways for the movement of water, nutrients and sediment throughout the watershed. Intermittent and ephemeral streams comprise a large portion of the stream network within watersheds. These features have greater relative moisture than the surrounding area, often stored in ground. In addition, when these features erode and downcut, gullies can form. This leads to soil loss and the surrounding water tables get deeper (Schumm, Harvey, and Watson 1984).

Quantity and Distribution of Streams

There are 6,203 miles of stream channels in the plan area. Intermittent streams account for 845 miles. There are 5,334 miles of mapped ephemeral channels. Perennial streams occur on 24.8 miles across 15 different 6^{th}-field hydrologic unit code (HUC-6) watersheds. These watersheds are listed in Table 24. Data used to populate this table are from the NHD and have not been completely ground-truthed. Mapped perennial waters using NHD are verified but there are smaller locations where perennial waters occur which are not mapped. Perennial streams are often located along very short stretches so reporting mileage in tenths of miles is necessary.

To assess the context or importance of perennial streams within the forest, the larger 6^{th}-field watersheds are used. Figure 31 shows the distribution of mapped perennial streams across the mountain districts. It can be seen from this information; there are fifteen 6^{th}-field watersheds that intersect the plan area with perennial water. Only six of these watersheds have mapped perennial water on NFS lands in the plan area.

It is unknown whether or not this amount of water has changed from historic condition. However, due to incisement, much of which occurred in the late 1800s to early 1900s, water tables have lowered in many of the streams, which likely resulted in reduced perennial flows (Scurlock 1998).

Streams have several characteristics:

- Stability of the stream channel
- Quality of the water within the streams, and
- Amount and timing of the water in the stream.

The reference condition for water quality is that stream meet water quality standards, are properly functioning, and stream flow is within the range of natural variation, unaffected by water uses, land uses, or groundwater withdrawals.

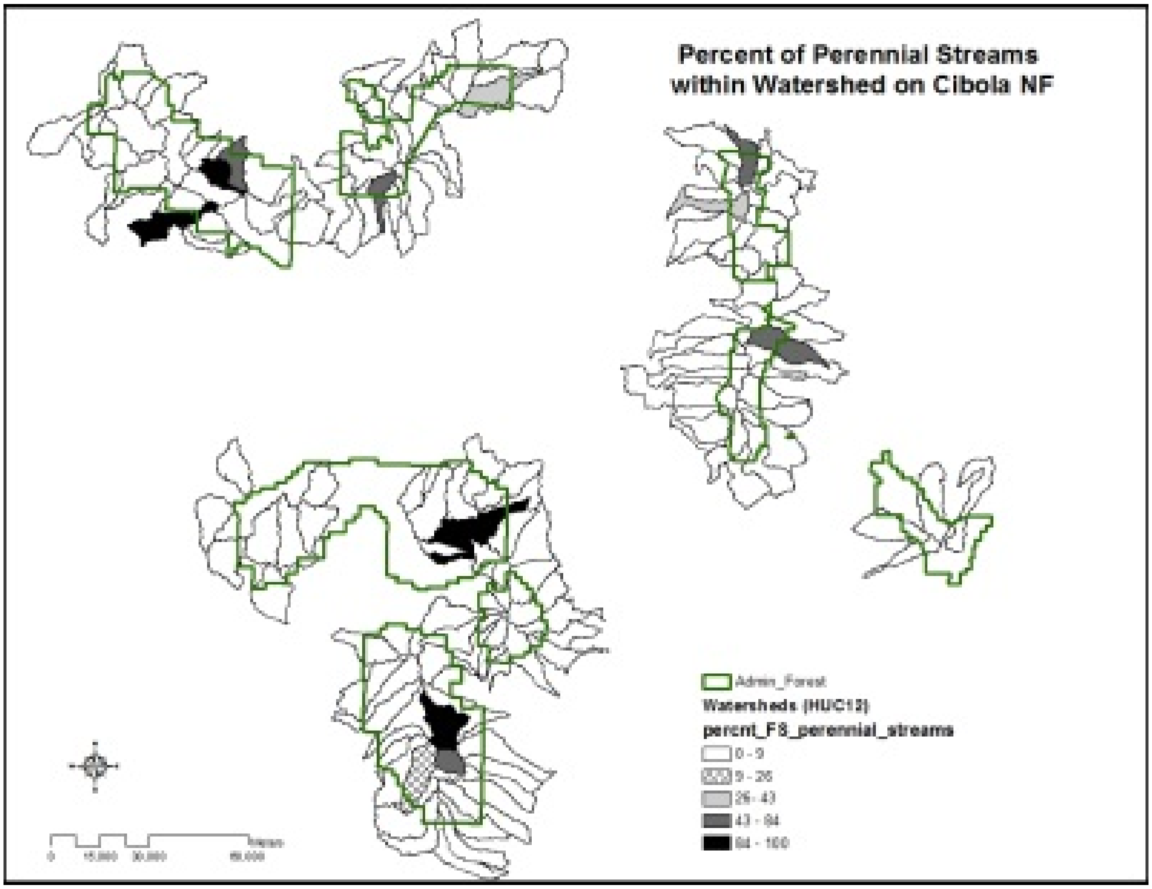


Figure 31. Distribution of perennial streams on the Cibola.

Existing condition for perennial streams is listed in Table 22. There is little information about the condition and water quality of intermittent and ephemeral stream in the plan area. Las Huertas Creek has water withdrawals directly from the stream to support water uses in the town of Placitas. These uses predate the establishment of the forest.

The federal Clean Water Act (CWA) requires states to restore and maintain the chemical, physical and biological integrity of the nation's waters. Section 303 of the Act requires states to adopt water quality standards necessary to protect designated uses whenever possible. Few streams in the plan area have been assessed by the state of New Mexico for water quality standards as shown in Table 22. Other than these few streams, it is unknown whether or not water quality in the project area meets New Mexico water quality standards (NMED 2012).

Table 22. Perennial streams – existing condition.

HUC-6	PFC*- Stability	Water Quality	Water Flow
Arroyo de Tajique	At risk	Not assessed	No withdrawals
Bluewater Lake – Bluewater Creek	At risk	Does not meet standards	No withdrawals
Ojo Redondo – Bluewater Creek	At risk	Does not meet standards	No withdrawals
Castillo Canyon	Not assessed	Not assessed	No withdrawals
Togeye Lake	Not assessed	Not assessed	No withdrawals
Rinconada Creek	Not assessed	Not assessed	No withdrawals
Canon Tapia	Not assessed	Not assessed	No withdrawals
Indian Creek	Not assessed	Not assessed	No withdrawals
San Mateo Canyon – Alamosa Creek	Not assessed	Not assessed	No withdrawals
Headwaters East Red Canyon	Not assessed	Not assessed	No withdrawals
Bear Springs Canyon	Not assessed	Not assessed	No withdrawals
Canon del Alamito – Rio Salado	Not assessed	Not assessed	No withdrawals
Dry Lake Canyon	Not assessed	Not assessed	No withdrawals
Las Huertas Creek	At risk	Does not meet standards	Water withdrawals
Arroyo del Pino	Not assessed	Not assessed	No withdrawals
Nogal Arroyo**	At risk	Not assessed	No withdrawals

* Proper Functioning Condition

** While the National Hydrography Dataset (NHD) does not categorize any of Nogal Arroyo as perennial, there are sections known to Forest personnel to be perennial. The NHD has not been completely ground-truthed and discrepancies exist.

Bluewater Creek and Las Huertas Creek have been listed as impaired in the 2012–2014 State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Report (NMED 2012). Bluewater Creek is in the Zuni Mountain unit. Las Huertas is located on the north end of the Sandia Mountains.

The portion of Bluewater Creek assessed by New Mexico is from Bluewater Reservoir to the headwaters of Bluewater Creek, assessment unit NM-2107.A_01. This reach is in category ‘4A’ which means that available data and/or information indicate that at least one designated or existing use is not being supported and a Total Maximum Daily Load (TMDL) is not needed because TMDLs have been completed. The designated use of coldwater aquatic life is not supported in this reach as indicated by a nutrient and temperature data collected in 2006.

Possible sources of impairment include: forest roads, loss of riparian habitat, rangeland grazing, silviculture harvesting, and streambank modification/destabilization. A survey in 2011 indicated much of this stream reach is intermittent which could result in changes to the designated uses currently assigned to this reach. In particular, the designated use of a cold water fishery, which is not fully supported, may not be appropriate for this reach. New Mexico may determine this during the 2014 listing cycle.

Las Huertas Creek, the perennial portions in the reach from Santa Ana Pueblo to the headwaters (assessment unit NM-2108.5_00) were last assessed by NMED (2012) in 2008. The designated use of high quality coldwater aquatic life is not supported in this reach as determined by nutrient and turbidity indicators. This designated use of a high-quality cold-water aquatic life may not be appropriate under current conditions. As with Bluewater Creek, NMED needs to reassess this listed use. Probable sources of impairment include flow alterations from water diversions, on-site treatment systems, streambank modifications/destabilizations, waste from pets, and unknown sources.

There are also several designated Outstanding National Resource Waters (ONRW), as designated by NMED, within the plan area. All of these are within the Apache Kid Wilderness in the San Mateo Mountains on the Magdalena ranger district. These waters include streams and wetlands as shown on the map below, Figure 32. Smith Canyon and Indian Creek have been designated as ONRW streams. These segments are 1.4 miles each, for a total of 2.8 miles. Sixteen areas within the Apache Kid Wilderness have been designated as ONRW wetlands, totaling 21.9 acres. Nonpoint sources of pollution in these areas must be minimized and controlled through the use of Best Management Practices (BMPs).

Springs

Springs on the Cibola National Forest are a valuable, but limited resource. Water in springs comes from groundwater. The flow paths through the subsurface are complex and can take from weeks to years to travel to the point of emergence (Stevens and Meretsky 2008). Water from springs supports ecosystems, often in locations where no other water is available. Consequently, these areas are very important for supporting plants and animals in these areas.

On the Cibola, springs are often the only natural water source during the summer. These springs supply water to streams as well. An assessment using GIS showed that over 80 percent of the streams on the Cibola’s mountain districts depend on springs for their water supply. This information was obtained using the spring and stream databases from the National Hydrology Dataset (USGS 2010). Because of this high percentage of streams dependent on springs for their water supply, understanding spring processes and monitoring the effects of climate change and land management decisions is crucial to maintaining these ecosystems.

There are 367 springs within the plan area. Some areas have more springs than others (Figure 33). There are only 3 springs in the Gallinas Mountains, while the Manzanos have 84 springs. The character of the springs is not well known. It is likely many of these springs are dry or only flow for short periods of time, or flow in high precipitation years.

Type of Springs

A spring classification system developed by Springer and others (2008) was applied to the springs within the plan area. A short assessment with a focus on sustainability was done in 2010 (Crowley 2010). Many springs are rheocrene, which means they are located along stream channels.

Table 23 summarizes the spring types and associated spheres of discharge found on the Cibola National Forest using the classification developed by Springer and others (2008). An inventory of these springs is ongoing. The Cibola has been working with the University of New Mexico to inventory springs across the forest and grasslands. This inventory provides basic information about springs and their associated surface and ground waters, using protocols developed by the U.S. Forest Service and other researchers (USFS 2012, Springer et al. 2008). Location, flow, chemistry and management status are some of the attributes to be collected.

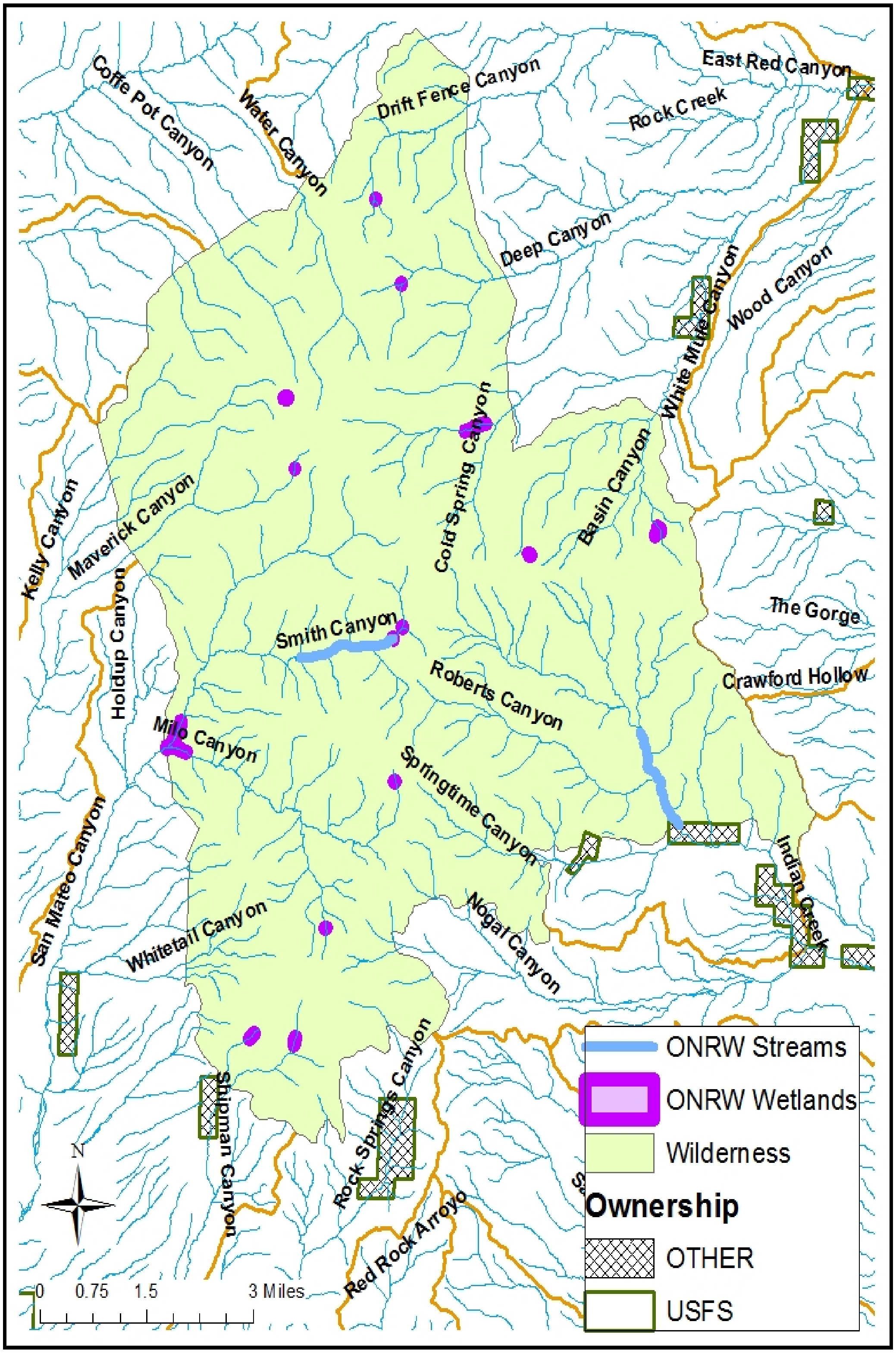


Figure 32. Outstanding National Resource Waters (ONRW) within the plan area.

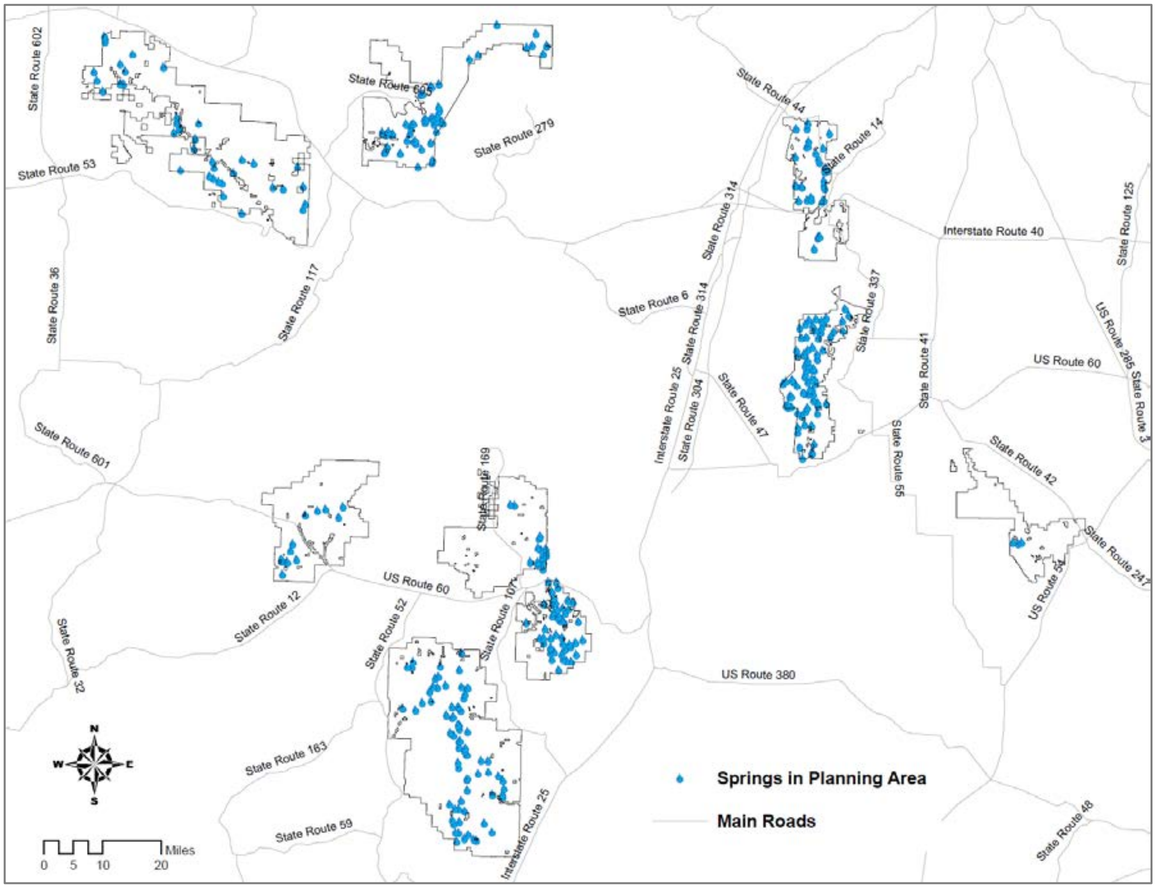


Figure 33. Springs on the Cibola.

Table 23. Spring types on the Cibola.

Spring Type	Sphere of Discharge (emergence setting and hydrogeology)
Hanging Garden	Dripping flow emerges usually horizontally along a geologic contact along a cliff wall of a perched unconfined aquifer
Hillslope	Emerges from confined or unconfined aquifers on a hillslopes (30-60° slope), often indistinct or multiple sources
Hypocrene	A buried spring where flow does not reach the surface, typically due to very low discharge and high evaporation or transpiration
(Carbonate) Mound Form	Emergences from a mineralized mound, frequently at magmatic or fault systems
Rheocrene	Flowing spring, emerges into one or more stream channels

In 2012, 49 springs were inventoried for characteristics and condition. This includes 19 springs on the Sandia ranger district. Of these springs, four were dry. On the Mount Taylor ranger district, 30 springs were assessed in the Zuni Mountains and 19 were dry at the time of the site visit. In the Zunis, Agua

Ramora is being monitored more extensively due to its importance to the Zuni Bluehead Sucker, a rare native fish recently listed as endangered under the federal Endangered Species Act.

Current and Historical Condition

Currently, of these 367 springs, over 80 percent of these springs have been developed for livestock use. Additional springs have been developed for drinking water and wildlife use. When springs are developed, the spring ecosystem is usually not maintained based on results of the ongoing spring inventory and field visits to springs by Forest personnel. Using GIS and available data, it is estimated that less than 10 percent of the springs within the plan area have intact ecosystems.

Historically, springs were not developed and the water from springs supported ecosystems according to each spring's potential. For example, Cienega Springs in the Sandia Mountains used to support stream flows and a riparian and wetland complex. Currently, much of the water from this spring system is piped to Sandia Park for public water supply. Another example, in the Gallinas Mountains, where there was a spring system on the east side that was developed for the railroad. Currently, this system is dewatered through groundwater withdrawals from a well that supplies the community of Corona with water. More seasonal springs are impacted by the drought, and in the long-term, by climate changes.

Water quality in the springs remains good and meets water quality standards. Since springs are supplied by waters which emerge from the ground, and have been filtered through soil and bedrock, the water quality tends to be good. It is likely that some springs have higher concentrations of trace elements (such as arsenic) but these are related to bedrock chemistry, rather than contaminants from management activities.

Figure 34 shows the percentage of the springs within each 12-digit hydrologic unit (HUC-12) watershed that is within the plan area. Within the 12-digit hydrologic units that intersect the plan area, the percent of springs on NFS lands in these watersheds varies from no springs to 100 percent in the watershed located in the plan area. This map shows the importance of the plan area for springs as a source of water in the larger regional context.

Spatial Context of Perennial Waters – Springs and Streams

While there are 6,204.4 miles of mapped stream channels (USGS 2010) in the plan area, only 24.8 miles are perennial and 844.7 miles are intermittent. The reason for this scarcity is that the potential for evaporation is much greater than precipitation in the entire state of New Mexico (NOAA 1985). When use of water by plants is added, called evapotranspiration, most precipitation is used by plants and/or simply vaporizes into the air.

Water in streams generally comes from runoff during rainfall events, snowmelt, and/or spring flow. As discussed, rheocrene springs support much of the perennial flow within the plan area. Within the mountains, local hillslope processes prevail, whereas in the larger 12-digit HUC, surface flows are the result of increasing proportions of groundwater contributions as watershed size increases (Frisbee et al. 2011). The surface and shallow subsurface flow paths in the mountains result in springs, given the right conditions.

Figure 35 shows the percentage of perennial water (springs and perennial streams) in 12-digit HUCs within the Cibola. This information shows a higher percentage of springs than perennial streams in the plan area. This is not surprising since most perennial water within the plan area is dependent on spring flows and local water tables. This highlights the importance of local recharge processes for providing water in the mountains of the plan area.

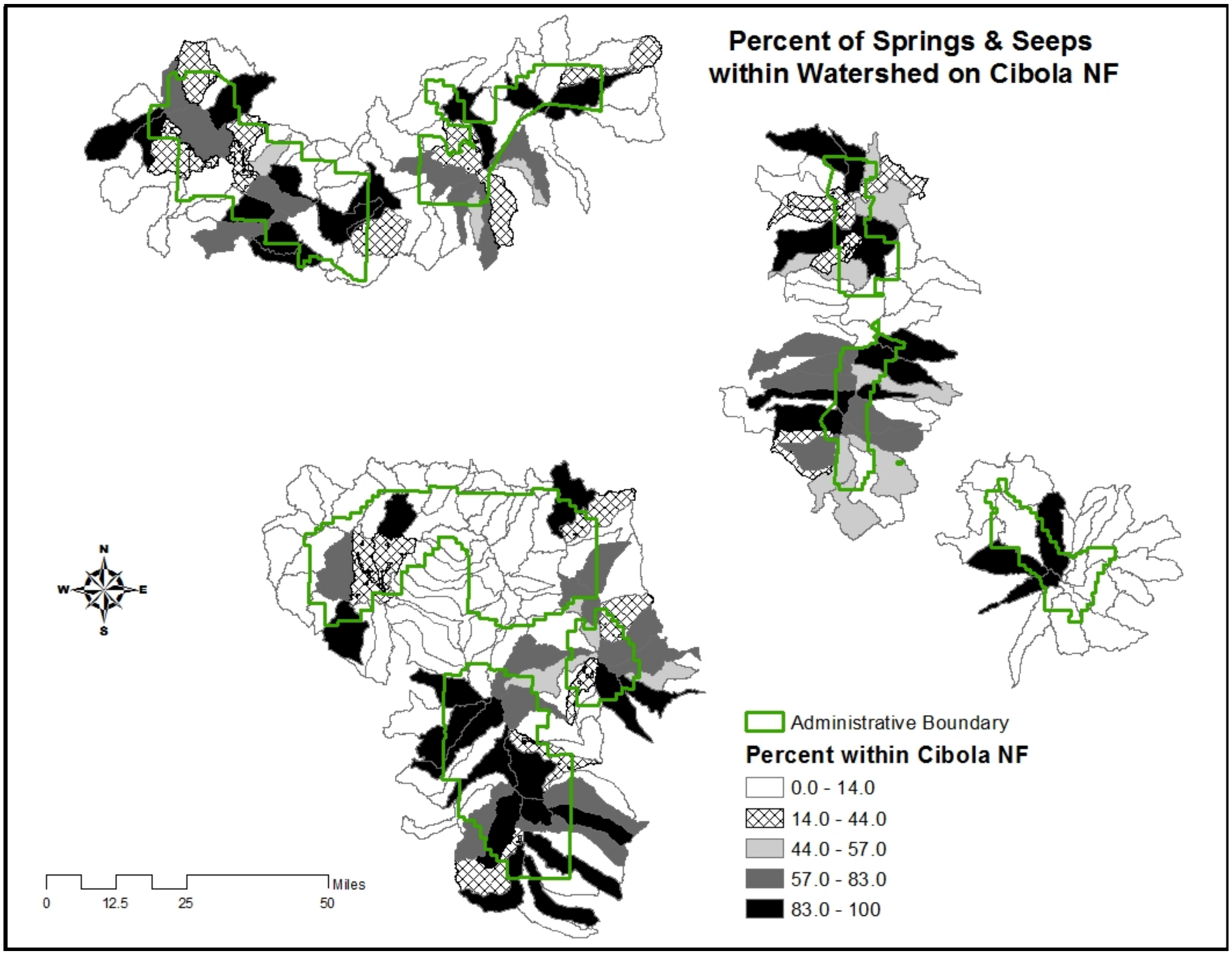


Figure 34. Percentage of springs in the plan area of total springs in each 12-digit hydrologic unit (HUC-12) watershed.

To provide additional information on context, the representativeness of springs and perennial streams was assessed. Representativeness is a measure of how the distributions of water resource features within the plan area are characteristic for the resource across subwatersheds, the 12-digit scale. Table 24 lists the calculated representativeness for each 12-digit subwatershed (HUC-6) that intersects the plan area. Where there are few features located within the plan area but a high percentage of plan area within the subwatershed, these features are considered underrepresented. Where there are more features within the plan area relative to the proportion of the HUC within the plan area, water resource features are considered overrepresented. Subwatersheds with representative amounts of water resource features are those where the percent of features on the forest is similar to the percent of features found outside of the plan area. There are two ways a representative rating can occur. When the actual percent of features and plan area in the subwatershed are low, this is representative-low. Subwatersheds with a high percentage of features with a high percentage of plan area in the subwatersheds are rated as representative-high. These are distinguished in (Table 24) because it is important to recognize when a feature is abundant even if it is representative.

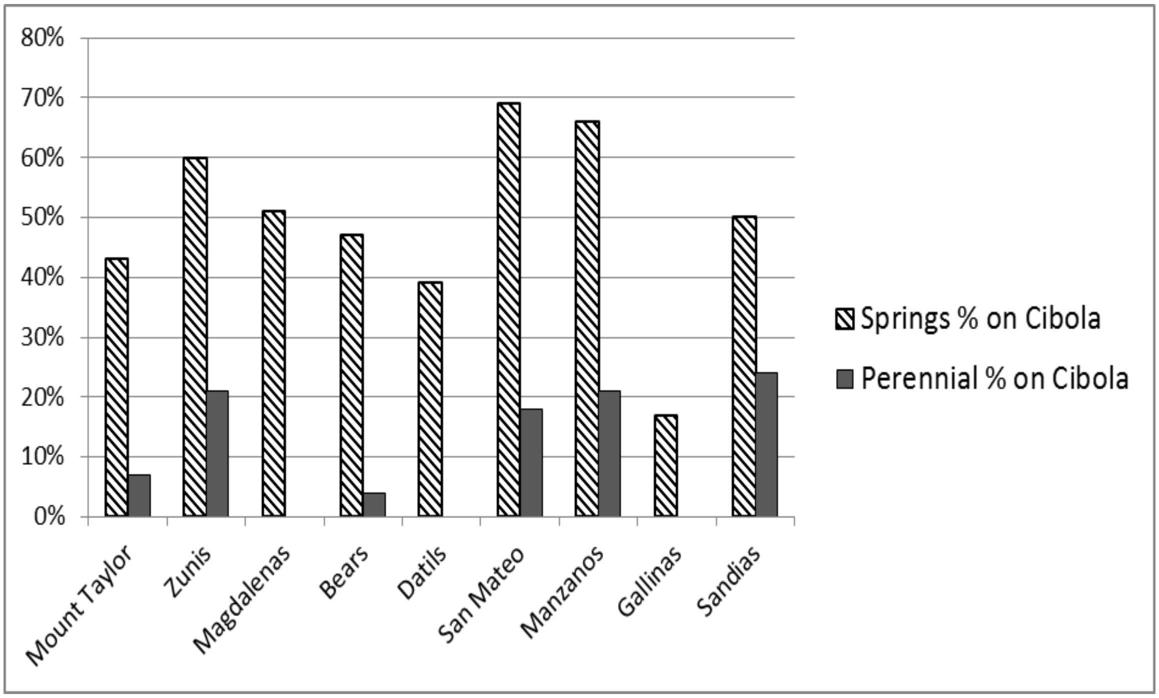


Figure 35. Percent of perennial water (springs and streams) in 12-digit HUCs intersecting plan area.

Table 24. Watersheds and data on perennial streams and springs by Geographic Area (GA). Data from the National Hydrography Dataset and have not been completely ground-truthed.

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Bear Mtns	Durfee Canyon 1302020801	Tres Montosas 130202080102	0	0	0	0	0	0	none	none
Bear Mtns	Middle Rio Salado 1302020905	Jaralosa Creek 130202090505	3	0	0	0	0	0	none	none
Bear Mtns	La Jencia Creek 1302020906	Gallinas Canyon 130202090601	1	0	0	0	0	0	none	none
Bear Mtns		Arroyo Montosas 130202090602	0	0	0	0	0	0	none	none
Bear Mtns		Dry Lake Canyo130202090603	0	0	0	<0.1	<0.1	100	none	representative-high
Bear Mtns		Goat Spring 130202090607	12	9	75	0	0	0	over	none
Bear Mtns		Outlet La Jencia Creek 130202090608	11	0	0	0	0	0	none	none
Bear Mtns	Lower Rio Salado 1302020907	La Jara Canyon 130202090701	1	0	0	0	0	0	none	none
Bear Mtns		Canon del Alamito-Rio Salado 130202090702	1	1	100	5.7	<0.1	<1	over	under
Bear Mtns		Baca Canyon-Rio Salado 130202090703	3	1	33	0	0	0	representative-low	none
Bear Mtns		Bear Springs Canyon 130202090704	3	0	0	0.9	0.9	100.0	none	representative-high

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Bear Mtns		Bear Spring Canyon-Rio Salado 130202090705	3	0	0	0	0	0	none	none
Datil Mtns	Veteado Draw 1302020602	Newton Draw 130202060201	1	0	0	0	0	0	none	none
Datil Mtns		Headwaters Veteado Draw 130202060202	0	0	0	0	0	0	none	none
Datil Mtns	White Lake 1302020802	Little Well 130202080203	0	0	0	0	0	0	none	none
Datil Mtns		Rincon Draw 130202080204	0	0	0	0	0	0	none	none
Datil Mtns		High Lonesome Well 130202080205	0	0	0	0	0	0	none	none
Datil Mtns		Main Canyon 130202080206	7	3	43	0	0	0	under	none
Datil Mtns		Headwaters White House Canyon 130202080207	5	2	40	0	0	0	under	none
Datil Mtns		Outlet White House Canyon 130202080208	0	0	0	0	0	0	none	none
Datil Mtns		White Lake 130202080209	0	0	0	0	0	0	none	none
Datil Mtns	Nester Draw 1302020804	Pino Draw 130202080402	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Datil Mtns		Headwaters Z Slash Draw 130202080405	9	6	67	0	0	0	representative-high	none
Datil Mtns		Outlet Z Slash Draw 130202080406	0	0	0	0	0	0	none	none
Datil Mtns	Sugar Loaf Canyon 1302020805	Sugar Loaf Canyon 130202080501	1	1	100	0	0	0	over	none
Datil Mtns		Montoya Well 130202080502	0	0	0	0	0	0	none	none
Datil Mtns		New Well 130202080503	0	0	0	0	0	0	none	none
Datil Mtns	Alamocita Creek 1302020901	Third Canyon-Alamocita Creek 130202090101	0	0	0	0	0	0	none	none
Datil Mtns		Ox Spring Canyon 130202090102	0	0	0	0	0	0	none	none
Datil Mtns		Red Canyon 130202090103	1	1	100	0	0	0	representative-high	none
Datil Mtns		Ox Spring Canyon-Alamocita Creek 130202090104	0	0	0	0	0	0	none	none
Datil Mtns		Pasture Canyon-Alamocita Creek 130202090105	0	0	0	0	0	0	none	none
Datil Mtns		Blue Mesa Canyon-Alamocita Creek 130202090106	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Datil Mtns	Middle Rio Salado 1302020905	Dog Springs Canyon 130202090501	0	0	0	0	0	0	none	none
Datil Mtns	Rito Creek 1502000301	Tres Lagunas Draw 150200030104	0	0	0	0	0	0	none	none
Gallinas Mtns	Pueblo Blanca Canyon 1305000107	Pueblo Blanca Canyon 130500010702	0	0	0	0	0	0	none	none
Gallinas Mtns		Little Cougar Tank 130500010703	0	0	0	0	0	0	none	none
Gallinas Mtns		Gallinas Spring 130500010704	1	1	100	0	0	0	over	none
Gallinas Mtns		Town of Progresso 130500010706	0	0	0	0	0	0	none	none
Gallinas Mtns	Mesa de Los Jumanos 1305000108	Rock Lake 130500010802	0	0	0	0	0	0	none	none
Gallinas Mtns		Haygood Tank 130500010803	0	0	0	0	0	0	none	none
Gallinas Mtns		Atkinson Flats 130500010804	1	1	100	0	0	0	over	none
Gallinas Mtns	Chavez Draw 1305000109	Martin Canyon 130500010904	0	0	0	0	0	0	none	none
Gallinas Mtns	Town of Cedarvale 1305000202	Town of Cedarvale 130500020202	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Gallinas Mtns		Pinos Well Cemetary130500020203	2	0	0	0	0	0	none	none
Gallinas Mtns		Going Thing Ranch130500020204	0	0	0	0	0	0	none	none
Gallinas Mtns	Sacate Draw 1305000301	Town of Claunch 130500030105	1	1	100	0	0	0	over	none
Gallinas Mtns	Largo Canyon 1305000302	Upper Largo Canyon 130500030201	0	0	0	0	0	0	none	none
Gallinas Mtns		Pinatosa Canyon 130500030204	0	0	0	0	0	0	none	none
Gallinas Mtns	Camaleon Draw 1306000302	Headwaters Camaleon Draw 130600030204	0	0	0	0	0	0	none	none
Gallinas Mtns	Bonita Canyon 1306000601	Upper Bonita Canyon 130600060101	0	0	0	0	0	0	none	none
Gallinas Mtns		South Wall Canyon 130600060102	0	0	0	0	0	0	none	none
Gallinas Mtns	Cola de Gallo Arroyo 1306000602	Rattlesnake Hill-Cola de Gallo River 130600060201	0	0	0	0	0	0	none	none
Gallinas Mtns	Headwaters Gallo Arroyo 1306000603	City of Corona-Gallo Canyon 130600060301	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Magdalena Mtns	Arroyo de La Matanza-Rio Grande 1302020310	Shakespeare Canyon 130202031001	40	14	35	0	0	0	representative-low	none
Magdalena Mtns		Nogal Arroyo 130202031002	14	9	64	0	0	0	representative-high	none
Magdalena Mtns		Arroyo de La Matanza 130202031005	7	5	71	0	0	0	over	none
Magdalena Mtns	Walnut Creek-Rio Grande 1302020311	Red Canyon 130202031101	2	1	50	0	0	0	over	none
Magdalena Mtns		Walnut Creek 130202031103	1	1	100	0	0	0	over	none
Magdalena Mtns	Tiffany Canyon-Rio Grande 1302020312	Sawmill Canyon 130202031205	15	13	87	0	0	0	over	none
Magdalena Mtns	La Jencia Creek 1302020906	Headwaters Arroyo Gato 130202090604	0	0	0	0	0	0	none	none
Magdalena Mtns		Outlet Arroyo Gato 130202090605	2	1	50	0	0	0	representative-low	none
Magdalena Mtns		Headwaters La Jencia Creek 130202090606	9	6	67	0	0	0	representative-high	none
Magdalena Mtns	Milligan Gulch 1302021102	Big Rosa Canyon-Milligan Gulch 130202110205	7	3	43	0	0	0	representative-low	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Magdalena Mtns		Puertecito Arroyo 130202110206	2	0	0	0	0	0	none	none
Manzano Mtns	Hells Canyon Wash 1302020304	Middle Hells Canyon 130202030402	1	0	0	0	0	0	none	none
Manzano Mtns		Ojito Canyon 130202030407	5	4	80	0	0	0	over	none
Manzano Mtns		Garcia Canyon 130202030408	4	3	75	0	0	0	over	none
Manzano Mtns		La Canada d La Loma de Arena 130202030409	10	7	70	0	0	0	over	none
Manzano Mtns	Abo Arroyo 1302020305	Canon Barranco-Abo Arroyo 130202030501	6	3	50	0	0	0	over	none
Manzano Mtns		Deer Canyon-Abo Arroyo 130202030502	4	0	0	0	0	0	none	none
Manzano Mtns		Canon Saladito-Abo Arroyo 130202030504	9	5	56	0	0	0	over	none
Manzano Mtns		Priest Canyon-Abo Arroyo 130202030505	16	9	56	0	0	0	representative-high	none
Manzano Mtns		Pipe Canyon 130202030506	3	2	67	0	0	0	over	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Manzano Mtns		Ojo Barreras 130202030507	5	2	40	0	0	0	over	none
Manzano Mtns	Canon Monte Largo-Rio Grande 1302020306	Arroyo del Cuervo 130202030605	6	6	100	0	0	0	over	none
Manzano Mtns		Canon Monte Largo 130202030606	8	8	100	0	0	0	over	none
Manzano Mtns		Canon Monte Largo-Rio Grande 130202030607	1	0	0	0	0	0	none	none
Manzano Mtns	Lower Salt Draw 1305000104	Arroyo de Chilili 130500010402	3	0	0	0	0	0	none	none
Manzano Mtns	Arroyo de Manzano 1305000110	Mesteno Draw 130500011001	10	7	70	0	0	0	over	none
Manzano Mtns		Upper Arroyo de Manzano 130500011002	13	10	77	0	0	0	over	none
Manzano Mtns		Middle Arroyo de Manzano 130500011003	0	0	0	0	0	0	none	none
Manzano Mtns	Torreon Draw 1305000111	Arroyo del Cuervo 130500011101	2	2	100	0	0	0	over	none
Manzano Mtns		Arroyo de Tajique 130500011102	10	9	90	3.6	2.4	67	over	over

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Manzano Mtns		Milbourn Draw 130500011103	1	1	100	0	0	0	over	none
Manzano Mtns		Torreon Draw 130500011104	11	6	55	0	0	0	over	none
Mt Taylor	Hay Meadow Canyon-Rio Puerco 1302020404	Guadalupe Canon-Rio Puerco 130202040401	8	0	0	0	0	0	none	none
Mt Taylor		Canon Tapia 130202040402	7	6	86	0.7	0.3	43	over	over
Mt Taylor		Canon del Camino-Rio Puerco 130202040403	3	1	33	0	0	0	representative-low	none
Mt Taylor		Canon Jara Lobo-Rio Puerco 130202040404	7	0	0	0	0	0	none	none
Mt Taylor		Hay Meadow Canyon-Rio Puerco 130202040405	0	0	0	0	0	0	none	none
Mt Taylor	San Miguel Creek 1302020501	San Lucas Canyon 130202050101	12	11	92	0	0	0	representative-high	none
Mt Taylor		Headwaters San Miguel Creek 130202050102	7	1	14	0	0	0	under	none
Mt Taylor		Canon El Dado 130202050103	2	2	100	0	0	0	over	none
Mt Taylor		Arroyo Sarcio 130202050104	3	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Mt Taylor		Outlet San Miguel Creek 130202050105	7	0	0	0	0	0	none	none
Mt Taylor	Headwaters Arroyo Chico 1302020502	Arroyo Tinaje 130202050205	1	0	0	0	0	0	none	none
Mt Taylor	Outlet Arroyo Chico 1302020507	Arroyo Seccion 130202050702	8	1	13	0	0	0	under	none
Mt Taylor	San Mateo Creek 1302020703	Upper San Mateo Creek 130202070301	19	8	42	0	0	0	under	none
Mt Taylor		Arroyo del Puerta 130202070303	0	0	0	0	0	0	none	none
Mt Taylor		Middle San Mateo Creek 130202070304	0	0	0	0	0	0	none	none
Mt Taylor		Lobo Creek 130202070305	16	12	75	0	0	0	representative-high	none
Mt Taylor		Lower San Mateo Creek 130202070306	0	0	0	0	0	0	none	none
Mt Taylor		Stanley and Carol Ranch 130202070307	0	0	0	0	0	0	none	none
Mt Taylor	Upper Rio San Jose 1302020704	Log Cabin Canyon-Rio San Jose 130202070405	1	0	0	0	0	0	none	none
Mt Taylor		Horace Mesa-Rio San Jose 130202070406	1	0	0	0	0	0	none	none
Mt Taylor	Middle Rio San Jose 1302020706	Tafoya Canyon-Rio San Jose 130202070603	2	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Mt Taylor		Rinconada Creek 130202070604	4	3	75	6.9	5.2	75	representative-high	representative-high
Mt Taylor		San Jose Canyon 130202070606	2	1	50	0	0	0	over	none
Mt Taylor		Castillo Canyon 130202070607	3	1	33	11.6	1.1	9	over	representative-low
Mt Taylor		Canon Seco-Rio San Jose 130202070608	3	2	67	0	0	0	over	none
Mt Taylor	Rio Paguate 1302020707	Seboyetita Creek 130202070701	2	1	50	0	0	0	over	none
Mt Taylor		Seboyeta Creek 130202070702	5	4	80	0	0	0	over	none
Mt Taylor	Arroyo Conchas 1302020708	Canada de Pedro Padilla 130202070801	0	0	0	0	0	0	none	none
San Mateo Mtns	Durfee Canyon 1302020801	Wolf Wells 130202080101	0	0	0	0	0	0	none	none
San Mateo Mtns		Durfee Canyon 130202080103	0	0	0	0	0	0	none	none
San Mateo Mtns		East Well 130202080104	0	0	0	0	0	0	none	none
San Mateo Mtns	C-N Lake 1302020803	Clemente Lake 130202080301	0	0	0	0	0	0	none	none
San Mateo Mtns		White Well130202080302	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
San Mateo Mtns		Point of Rocks Canyon130202080303	3	3	100	0	0	0	representative-high	none
San Mateo Mtns		Taylor Well130202080305	0	0	0	0	0	0	none	none
San Mateo Mtns	East Red Canyon 1302021101	Headwaters East Red Canyon 130202110101	17	16	94	0.3	0.3	100	representative-high	representative-high
San Mateo Mtns		Outlet East Red Canyon 130202110102	10	4	40	0	0	0	under	none
San Mateo Mtns	Milligan Gultch 1302021102	Rock Springs-Milligan Gultch 130202110201	3	2	67	0	0	0	over	none
San Mateo Mtns		Mill Canyon-Milligan Gultch 130202110202	4	2	50	0	0	0	representative-low	none
San Mateo Mtns		Alemeda Spring-Milligan Gultch 130202110203	1	0	0	0	0	0	none	none
San Mateo Mtns		Big Rosa Canyon 130202110204	6	5	83	0	0	0	representative-high	none
San Mateo Mtns		Puertecito Arroyo-Milligan Gultch 130202110207	0	0	0	0	0	0	none	none
San Mateo Mtns		Tenmile Hill-Milligan Gultch 130202110208	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
San Mateo Mtns	Milligan Gultch-Rio Grande 1302021103	Simon Canyon 130202110303	0	0	0	0	0	0	none	none
San Mateo Mtns		Lumbre Canyon-Rio Grande 130202110306	3	2	67	0	0	0	over	none
San Mateo Mtns		Crawford Hollow-Rio Grande 130202110307	1	1	100	0	0	0	over	none
San Mateo Mtns	San Jose Arroyo-Rio Grande 1302021105	Indian Creek 130202110501	1	1	100	3.8	3.2	84	representative-high	representative-high
San Mateo Mtns		Nogal Canyon-Rio Grande 130202110502	3	2	67	0	0	0	over	none
San Mateo Mtns		Cuervo Canyon-Rio Grande 130202110503	0	0	0	0	0	0	none	none
San Mateo Mtns		San Jose Arroyo-Rio Grande 130202110504	2	2	100	0	0	0	over	none
San Mateo Mtns	Headwaters Alamosa Creek 1302021106	Limestone Canyon-Alamosa Creek 130202110601	1	1	100	0	0	0	over	none
San Mateo Mtns		Big Pigeon Canyon-Alamosa Creek 130202110602	9	9	100	0	0	0	representative-high	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
San Mateo Mtns		Little Pigeon Canyon-Alamosa Creek 130202110603	0	0	0	0	0	0	none	none
San Mateo Mtns		Whitewater Canyon-Alamosa Creek 130202110604	0	0	0	0	0	0	none	none
San Mateo Mtns		West Red Canyon 130202110605	5	5	100	0	0	0	representative-high	none
San Mateo Mtns		Sim Yaten Canyon-Alamosa Creek 130202110607	0	0	0	0	0	0	none	none
San Mateo Mtns		Wildhorse Canyon-Alamosa Creek 130202110609	4	0	0	0	0	0	none	none
San Mateo Mtns	Outlet Alamosa Creek 1302021107	Grapevine Canyon-Alamosa Creek 130202110701	3	2	67	0	0	0	representative-high	none
San Mateo Mtns		San Mateo Canyon-Alamosa Creek 130202110702	8	8	100	5.3	1.4	26	representative-high	under
San Mateo Mtns		Garcia Falls-Alamosa Creek 130202110703	14	4	29	0	0	0	representative-low	none
San Mateo Mtns		Carada de Ila-Alamosa Creek 130202110704	4	4	100	0	0	0	over	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
San Mateo Mtns		Elephant Butte Reservoir-Alamosa Creek 130202110705	2	0	0	0	0	0	none	none
San Mateo Mtns	Elephant Butte Reservoir-Rio Grande 1302021108	Romero Canyon 130202110801	2	0	0	0	0	0	none	none
San Mateo Mtns		Mitchell Canyon 130202110802	2	2	100	0	0	0	over	none
Sandia Mtns	Arroyo Tonque 1302020105	Headwaters San Pedro Creek 130202010501	11.000000	6.000000	55.000000	0	0	0	over	none
Sandia Mtns		Outlet San Pedro Creek 130202010502	6	2	33	0	0	0	over	none
Sandia Mtns		Canon Tejon 130202010505	2	1	50	0	0	0	representative-low	none
Sandia Mtns	Arroyo Tonque-Rio Grande 1302020106	Las Huertas Creek 130202010610	7	6	86	4	2.6	65	representative-high	representative-high
Sandia Mtns	Arroyo de Las Calabacillas-Rio Grande 1302020301	Arroyo Venado-Rio Grande 130202030101	2	2	100	0	0	0	over	none
Sandia Mtns		Sandia Wash-Rio Grande 130202030104	4	0	0	0	0	0	none	none
Sandia Mtns		Town of Corrales-Rio Grande 130202030107	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Sandia Mtns	Tijeras Arroyo 1302020302	Upper Tijeras Arroyo 130202030201	6	6	100	0	0	0	over	none
Sandia Mtns		Middle Tijeras Arroyo 130202030202	11	4	36	0	0	0	representative-low	none
Sandia Mtns		Lower Tijeras Arroyo 130202030203	7	4	57	0	0	0	representative-high	none
Sandia Mtns	City of Albuquerque-Rio Grande 1302020303	Arroyo de Domingo 130202030301	3	1	33	0	0	0	representative-low	none
Sandia Mtns		Arroyo del Pino 130202030302	9	4	44	1.4	0.5	36	representative-low	representative-low
Sandia Mtns		City of Albuquerque 130202030304	1	1	100	0	0	0	over	none
Sandia Mtns	Hells Canyon Wash 1302020304	Upper Hells Canyon Wash 130202030401	4	0	0	0	0	0	none	none
Sandia Mtns		130202030403	0	0	0	0	0	0	none	none
Sandia Mtns		Hubbell Spring 130202030404	0	0	0	0	0	0	none	none
Sandia Mtns	Middle Salt Draw 1305000103	Juan Tomas Canyon 130500010301	0	0	0	0	0	0	none	none
Sandia Mtns	Lower Salt Draw 1305000104	Arroyo de Yrisam 130500010401	1	0	0	0	0	0	none	none
Zuni Mtns	Log Cabin Canyon 1302020607	Agua Fria Creek 130202060704	0	0	0	0	0	0	none	none
Zuni Mtns		Bonita Canyon 130202060705	0	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Zuni Mtns		Log Cabin Canyon 130202060706	5	2.	40.	0	0	0	over	none
Zuni Mtns	Bluewater Creek 1302020702	Agua Medio-Bluewater Creek 130202070201	5	4	80	0	0	0	representative-high	none
Zuni Mtns		Headwaters Cottonwood Creek 130202070202	16	6	38	0	0	0	under	none
Zuni Mtns		Sawyer Creek 130202070203	2	1	50	0	0	0	under	none
Zuni Mtns		Outlet Cottonwood Creek 130202070204	0	0	0	0	0	0	none	none
Zuni Mtns		Ojo Redondo-Bluewater Creek 130202070205	2	2	100	2.2	2.2	100	representative-high	representative-high
Zuni Mtns		Bluewater Lake-Bluewater Creek 130202070206	0	0	0	5.60	4.5	80	none	representative-high
Zuni Mtns		Reynold Draw-Bluewater Creek 130202070207	0	0	0	0	0	0	none	none
Zuni Mtns	Upper Rio San Jose 1302020704	Limekiln Canyon 130202070401	0	0	0	0	0	0	none	none
Zuni Mtns		Prop Canyon-Rio San Jose 130202070402	0	0	0	0	0	0	none	none
Zuni Mtns		Zuni Canyon 130202070403	2	2	100	0	0	0	representative-high	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Zuni Mtns		Zuni Canyon-Rio San Jose 130202070404	2	2	100	0	0	0	over	none
Zuni Mtns	Cebolla Creek 1502000401	Muerto Canyon 150200040101	2	2	100	0	0	0	over	none
Zuni Mtns		Togeye Canyon 150200040102	0	0	0	0	0	0	none	none
Zuni Mtns		Cebolla Creek 150200040103	1	0	0	0	0	0	none	none
Zuni Mtns	Rio Nutria 1502000402	Upper Rio Nutria 150200040201	4	3	75	0	0	0	representative-high	none
Zuni Mtns		Stinking Spring 150200040202	1	1	100	0	0	0	over	none
Zuni Mtns		Middle Rio Nutria 150200040203	3	1	33	0	0	0	representative-low	none
Zuni Mtns		Lower Rio Nutria 150200040205	0	0	0	0	0	0	none	none
Zuni Mtns	Cebolla Creek-Rio Pescado 1502000403	Valle Largo 150200040305	1	1	100	0	0	0	over	none
Zuni Mtns		Monument Lake 150200040306	1	1	100	0	0	0	over	none
Zuni Mtns		Togeye Lake 150200040307	4	3	75	<0.1	<0.1	100	over	over
Zuni Mtns		Pescado Draw-Rio Pescado 150200040310	2	0	0	0	0	0	none	none

GA	HUC-5	HUC-6	Springs in HUC-6	Springs on FS in HUC-6	% Springs on FS in HUC-6	Perennial Streams in HUC-6 (miles)	Perennial Streams on FS in HUC-6 (miles)	% Perennial Streams on FS in HUC-6	Representativeness of Springs	Representativeness of Perennial Streams
Zuni Mtns	South Fork Puerco River 1502000601	Smith Canyon-South Fork Puerco River 150200060101	1	1	100	0	0	0	over	none
Zuni Mtns		Fourmile Canyon-South Fork Puerco River 150200060102	0	0	0	0	0	0	none	none
Zuni Mtns		Milk Ranch Canyon 150200060103	5	4	80	0	0	0	representative-high	none
Zuni Mtns		Milk Ranch Canyon-South Fork Puerco River 150200060104	3	1	33	0	0	0	representative-low	none
Zuni Mtns	Defiance Draw-Puerco River1502000604	Headwaters Bread Springs Wash150200060401	0	0	0	0	0	0	none	none
Zuni Mtns	Whitewater Arroyo 1502000605	Skeets Arroyo-Whitewater Arroyo 150200060501	1	1	100	0	0	0	over	none

The data on representativeness is shown in Figure 36 and Figure 37 for perennial streams and springs. These two features have different patterns of representativeness.

Perennial streams are not common, yet there are three subwatersheds that are overrepresented due to most of the perennial stream segments being located within the plan area relative to the amount of National Forest Lands within the subwatershed. These are located in the Zuni Mtns, Mt Taylor, and Manzano Mtns Geographic Areas (GAs). This highlights the importance of the plan area in these subwatersheds as a source of perennial streams since most of the resource is in the plan area. One subwatershed in the San Mateo Mtns GA on the Magdalena RD is underrepresented since most of the perennial stream segments in that watershed are located outside of the plan area. In this watershed, conditions are largely outside of the influence of the Plan. Representative subwatersheds are located in every GA except the Gallinas Mtns. In these watersheds, the amount of perennial stream segments is commensurate with the amount of land in the plan area. In these subwatersheds, the focus is on maintaining ecological integrity and addressing problem areas.

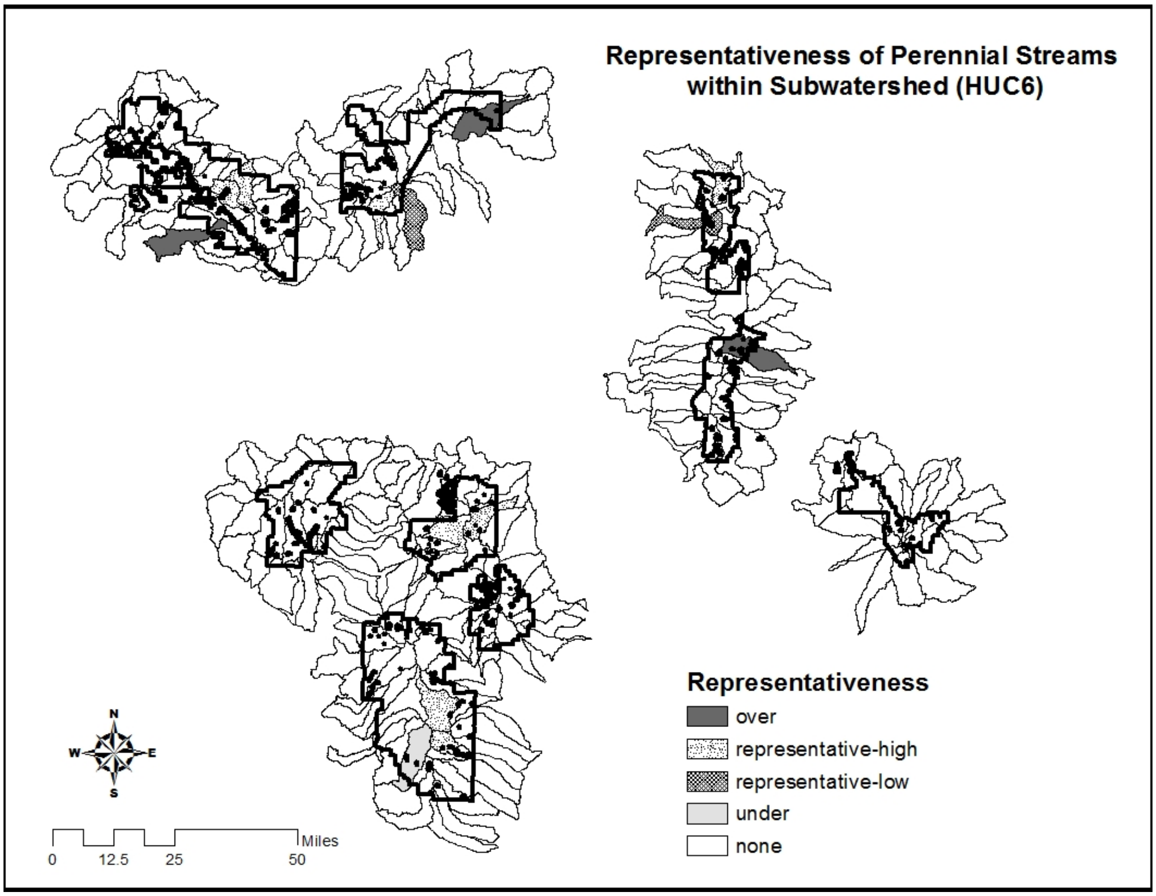


Figure 36. Representativeness of perennial streams within subwatersheds in the plan area.

As discussed previously, springs are located across the plan area. The pattern of representativeness for springs is more complex than for perennial streams. Eight subwatersheds are underrepresented, with fewer springs than would be expected considering the amount of area in the plan area. As with perennial streams, the ability to influence sustainability is limited in these subwatersheds. Twenty three subwatersheds are representative with high percentages of springs and associated plan area. Thirteen subwatersheds are representative – low, having small percentages on small fractions of plan area. The focus for springs in these watersheds is maintaining ecological conditions and addressing problems as they arise.

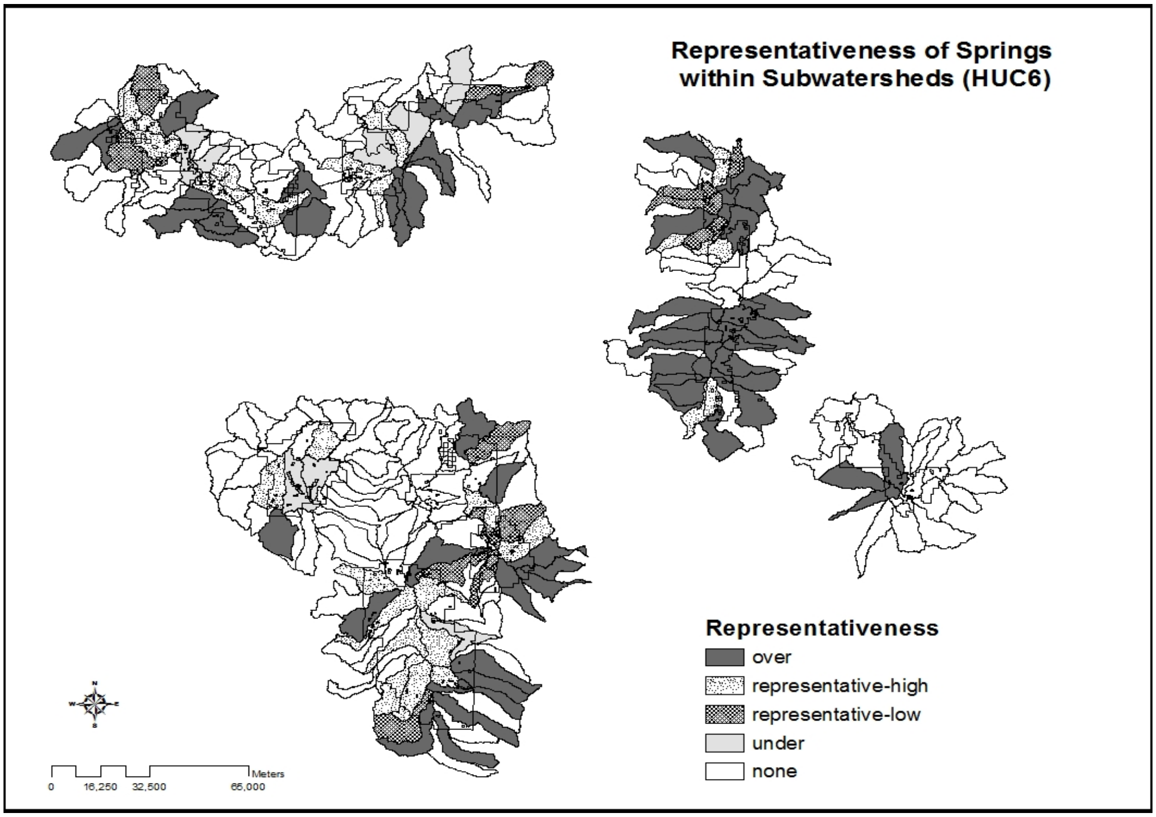


Figure 37. Representativeness of springs within subwatersheds in the plan area.

Of particular interest, are the fifty four subwatersheds that are overrepresented for springs—these occur in every GA (Table 25). There are a greater percentage of springs in these subwatersheds than would be expected considering the plan area within those subwatersheds. Even though the amount of National Forest Service Lands in these watersheds is relatively low, the amount of springs is high. In these subwatersheds, there is a greater responsibility to protect and maintain these springs due to their importance to the entire subwatershed. The remaining subwatersheds with springs are representative. Twenty three of these have high percentages of springs and high percentages of plan area. Thirteen have lower amounts. The Plan can influence conditions in these watersheds more easily. These subwatersheds are important to maintain and address problem areas as needed.

Table 25. Overrepresented subwatersheds for springs by Geographic Area.

Geographic Area (GA)	Number of Overrepresented Subwatersheds
Bear Mtns	2
Datil Mtns	1
Gallinas Mtns	3

Geographic Area (GA)	Number of Overrepresented Subwatersheds
Magdalena Mtns	4
Manzano Mtns	15
Mt Taylor	7
San Mateo Mtns	8
Sandia Mtns	5
Zuni Mtns	9

Native and Nonnative Fish Distribution

Fish surveys have been conducted somewhat sporadically on the Cibola and numerous data gaps exist. For those streams that do have survey information there is typically not population trend data available because sampling is not consistent. The exception is the Zuni Bluehead Sucker, which is federally listed as endangered and is described in more detail in Chapter 5. We queried the Natural Heritage New Mexico database and consulted with fish biologists at the U.S. Forest Service (both on the Cibola and at the Region 3 office), the Museum of Southwestern Biology, and the New Mexico Department of Game and Fish. We also referenced the Fishes of New Mexico (Sublette et al. 1990) for historic data on fish distribution. Because of the relative lack of permanent water on the Cibola, there are few streams that potentially harbor fish. Of those that do contain fish, the vast majority are nonnative, introduced species (Table 26). There is no trend information available for nonnative species. The Nature Conservancy reports general declining trends for native fish including Rio Grande Sucker, Rio Grande Chub, Speckled Dace, and Zuni Bluehead Sucker (R. Maes, pers. comm.).

Table 26. Native fish distributions in perennial streams.

Geographic Area (GA)	Stream Name 10-digit HUC	Mosquito Fish	Fathead Minnow	Rio Grande Sucker	Rio Grande Chub	Zuni Bluehead Sucker	Speckled Dace	Number Nonnative Species Reported
Bear Mtns	La Jencia Creek 1302020906							
	Lower Rio Salado 1302020907							
Datil Mtns	Middle Rio San Jose 1302020706							
Magdalena Mtns	La Jencia Creek 1302020906							
Manzano Mtns	Torreon Draw 1305000111							1
Mt Taylor	Hay Meadow Canyon-Rio Puerco 1302020404							
	Middle Rio San Jose 1302020706							

Geographic Area (GA)	Stream Name 10-digit HUC	Mosquito Fish	Fathead Minnow	Rio Grande Sucker	Rio Grande Chub	Zuni Bluehead Sucker	Speckled Dace	Number Nonnative Species Reported
San Mateo Mtns	East Red Canyon 1302021101							
	San Jose Arroyo-Rio Grande 1302021105							
	Outlet Alamosa Creek 1302021107			C	C			
Sandia Mtns	Arroyo Tonque-Rio Grande 1302020106							1
	City of Albuquerque-Rio Grande 1302020303							
Zuni Mtns	Bluewater Creek 1302020702	C	C					7
	Rio Nutria 1502000402**					C	C	2
	Cebolla Creek-Rio Pescado 1502000403					H		

*Table developed with incomplete data, no entry means that there are no recorded observations of that species, or that stream has not been assessed. It does not imply that the species is not present, nor was it historically present, in that stream. H = historically present, C = currently present in the HUC (though not necessarily confirmed as present on the Cibola NF within that HUC).
**This stream is a spring-fed system, not considered a perennial stream. However, it is listed here because of its importance to the Zuni Bluehead Sucker.

Groundwater

Groundwater is an important component of water resources on the Cibola National Forest. Much of the water on the forest comes from groundwater resources. In addition, the mountains on the Cibola provide water for recharging many aquifers in the region. There are local and regional aquifer systems. Aquifers are underground areas where water occurs in rock formations in sufficient quantities to be utilized.

The plan area is located within seven groundwater basins as identified by the state of New Mexico (NMOSE 2006). These are the Bluewater, Estancia, Gallup, Rio Grande, Roswell, Sandia, and Tularosa Basins (Figure 38).

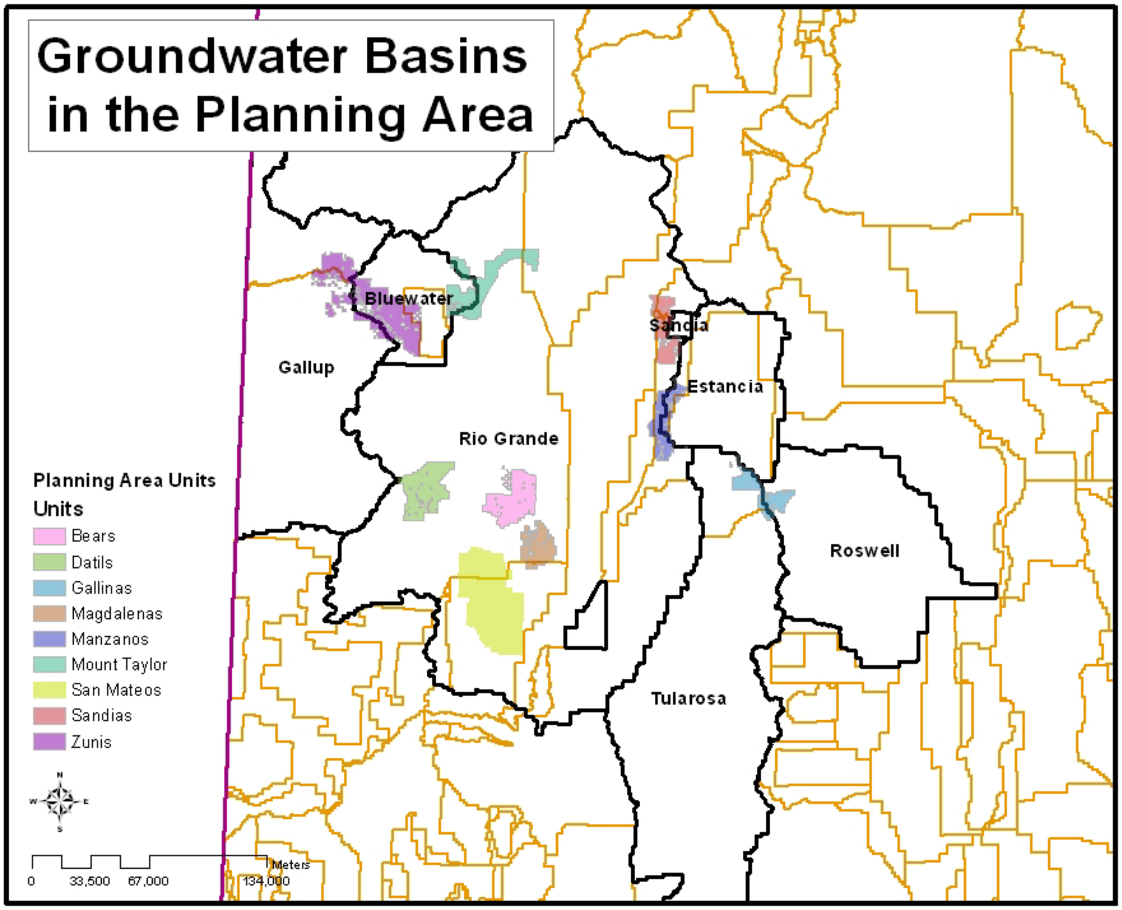


Figure 38. Groundwater basins in the Cibola plan area.

Recharge

Recharge depends mostly on precipitation which is greatest at the higher elevations within the plan area. In the summer, recharge occurs when summer precipitation collects in channels and then infiltrates through the bed to the ground in years when more than seven inches of rain is recorded at Sandia Park (McCoy 2008). In the winter, precipitation can percolate through the soil cover (Titus 1980). Groundwater flows out from the mountains from all sides; generally there is no other source of water for the aquifers in the region. Because of this, recharge in the mountains of the Cibola National Forest is very important to the groundwater resources of the region. One study showed that recharge from monsoon rains reaches aquifers on the eastern slopes of the Sandia Mountains one to five months afterwards (McCoy 2008). Wells within the Tijeras Graben, to the east of the Sandia Mountains, do not appear to be related to individual precipitation events, meaning these areas could be at risk for groundwater depletion.

In the Albuquerque Basin, there are several mountain front window areas where surface flow and shallow underflow percolates into basin and valley fill deposits at or near canyon mouths.

- **On the north slope of the Sandia Mountains**, Las Huertas Canyon, Cafion Agua Sarca, and Cafion del Agua have been identified as this type of recharge areas.

- **On the west slope of the Sandias**, Juan Tabo Canyon, La Cueva Canyon, Domingo Baca Canyon, Pino Canyon, Bear-Oso Canyon, Embudito Canyon, Embudo Canyon, and Tijeras Canyon provide recharge through basin and valley fill deposits.

- **In the Manzanita and Manzano Mountains**, Coyote Canyon, Hells Canyon, Sais Canyon, Comanche Canyon, Trigo Canyon, Canon Monte Largo and Abo Canyon provide recharge through the basin and valley fills.

There is also recharge occurring where ephemeral arroyos with coarse grained deposits contact the basin fill deposits along lower Tijeras Arroyo, Lower Hells Canyon Wash, and Lower Sandia Wash. These reaches are outside of the forest boundary but their watersheds extend onto the plan area on the Cibola National Forest, where much of the runoff originates. For all of these areas, much of the surface flow and shallow underflows which recharge the groundwater in the Albuquerque Basin originates on National Forest System lands.

Similarly, mountain front recharge and recharge through ephemeral arroyos occur in all GAs in the plan area. While these areas are not as well-studied as those in the Rio Grande groundwater basin, this process is an important source of water for these groundwater basins too.

Mountain front recharge and recharge through arroyos occurs when water runoffs into channels, usually during high precipitation events and snowmelt. The amount of water involved in these events is related to seasonal weather patterns in the short-term and climate in the long-term. Drought reduces the amount of water available for runoff. Climate change could also have this effect.

Another interpretation of climate change is that there will be more extreme weather events (ATWG 2005). It is possible that extreme precipitation events could increase the number of flood events, allowing waters to flow off the forest and infiltrate along mountain fronts and arroyos. In addition, instream structures can change where runoff infiltrates by slowing and storing water in stream channels. These instream structures include earthen dams for stock ponds and watershed improvement structures. It is unknown to what extent these structures effect groundwater recharge.

Water Rights and Uses

Water is used on the forest for many different purposes. Groundwater wells and surfaces waters are utilized for drinking water, waste disposal, livestock, and wildlife. Some of these uses are for NFS purposes, but others provide water for users off the forest such as public water supplies and reservoir storage. These water uses are an ecosystem service provided by the NFS to the public and is part of it mission, “to provide favorable conditions of flow.” This groundwater is largely recharged by runoff and infiltration related to the plan-area GAs. Surface rights are less common. Several of the surface rights within the plan area predate the creation of the NFS lands and are held by private land owners or public water suppliers. These reserved rights allow for the use of these water rights but are subject to management through special uses for associated infrastructure, such as pipelines.

Riparian Areas

The new planning directive (36 CFR 219.19) defines riparian areas as “three-dimensional ecotones (the transition zone between two adjoining communities) of interaction that include terrestrial and aquatic ecosystems that extend down into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at variable widths.”

Ecosystem Services

Riparian habitats are among the most critical elements of biodiversity within the landscape and they provide key ecosystem services available from no other resource. This includes ecosystem-supporting services such as nutrient cycling; provisioning services such as fresh water, forage and habitat for wildlife; regulating services such as carbon storage, water and flood regulation, water quality, erosion control; and cultural services such recreation, scientific discovery and education, cultural, intellectual and spiritual inspiration. Where riparian areas are intact and functioning, these ecosystem services can be assumed to be stable; but where riparian areas have degraded or been lost, these services are missing or at risk.

In Arizona and New Mexico, an estimated 80 percent of all vertebrate species use riparian areas for at least half their life cycles, and more than half of these are totally dependent on riparian areas (Chaney et al. 1990). According to the Arizona Riparian Council, 60 to 70 percent of the state's wildlife species depend on riparian areas to sustain their populations, even though riparian habitats occupy less than half a percent of the land area (Arizona Riparian Council 1995). Similar numbers can be assumed for New Mexico. Likewise, aquatic and fish productivity are directly related to a properly functioning and healthy riparian habitat. These areas are typically, but not always, characterized by vegetation and animal communities associated with water such as phreatophytic plants like willows and sedges. They experience routine inundation by water during seasonal high flows and storm events.

Reference Condition, Current Condition, and Trend

Reference Condition

Quantitative assessment information for reference condition of riparian areas in the plan area is not available; therefore qualitative statements will be made. Reference condition is assumed to be proper functioning condition (Prichard et al. 1998). Riparian-wetland areas are functioning properly when adequate vegetation, land form, or woody material is present to dissipate stream energy during high flows, filter sediment, capture bedloads, aid in floodplain development, improve flood-water retention and ground water recharge, develop root masses that stabilize streambanks, and develop diverse characteristics which provide habitat to support greater biodiversity within their potential to achieve this condition (Prichard et al. 1998). By having these characteristics, a riparian area is resilient during floods. This resiliency allows an area to provide desired values, such as fish habitat, neotropical bird habitat, or forage over time.

Current Condition

The most detailed information about riparian areas on the Cibola is available from the Regional Riparian Mapping Project (RMAP; USFS 2012). This project combined existing data with remote sensing and advanced valley bottom modeling techniques to map riparian plant communities within the 10-digit HUCs that intersect the forests and grasslands of the Southwest region. Valley bottom modeling provides a spatial concept from which to base photo interpretation of riparian vegetation types and their extent, and to map riparian communities. High resolution infrared photography and other key ancillary references were used to develop and corroborate inferences of riparian settings.

One objective of RMAP was to provide planning teams with spatial data on riparian features sufficient to complete ecological sustainability analyses and planning at landscape scales (1:24,000 scale and greater). For the purposes of RMAP, potential riparian areas were identified if they met the following criteria:

- Riparian areas are plant communities contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent lotic and lentic water bodies (rivers, streams, lakes, or drainage ways). Riparian areas have distinctively different vegetative species than adjacent areas (USFWS 1997).
- Where indicator plants may not be present, riparian areas are identified by signs of fluvial processes and/or fluvial features created under the current flow and climatic regimes.
- USFS Region 3 qualifier on riparian/wetland species: Aside from early successional communities where plant indicators may be sparse or absent, riparian mapping is conducted where riparian/wetland

plant species are common; that is, where “obligate wetland” and “facultative wetland” national indicator taxa designated by the US Fish and Wildlife Service (USFWS 1996) comprise at least 1 percent canopy cover (aerial extent) at the minimum map feature standard of 1 hectare.

There are 7,569 acres of riparian areas (using the RMAP data) occurring in the four mountain districts. This is approximately 0.5 percent of the plan area. When riparian data is examined at a contextual scale that includes all riparian areas within 6th-field HUCs that intersect the Cibola, the total riparian area within these watershed is 28,588 acres. Twenty six and one-half percent) of these riparian acres are within the Cibola, demonstrating the contribution of the Cibola riparian areas to the larger landscape. Each GA in the plan area contributes differently to this percentage. Table 27 lists the amount of riparian areas within the larger 6th-field watersheds and the portion of those riparian areas within each GA. It can be seen that combined with results for each GA listed in Table 27.

- The Datils have the largest percentage of riparian area within the intersecting 6th-field watersheds. However, the RMAP process in this area has not been verified, resulting in a larger number of riparian acres than actually exist, especially on the north side of the Datils. This is a known error which is in the process of being addressed. It is likely the amount of riparian within the Datils is closer to what is found in the nearby Bear Mountains, where almost 6 percent of the riparian areas within the larger 6th-field watersheds are located within the plan area.
- National Forest System lands on the Magdalena and San Mateo Mountains account for over half of the riparian areas within the intersecting 6th-field watersheds.
- Mount Taylor has almost half of the riparian areas within the intersecting 6th-field watersheds. Riparian areas on NFS lands in the Zuni, Sandia, and Manzano Mountains account for 25, 20, and 15%, respectively.
- The Gallinas Mountains are very dry and have less than 1 percent of the riparian areas within the intersecting 6th-field watersheds within the plan area.

Table 27. Riparian area summarized by Geographic Area at the 6th-field Hydrologic Unit Code (HUC) watersheds for both the entire watershed and forest-owned lands.

Geographic Area (GA)	Riparian Area for all 6th-field HUCs (acres)	Riparian Area for forest-owned lands (acres)	Forest-owned portion of total riparian in the 6th-field HUCs (%)
Bear Mtns	1,088.05	64.97	5.97
Datil Mtns	1,659.91	1,629.99	98.20
Gallinas Mtns	5,848.47	8.37	0.14
Magdalena Mtns	372.20	257.44	69.17
Manzano Mtns	4,016.20	612.93	15.26
Mt Taylor	1,334.07	557.61	41.80
San Mateo Mtns	2,062.28	1,422.68	68.99
Sandia Mtns	2,411.49	480.36	19.92
Zuni Mtns	9,795.29	2,535.12	25.88
Total	**28,587.95**	**7,569.48**	**26.48**

The RMAP produced a GIS dataset that further classified riparian areas into different vegetation types. Fifteen of the vegetation types are present on the 6th-field HUCs that intersect the Cibola (Table 28). Rio

Grande cottonwood-shrub is the most abundant vegetation type and is particularly abundant in the Manzano and the Zuni Mountains. The second largest amount of riparian vegetation is the herbaceous group and most of this is located in the Zuni Mountains. The third most common vegetation type is labeled historic riparian, most of which has been converted to agricultural and this all lies within the Gallinas Mountains.

Table 28. Riparian areas as identified by RMAP by vegetation types at the 6th-field Hydrologic Unit Code (HUC) watersheds by Geographic Area. Note these data represent riparian area for the entire watershed, not just the Forest-owned portion.

	Bear Mts	Datil Mts	Gallinas Mts	Magdalena Mts	Manzano Mts	Mt Taylor	San Mateo Mts	Sandia Mts	Zuni Mts
	Acres per Geographic Area								
Arizona Alder - Willow				29.8	54.5				
Desert Willow					97.2				
Fremont Cottonwood - Conifer				139.9	11.6				
Fremont Cottonwood - Oak							103.8		
Fremont Cottonwood - Shrub							502.8	603.2	
Herbaceous					24.9	513.6		54.7	6100.0
Narrowleaf Cottonwood - Shrub				77.7	149.7	199.2	1193.8	77.3	430.2
Oak - Desert Willow									0.7
Rio Grande Cottonwood - Shrub	1088.1	1659.9			2975.9	26.6		1528.7	2753.8
Upper Montane Conifer - Willow					73.1	8.1	153.8		
Willow - Thinleaf Alder					351.7	407.3		128.7	486.0
Arizona Walnut							8.7		
Sparsely Vegetated							17.5		
Ponderosa Pine - Willow			9.7	124.8	277.6	179.2	81.9	19.0	24.6
Historic Riparian			5838.8						

	Bear Mts	Datil Mts	Gallinas Mts	Magdalena Mts	Manzano Mts	Mt Taylor	San Mateo Mts	Sandia Mts	Zuni Mts
- Agricultural									
Total	1088.1	1659.9	5848.5	372.2	4016.2	1334.1	2062.3	2411.5	9795.3

Most riparian areas on the Cibola are currently at risk, and completely missing in some places. This is a largely a function of legacy issues, including roads (authorized or otherwise), uncharacteristic wildland fire, developed recreation, dispersed recreation, historically unmanaged grazing by livestock and unmanaged herbivory by wildlife, and water development and diversion both on and off the Cibola. Riparian areas can also be impacted by climate trends such as drought.

The condition of Cibola riparian areas was assessed as part of the classification of watershed condition (USFS 2011b). This assessment used proper functioning condition assessments where available, to determine the condition rating for the riparian indicator. Figure 39 shows the results of this assessment.

Riparian areas in the plan area were rated as good or functioning properly on 96 (46%) of the 6th-field watersheds. A fair rating, functioning at risk, was given to 70 (34%) of the 6th-field watersheds. None of the watersheds were rated as poor or impaired. Forty-two (20%) 6th-field watersheds were not rated since these watersheds have less than 10 percent of their area within the plan area. It should be noted that where no riparian areas exist within a watershed, a rating of good was assigned, unless the watershed has less than 10 percent on NFS lands. Given this information, on the 113 6th-field watershed which do have riparian areas, 53 percent are rated as fair, 35 percent are rated as good, and 12 percent were not rated.

Future Condition and Trend

Riparian areas on the Cibola are expected to continue to degrade for many of the reasons listed above. The effects of herbivory are being managed through wildlife and livestock management plans with levels well below what existed before the establishment of the Cibola National Forest. These lower levels have allowed some of the riparian areas to recover from past effects, where possible. The Sandia ranger district does not have livestock use, so this allows for quicker recovery of riparian conditions. Where projects have been developed to conserve or protect remaining riparian areas or to rehabilitate and restore missing riparian areas, local conditions might be expected to improve, and these areas can move closer to proper functioning condition. However, external factors such as climate change and continued drought can be assumed to continue to exert stress on these areas.

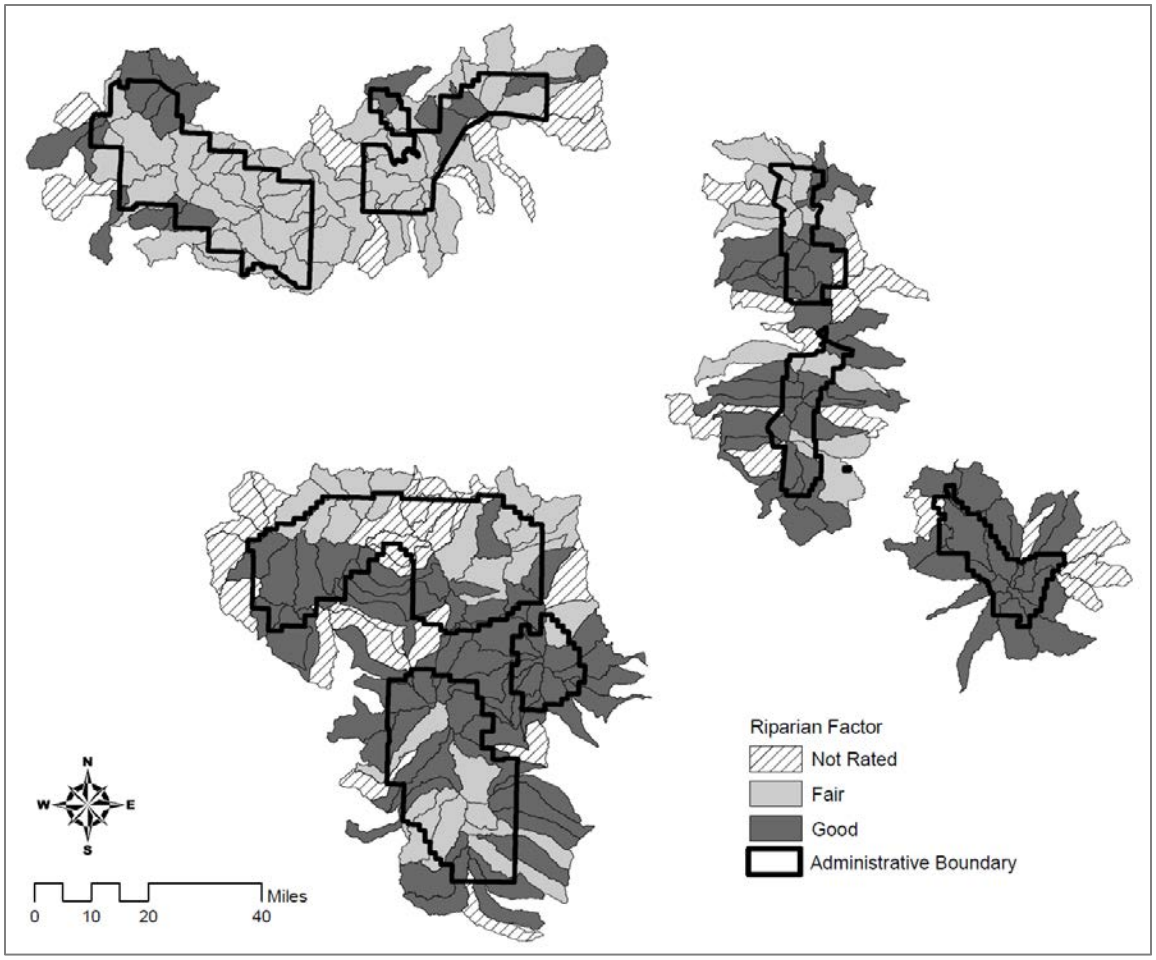


Figure 39. Riparian condition from the watershed condition assessment for the Cibola plan area.

Watersheds

A watershed is a “region or land area drained by a single stream, river, or drainage network; a drainage basin” (36 CFR 219.19). These drainage areas are defined by the highest elevations surrounding a selected location on a stream so that a drop of water falling inside the boundary will drain to the stream while a drop of rain falling outside of the boundary will drain to another watershed. Watersheds encompass all of the ecosystem elements – water, soils, vegetation, and animals. Watersheds also span the landscape at many different scales. Watershed boundaries cross ownership boundaries since they are based on topography. A systematic method of delineating watershed boundaries and giving them a number code was developed by the USGS (Seaber et al. 1987). The number code is called the hydrologic unit code (HUC).

The plan area is located within two regions:

- **The Rio Grande Region** (HUC-13) is on the eastern side of the Continental Divide. Within this region, the plan area is located in four subregions: Rio Grande-Elephant Butte (1302), Rio Grande – Mimbres (1303), Rio Grande – Closed Basins (1305), and Upper Pecos (1306).
- **The Lower Colorado Region** (HUC-15) drains to the west. In this region, the plan area is located in one subregion, the Little Colorado (1502).

Scales of Analysis

This analysis uses the 5th- and 6th-field HUCs at the context scale, above the planning-unit scale. The individual Geographic Areas (GAs) are used as the analysis unit at the local-scale. The 5th-field watersheds range from 60,000 to 320,000 acres and were used to assess stressors and risk of impaired watershed condition. The 6th-field hydrologic units range in size from 10,000 to 50,000 acres and were used to assess of watershed condition and the factors that contribute to watershed condition. These watershed scales provide information about the regional context and extend well beyond the boundaries of the plan area. The smallest scale is the GAs within the plan area. This scale provides context in terms of the individual mountain ranges and are used for risk assessment analysis.

On the Cibola, the plan area is located within portions of sixty 5th-field watersheds. Nested within these larger watersheds, there are 205 individual 6th-field HUCs which intersect the plan area.

Watersheds and Stressors/Disturbance Factors

In 2010, a study was done to assess the risk of impaired watersheds at the 5th-field HUC (Brown and Froemke 2010). This approach used stressors that tend to impair the condition of watersheds and resources within the watersheds that are sensitive to such stressors. Indicators in this study included stressors, at risk resources, and watershed condition variables. Stressors were grouped into five categories: development group, roads group, farm and ranch group, mining group, and an ‘other’ group. At-risk resources include: water bodies and streams, drinking water supplies, and animal and plant species. Measure of watershed condition included water quality, water temperature, water quantity, fish populations, and soil quality.

The data from this 2010 study showed some interesting relationships. Population density correlated highly with developed land cover, housing density, roads density, and road-stream crossings. Road density correlated with other road related measure such as road-stream crossings and length of roads in riparian areas. Livestock grazing and confined animal feeling correlated with measure of agricultural activity. Indicators vary by land ownership as well. Non-NFS parts of watersheds tend to have the greater densities of population, housing, roads, road, stream crossings, roads in riparian areas, livestock grazing mines, dams and driving water intakes, and more acres in cultivation and mining. On NFS lands, there is a greater density of roads on steep slopes and more forest area with higher risks of uncharacteristic fire.

On the Cibola National Forest, the plan area is located within portions of sixty 5th-field watersheds; however, only 32 of these were assessed in the study because the rest had less than one percent on NFS lands. Risk levels were assigned a value from 1–6. This scale indicates the risk of impaired condition relative to the other rated watersheds. One is the lowest risk rating, while six is the highest. Figure 40 shows these ratings across the mountain districts.

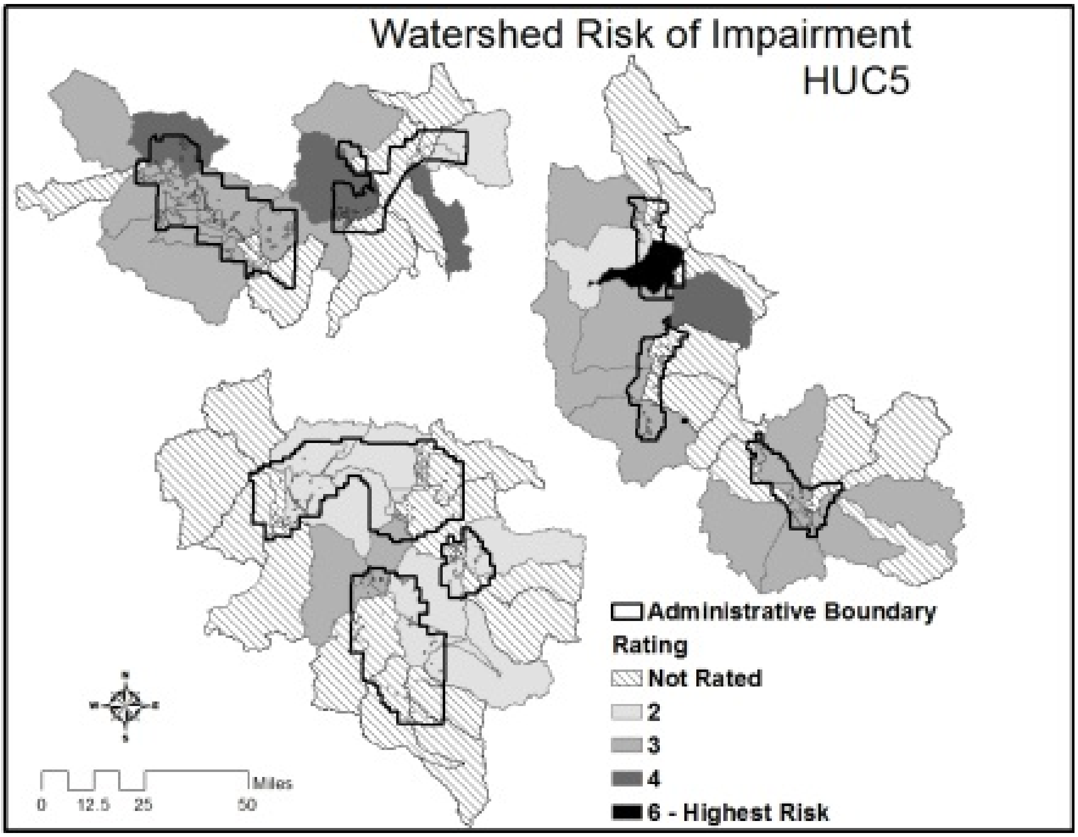


Figure 40. Watershed risk ratings across the Cibola.

The stressors used for this study are listed in Table 29 and depicted in Figure 41. This data is the scaled data for the 10-digit HUCs in the plan area. Scaling was a procedure used to combine indicators to achieve an overall measure of risk of impaired watershed condition (Brown and Froemke 2010). A higher value indicates a greater level of concern. It can be seen from this data that population growth, road-stream crossings, and roads in riparian areas cause a higher likelihood for the risk of watershed impairment. Road density, grazing, animal feeding, fire condition class, and atmospheric deposition also contribute to a higher risk of watershed impairment by causing stresses to the functioning of the watersheds in the plan area. These ratings include the entire 10-digit watersheds, not just what is occurring on NFS lands. These stressors have contributed to the current condition of watersheds. The current condition is assessed at the 12-digit HUC scale using another method which considers the effects of these stressors. For example, impaired waters within a watershed are one of the indicators for watershed condition which is the result of the stressors identified in this study. Table 29 shows the link between the stressors in the 10-digit HUC study used to assess risk (Brown and Froemke 2010) and the study done at the 12-digit HUC scale to assess existing watershed condition (USFS 2011b).

Table 29. Stressors and related effects on the Cibola.

Stressor groups – Risk of Watershed Impairment	Related Effect – Watershed Condition
Development Group Population density, population growth, developed land cover, housing density	• Water quality– sediment, toxics, nutrients • Water quantity– increased uses, increased runoff • Aquatic habitat–loss and degradation

Stressor groups – Risk of Watershed Impairment	Related Effect – Watershed Condition
	• Riparian/wetland– decline in extent and condition • Soil condition– erosion, compaction, overall loss of condition • Invasive species–increased
Roads Group Road density, road-stream crossings, roads in riparian areas, roads on steep slopes	• Water quality– sediment • Water quantity– increased runoff • Aquatic habitat–loss and degradation • Riparian/wetland–decline in extent and condition • Soil condition–decline • Invasive species–increase
Farm and Ranch Group Cultivation, livestock grazing, confined animal grazing	• Water quality–sediment, nutrients • Water quantity– increased runoff and use • Aquatic habitat–loss and degradation • Riparian/wetland–decline in extent and condition • Soil condition–increased erosion, compaction • Invasive species–increase
Mining Group Mining land cover, mines	• Water quality–sediment, toxics • Water quantity–increased runoff and use • Aquatic habitat–loss and degradation • Riparian/wetland–decline in extent and condition • Soil condition–increased erosion, compaction • Invasive species–increase
Other Group Area of potentially damaging wildfire, atmospheric deposition, dams	• Water quality–sediment, nutrients • Water quantity–increased runoff and use • Aquatic habitat–loss and degradation • Riparian/wetland–decline in extent and condition • Soil condition–increased erosion, compaction • Invasive species–increase • Forest cover–loss and change of composition

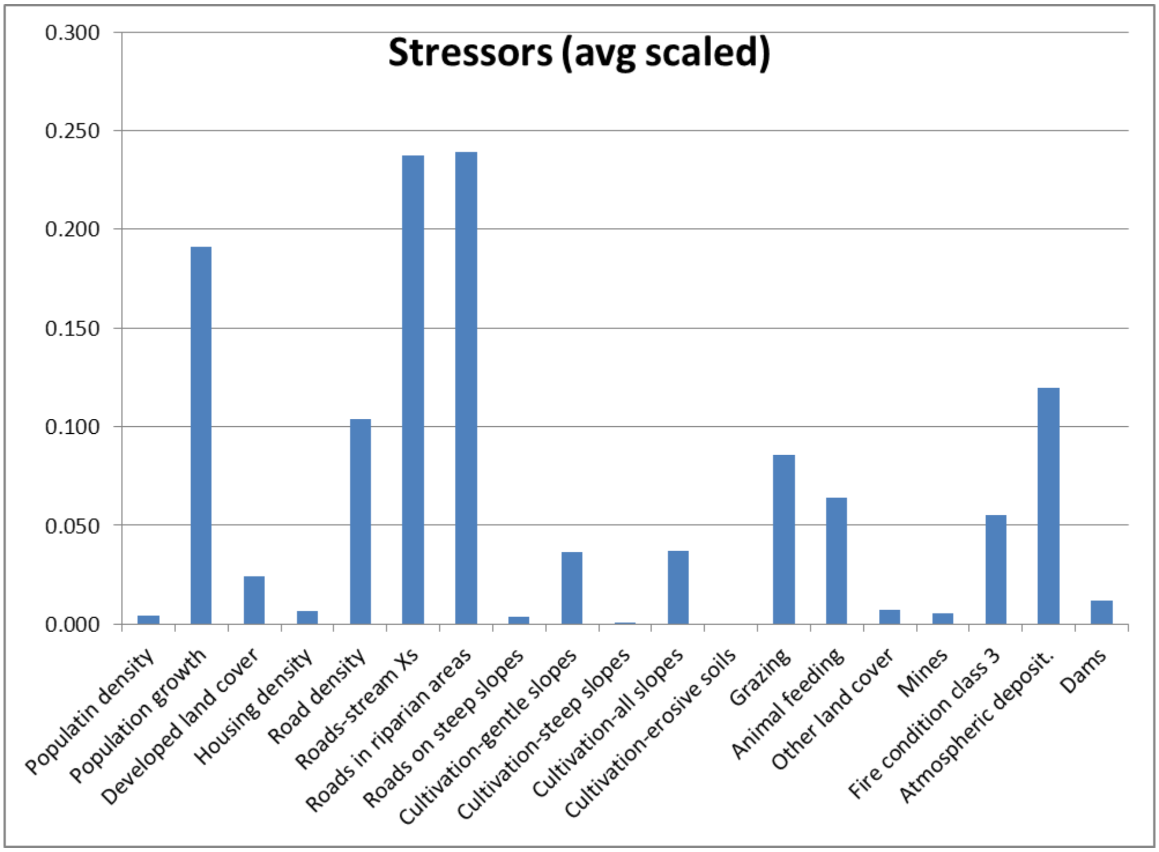


Figure 41. Stressors and related effects on the Cibola. Vertical scale is a relative rating of the stressors.

Reference Condition, Current Condition, and Trend

The reference condition for watersheds is “properly functioning,” as rated using the Watershed Condition Framework (WCF) methodology (USFS 2011b). Properly functioning refers to watersheds with high geomorphic, hydrologic, and biotic integrity relative to natural potential condition. This reference condition for watersheds considers the natural range of variation (NRV) of the processes which have combined to result in a properly functioning watershed. For watersheds, there are events over time that result in changes to watershed functions. When these changes are part of processes, watershed condition is not affected since it is relative to the natural condition. Natural events include floods, drought, and wildfire. Therefore, changes in climate have the potential to change watershed character.

There are changes which occur to watershed as the result of disturbance related to human activities. These changes are not within the range of natural variability and can result in variations away from the natural condition of properly functioning. For example, fluvial changes occur naturally on undisturbed watersheds but occur more easily on disturbed lands. This is because disturbance often results in reduced ground cover, changes to runoff patterns, and/or soil changes. Arid lands are more susceptible to change due to their natural condition of less cover (USFS 1998a). Therefore, thresholds for change vary within individual watersheds, depending on is characteristics. Of particular interest is how this threshold for change has altered due to the influence of management activities.

The function of many watersheds and their streams was altered during the mid- to late-1800s during a period of overgrazing by cattle and sheep (USFS 1998a). Many streams downcut during this time, resulting in lowered water tables and loss of riparian areas. In the more arid environments, recovery from this impact is very slow. Subsequent logging exacerbated the problem by removing cover, woody material from the ground and streams, and channelizing. These effects caused departures from the range of natural variability in how much water ran off into streams during floods at the expense of water infiltrating into the ground to support groundwater and springs (USFS 1998a and Scurlock 1998) . Many watersheds were impacted, resulting in a loss of watershed functions of storage, transmission, and filtering of water.

Current watershed condition for the Cibola and intersecting subwatersheds was rated using the WCF methodology: 119 watersheds were rated as functioning properly, 46 watersheds were rated as functioning at risk, and 1watershed was rated as impaired (Figure 42). Forty-two watersheds were not rated since these watersheds have less than 10 percent of their area within the plan area. The condition rating only applies to the National Forest System lands within each watershed.

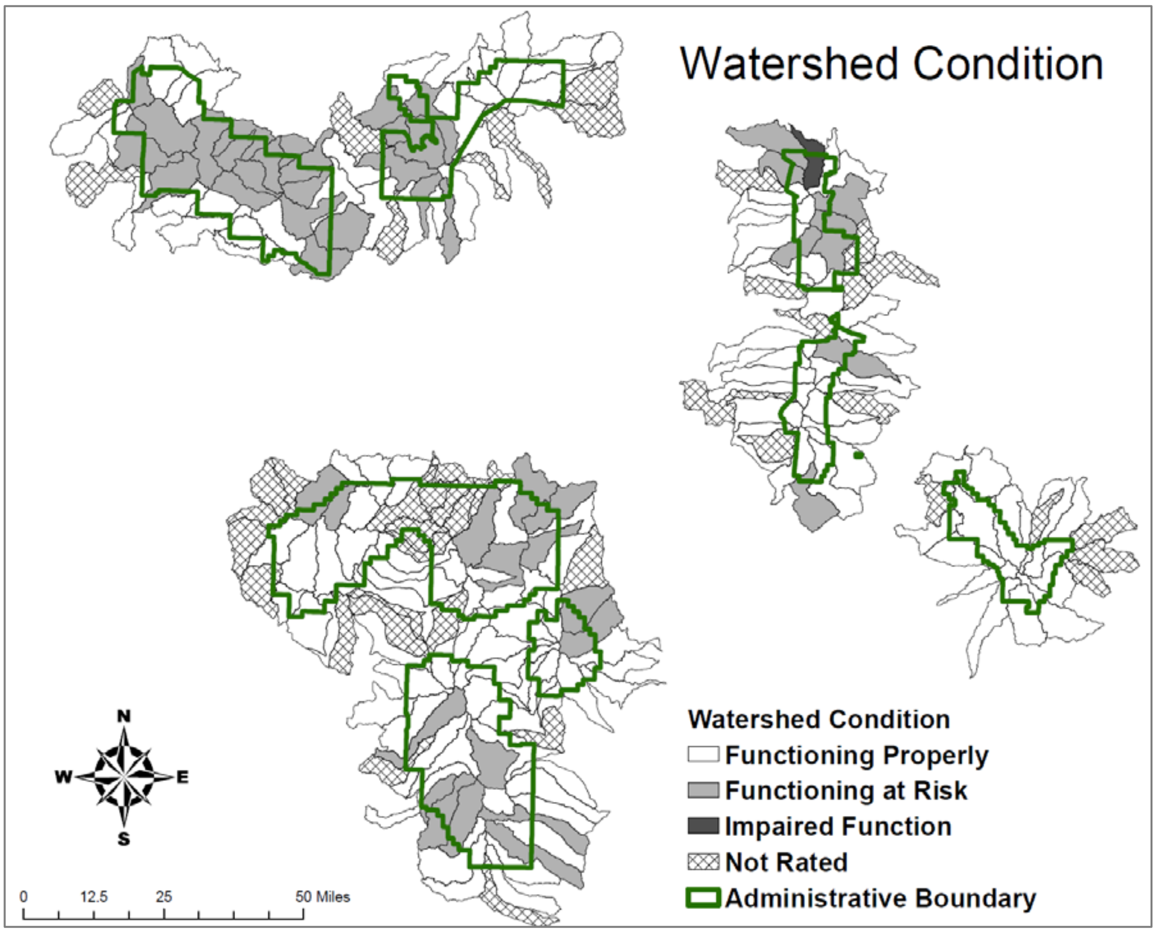
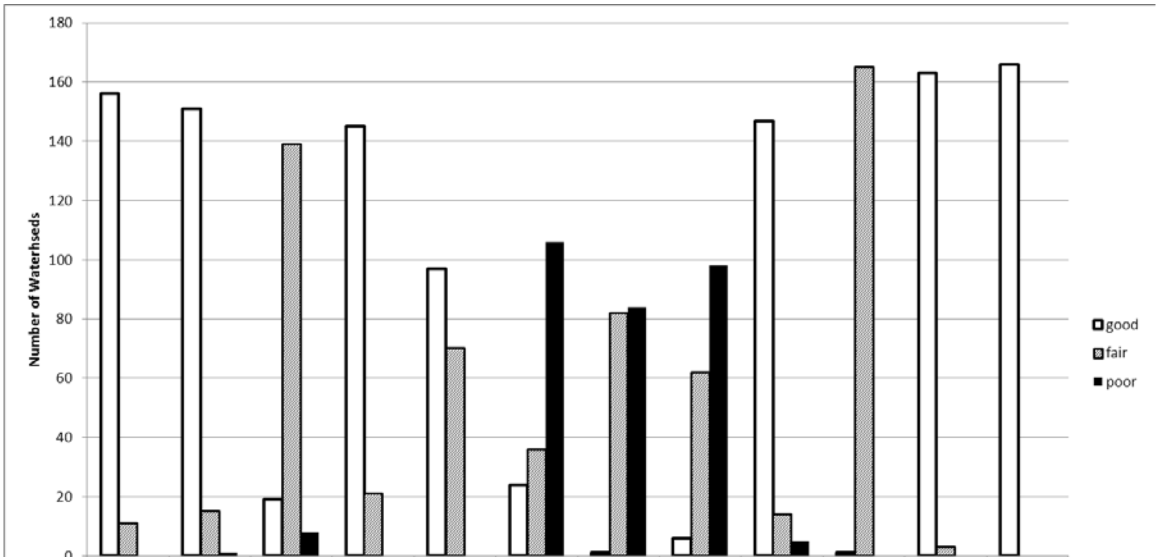


Figure 42. Watershed condition ratings on the Cibola and intersecting subwatersheds.

Watershed condition is assessed using 12 indicators. Figure 43 shows the ratings of these indicators for the watersheds on the mountain ranger districts.

The trend for watershed condition depends on the indicators within the watershed condition rating. As described in other assessments, the trend for riparian condition is downward, water quality is upward, water quantity is down and the trend for soil condition is not clear. However, overall watershed condition is addressed through the watershed condition framework. By using a watershed approach, all of the 12 indicators which contribute to watershed condition are considered. This process includes: identifying priority watersheds for restoration, developing watershed action plans, and implementing projects to improve watershed condition. Within the assessment area for the Cibola, Bluewater and Las Huertas were chosen as priority watersheds with essential projects identified to improve watershed condition. As essential projects in these watersheds are completed, priority watersheds will be removed from the list and replaced by new priority watersheds that need restoration. By using this methodology, watersheds can move to properly functioning condition in a systematic way. Implementing this strategy is expected to result in a properly functioning condition for all watersheds within the assessment area.



	Water Quality	Water Quantity	Aquatic Habitat	Aquatic Biota	Riparian & Wetland	Roads and Trails	Soils	Fire Regime or Wildfire	Forest Cover	Rangeland Vegetation	Terrestrial Invasive Species	Forest Health
good	156	151	19	145	97	24	1	6	147	1	163	166
fair	11	15	139	21	70	36	82	62	14	165	3	0
poor	0	1	8	0	0	106	84	98	5	0	0	0

Figure 43. Summary of 12 indicators used to determine watershed condition.

Summary of Condition and Trend

The information provided in this assessment is summarized in Table 30. This table lists the reference condition, current condition, and trend for each of the water resource features and associated ecosystem characteristics as discussed in each section. Overall, surface waters are not well-studied. Most springs have been developed to the detriment of the associated ecosystem. Riparian areas are at risk from several factors, including past uses. Water quality in springs generally meets standards while water in assessed streams does not. Most watersheds are functioning properly, but there are concerns with roads and trails, soil condition, and fire regime. Groundwater appears to meet standards for associated uses such as livestock watering, but recharge to groundwater is of concern, largely due to climate change and increased demands.

Table 30. Summary of water resources and key ecosystem characteristics.*

	Water Quality			Water Quantity			Condition		
	Reference	Current	Trend	Reference	Current	Trend	Reference	Current	Trend
Perennial Streams	Standards are met	Assessed reaches do not meet standards	varies	No withdrawals	Withdrawals on some streams – see table	Decrease – increased demand for due to climate change and drought	PFC	At risk	varies with continued at risk condition
Springs and Seeps	Standards are met	Standards are met as measured	stable	No withdrawals	>80% developed	Decrease no direction on withdrawals/ development	PFC	At risk to non-functioning	decrease
Riparian /Wetland Areas	n/a	n/a	n/a	No withdrawals	Withdrawals on some streams – see table	Decrease	PFC	At risk	varies
Watershed	n/a	n/a	n/a	n/a	n/a	n/a	Good - PFC	In WCF	Improve thru WCF
Waterbodies	Standards are met	Assessed lakes do not meet standards	Down due to climate change and drought	No withdrawals	No withdrawals	Down due to climate change and drought	PFC	At risk	decrease
Groundwater	Standards are met	Standards are met	stable	No withdrawals	withdrawals	Downward due climate change, drought, and water withdrawals in localized areas	stable	Lowered water levels	declining

*n/a = not applicable.

Risk to Ecological Integrity of Water Resource Features

Where there is little actual information on trend of the condition of water resource feature, other measures were used to determine the degree to which the ecological integrity of the system or feature is at risk. This information supplements the summary of the reference, current condition, and trend in Table 30. Several methods were used to assess ecological risk to water resource features. These include the use of representativeness and redundancy for perennial streams, riparian areas, and springs, watershed assessments results, and numerical data for groundwater resources as shown in Table 31. Where no features are mapped or exist, “none mapped” is listed.

Table 31. Risk assessment methods by water resource feature.

Water Resource Feature	Risk Assessment Method
Streams	Representativeness and Redundancy
Springs/seeps	Representativeness and Redundancy
Groundwater	Numeric
Riparian areas, wetlands	Representativeness and Redundancy
Watershed	Watershed Condition Classification (2011) Risk from Brown and Froemke (2010)

The concept of representativeness was utilized earlier in this chapter under the heading of Spatial Context of Perennial Waters. In this section, Risk to Ecological Integrity, representativeness is combined with the concept of redundancy. This approach helps identify vulnerable water resource features and has been used in other locations (Chapa-Vargas and Monzalvo-Santos 2012, Stevens 2002). Representativeness is a measure of the distribution of a resource (e.g., stream miles, number of springs, acres [extent] and condition of riparian areas) within the plan area compared to the total of all of these features (inside and outside of the plan area) in each 12-digit scale watershed. The result is a map of watersheds showing where features are over or underrepresented. Features that are not well represented within the Cibola plan area may necessitate more attention to ensure adequate function. Similarly, features that are largely represented within the plan area but are rare outside the Forest may impose a greater responsibility on the Forest to maintain integrity of those features. The risks to ecological features can be managed if features are located within the plan area, while features outside of the plan area are not able to be improved or protected through management direction of a forest plan.

Redundancy calculates the distribution and extent of repetitiveness of water resource features such as streams, springs, or riparian areas across the landscape. Features that are rare on the landscape or clustered in one area have low redundancy. These low redundancy feature are more vulnerable to catastrophic events or management actions as compared to features which occur repeatedly and are widely distributed.

Representativeness and redundancy are combined for an overall risk to ecological integrity rating. Table 32 was used to determine overall risk using representativeness and redundancy. Moderate or high risk ratings trigger a closer examination of the water resource feature in question to determine if system integrity is satisfactory or not.

Table 32. Risk matrix for representativeness and redundancy method.

		Representative?	
Redundant?		**Yes**	**No**
	Yes	Low Risk	Moderate Risk
	No	Moderate Risk	High Risk

Perennial Streams

Water quality, streamflow, and stability have all been identified earlier in this chapter as ecological characteristics departed from reference conditions. Where water quality has been measured, it has been shown that water quality standards are not being met due to sediment, nutrients, and/or temperature. Streamflow is at risk in several perennial streams due to water withdrawals and projected climate change effects. Where streams have been assessed for proper functioning condition (Prichard et al. 1998), the result has been that streams are functioning at risk relative to their capability and potential. This means these systems have a high probability of degradation from high flow events. Conditions contributing to this at risk condition include: roads, trails, lack of riparian vegetation, recreation, water withdrawals, and legacy conditions. Climate change is expected to increase the risk to perennial stream in all locations. This is because many perennial streams are dependent on spring flows which are expected to decrease due to the lack of snow in higher elevations.

Table 33 lists the overall risk rating for perennial streams within each GA as derived using the representativeness and redundancy method. The stream miles in each risk category were totaled for each GA. The risk category with the greatest number of miles was assigned as the risk rating. Where no perennial streams are mapped in a GA, “none mapped” is listed. No perennial streams have been mapped in the Datil Mtns, Magdalena Mtns, and Gallinas Mtns GAs. The risk to perennial streams is high in the Manzano Mtns GA. This is because there is one perennial stream, Tajique Creek, within one watershed and it is located within the plan area. This one stream therefore, has a high risk. There is a moderate risk for the ecological integrity of perennial streams on the Mt Taylor, Zuni Mtns, Bear Mtns, San Mateo Mtns, and Sandia Mtns GAs. This is due to a combination of low redundancy and representative distribution of these features. While the perennial streams are rare, they are distributed across the landscape in these GAs. In these areas, there are perennial streams outside of the plan area which reduces the risk to moderate.

Table 33. Risk to ecological integrity of perennial streams.

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
High	5%	1%	0%	none mapped	none mapped	29%	none mapped	100%	0%
Moderate	95%	99%	100%	none mapped	none mapped	71%	none mapped	0%	100%

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Low	0%	0%	0%	none mapped	none mapped	0%	none mapped	0%	0%
Overall Rating	moderate	moderate	moderate	none mapped	none mapped	moderate	none mapped	high	moderate

Springs

Springs are present in every GA. These springs, their associated ecosystems, and flow regimes, have all been identified as components departed from reference conditions. An ongoing inventory of springs combined with historic information has shown that spring discharges are decreasing. In addition, spring ecosystems have been greatly reduced largely due to development of these features as water sources. Most of these developments are for livestock purposes, but drinking water supply and wildlife watering are also uses.

These types of risk, once recognized, can be addressed in the revised forest plan through desired conditions, objectives, standards, and guidelines. For example, when spring developments are improved to provide water to ecosystem processes, conditions often improve, although restoration of the original conditions may not be possible (Stevens 2008). The risk to springs from groundwater withdrawals can be managed with improved well locations. However, where legacy well developments impact springs, springs ecosystem are unlikely to be restored since these uses are usually for public drinking water supplies and are not subject to removal.

More problematic are large-scale risks related to climate change. Research has shown the importance of a snow pack in to groundwater in the Magdalena Mountains (Earman et al. 2006) and springs in the Zuni Mountains (Drakos et al. 2013). The snow pack is predicted to decrease (Finch et al. 2012, Mote et al. 2005, Cayan et al. 2010). Further, the elevation at which snowpack accumulates is expected to increase (Rango 2007). This prediction means springs would lose recharge, and, as a result, lose spring flows. In many cases this could mean springs become dry. This has already been evident from recent spring surveys funded through a cost share agreement with University of New Mexico.

The risk rating was calculated by the redundancy and representativeness process. The overall risk rating for each GA was summarized using the risk rating with the highest percent. These results (Table 34) show that five GAs have a high risk to the ecological integrity of springs. Four GAs have a moderate rating. Springs are uncommon, they tend to cluster is areas where hydrogeologic conditions are favorable, leading to an uneven distribution across many areas. High risk ratings are largely due to low redundancy combined with non-representative distributions. A more even distribution of spring inside and outside of the plan area leads to a moderate rating.

Table 34. Risk to ecological integrity of springs.

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
High	50%	55%	91%	46%	38%	27%	100%	89%	46%

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Moderate	50%	45%	9%	54%	62%	73%	0%	11%	54%
Low	0%	0%	0%	0%	0%	0%	0%	0%	0%
Overall Rating	high	high	high	moderate	moderate	moderate	high	high	moderate

Riparian Areas

Riparian areas are associated with perennial waters (streams and springs) and intermittent streams, and springs. There are two aspects of risk to riparian areas, condition and extent. Both of these have been shown earlier in this chapter to be departed from reference condition. Historic impacts reduced the extent and condition of most riparian areas in the Southwest (DeBano et al. 1996). In addition, riparian areas within the plan area, when assessed using the PFC method (Prichard et al. 1998), have been found to be at risk, meaning these systems are functional but existing conditions make them more susceptible to degradation. Currently, poorly located or designed roads, high demand for water withdrawals, high recreation use, some livestock management practices, and use by wild ungulates such as elk are factors which contribute to reduce riparian condition and extent. Predicted effects related to climate change, such as declining snow packs, reduced streamflow, and declining groundwater levels, are expected to worsen these effects.

The risk to riparian areas was calculated using the redundancy and representativeness matrix and process. This process identified those riparian areas at risk due to distribution across the landscape and within the plan area. Riparian areas within the plan area are currently managed through Forest Service guidance while outside of the plan area; riparian areas are subject to more diverse effects due to multiple land ownerships and jurisdictions. The Manzano Mtns, Magdalena Mtns, and Bear Mtns GAs have a high risk due to low acres and distribution largely located within the plan area (Table 35). Moderate risk ratings occur in the Sandia Mtns, Mt Taylor, Zuni Mtns, and Datil Mtns GAs due to distributions outside as well as within the plan area. The San Mateo Mtns GA has a good diversity of riparian area located outside and inside the plan area, resulting in a low rating. The projected effect of climate change would reduce the extent of riparian areas due to reduced surface water and groundwater, increasing risk for these water-dependent ecosystems.

Table 35. Risk to ecological integrity of riparian areas.

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
High	20	11	100	7	100	23	none mapped	99	37

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Moderate	52	42	0	93	0	29	none mapped	1	63
Low	28	47	0	0	0	48	none mapped	0	0
Overall Rating	moderate	moderate	high	moderate	high	low	none mapped	high	moderate

Groundwater Risk

The risk to groundwater quantity comes from groundwater withdrawals and climate change. Much of the impact from groundwater withdrawals occurs outside of the plan area. However, the risk from climate change to groundwater within the plan area is related to the projected loss of recharging waters especially those from snow pack (Robertson et al. 2013).

Risk to groundwater is determined from the well information and from the projected effects of climate change on the higher elevation groundwater resources located within the plan area. This risk assessment uses the number of wells in and adjacent to the planning area and in the 12-digit HUCs intersecting each GA as shown in Table 36. This risk rating is relative among the GAs. While the actual risk is tied to which aquifer water is withdrawn from, this measure give a general risk rating. Natural breaks using the Jenks method were used to categorize the data into three risk ratings. This is combined with the percentage of groundwater wells located within the plan area. When more than 10% of the groundwater rights are located within the plan area, the risk rating is increased by a category. This is because groundwater pumping within the HUC has the potential to affect groundwater resources within the planning area.

Based on this numerical method, the Sandia Mtns GA was rated at high risk due to the large number of groundwater wells within the watershed and in the plan area relative to the other GAs. The Mt Taylor, Zuni Mtns, Datil Mtns, Gallinas Mtns, and Manzano Mtns GAs have a moderate rating due to fewer wells in and around the plan area and with numerous wells in the connecting watersheds. The lower numbers of wells associated with the Bear Mtns, Magdalena Mtns, and San Mateo Mtns GAs result in a relative risk rating of low. Climate change is expected to reduce recharge rates, especially on the higher elevation areas due to reduced snow packs, reducing groundwater resources and increasing risk.

Table 36. Ecological risk to groundwater quality.

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Number of ground-water rights in/near plan area	22	68	20	101	35	40	26	48	215

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Total number of ground-water rights in 12-digit HUCs	1247	2234	307	556	406	455	260	2826	9350
Percent in/near plan area	1.8%	3.0%	6.5%	18.2%	8.6%	8.8%	10.0%	1.7%	2.3%
Overall Rating	moderate	moderate	low	moderate	low	low	moderate	moderate	high

Watershed Risk

Watershed risk was determined using a combination of the watershed condition rating at the 12-digit HUC and the risk assessment by Brown and Froemke at the 10-digit scale (see Watersheds section earlier in this chapter for supporting data and narrative). Each set of data was summarized by adding the number of watersheds in each risk category for each GA. The overall risk rating was assigned based on the category with the highest number of watersheds. These two ratings were combined, resulting in an overall risk rating which takes into account both watershed condition and risk factors. This is because the risk factors may lead to a change in watershed condition in the future. One risk factor not considered in either assessment is climate change. The predicted changes discussed in the other resources (groundwater, riparian, springs, perennial streams) are likely to result in a reduced potential for watershed functions and condition capabilities.

From Table 37, it can be seen that the risk to watershed condition is high in the Sandia Mtns GA. The Mt Taylor, Zuni Mtns, Bear Mtns, Gallinas Mtns, and Manzano Mtns GAs have a moderate risk. In the Datil Mtns, Magdalena Mtns, and San Mateo Mtns GAs, the risk is low based on the method used. Climate change is likely to increase this risk in all GAs due to the predicted loss of groundwater, snow pack, and increased fire risk and severity.

Table 37. Risk to ecological integrity of watersheds.

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Condition Rating Risk (12-digit)	moderate	moderate	moderate	low	low	low	low	low	moderate
Risk Rating (10-digit)	moderate	moderate	low	low	low	low	moderate	moderate	high

Risk Rating	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Overall Rating	moderate	moderate	moderate	low	low	low	moderate	moderate	high

Summary of Risk Ratings for Water Resources

Figure 44 is a graphic representation of the summarized risk ratings for the five water resource features (streams, springs, riparian, groundwater, and watersheds) across the GAs. Table 38 combines each risk rating for each water resource. From this, it can be seen that two GAs, the San Mateo Mtns and Datil Mtns, do not have a high risk rating for any of the categories. The Sandia Mtns and Manzano Mtns GAs have elevated risk ratings as do the Mt Taylor, Bear Mtns, and Zuni Mtns GAs to a lesser extent. The Gallinas Mtns GA was not rated in several categories since it did not have any mapped perennial streams or riparian areas. The projected effects of climate change would increase the risk to water resources in all GAs.

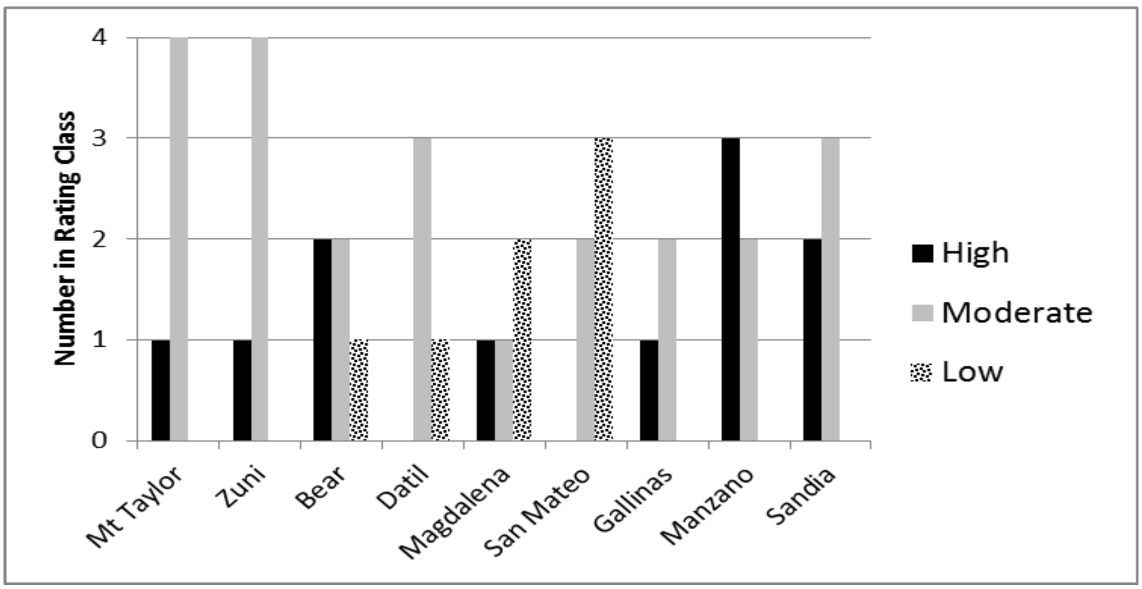


Figure 44. Summary of risk ratings by Geographic Area.

Table 38. Combined table of ecological risk to water resource features.

Feature	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Perennial Streams	moderate	moderate	moderate	none	none	moderate	none	high	moderate

Feature	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Springs	high	high	high	moderate	moderate	moderate	high	high	moderate
Riparian	moderate	moderate	high	moderate	high	low	none	high	moderate
Ground-water	moderate	moderate	low	moderate	low	low	moderate	moderate	high
Water-shed	moderate	moderate	moderate	low	low	low	moderate	moderate	high

This information on ecological risk to water resource features shows a need for change, especially where the risk rating is high. While certain factors are outside of the authority of the Forest to influence, other factors can be managed to improve the ecological risk to these features. As described, all water resource features will be impacted by predicted climate change effects. This effect is outside of the influence of the management of the Forest Service; however there are practices which could work to reduce these effects. For example, the predicted reduction of the snowpack could be mitigated with practices which encourage a persistent snowpack such as optimizing the size of openings in forest areas. The challenge presented by more extreme precipitation events can be met by improving the condition of stream channels and ground cover. The increasing demand for water will lead to increased groundwater withdrawals, especially outside of the plan area. These withdrawals could affect groundwater levels within the Plan are, but the Forest Service does not have jurisdiction over these withdrawals. Within the plan area, groundwater use can be managed to ensure withdrawals do not affect adjacent water resources.

There are varying risk levels across each GA for each water resource feature. There is a moderate risk to perennial streams, where they exist, across all GAs except for the Manzano Mtns, where the risk is high. The feature at risk in this area is Tajique Creek, a small stream with a road immediately adjacent and high recreational use. There is a high ecological risk to springs in the Mt Taylor, Zuni Mtns, Bear Mtns, Gallinas Mtns, and Manzano Mtns GAs with a moderate risk elsewhere. These higher risk levels indicate that springs are vulnerable to impacts. When springs are located within the plan area, there are management actions which could work to protect these important features. Unfortunately, climate change has the potential to dry up springs and streams and associated riparian areas, regardless of management actions. Outside of climate change risks, riparian areas have a calculated high ecological risk on three of the nine GAs—the Bear Mtns, Magdalena Mtns, and Manzano Mtns. The San Mateo Mtns GA has a low ecological risk to riparian areas, while the other GAs have a moderate risk. Many risks to riparian areas are possible to manage through plan components. This provides an opportunity to improve the existing and future condition of these features. The risk to groundwater varies from high to low. The Sandia Mtns GA has a high risk due to its wildland-urban interface and high number of wells immediately adjacent. The Bear Mtns, Magdalena Mtns, and San Mateo Mtns GAs have a low risk while the other GAs have a moderate risk. These risks are related to the number of wells in and around each area. Climate change has the potential to reduce the amount of recharge to groundwater resources, especially in the plan area since the higher elevations are largely recharged by snowmelt.

Sustainability of Water Resources

Sustainability refers to the economic, environmental, and social aspects of a resource. The environmental sustainability of water resources was discussed in each section of this report. Additional detail for springs can be found in the 2010 report (Crowley). The economics of water resources relate to the value placed on water resources, primarily for the consumptive uses, such as drinking water, irrigation, and household uses. Non-consumptive uses, such as providing habitat for wildlife, supporting riparian and wetlands areas, and sustaining vegetation on the landscape also provide economic values as well as social value.

Key Message

Most of the water resources on the Cibola are at risk; this risk is expected to increase due to the effects of projected climate change.

Chapter 5. Air[34]

Introduction

Air provides many ecosystem services on which life depends. Air provides *supporting* ecosystem services by supplying (1) oxygen for respiration by plants and animals, (2) carbon dioxide for photosynthesis, and (3) nitrogen for plant nutrition. Air also provides *regulating* ecosystem services, as it is key to global redistribution of biological and physical byproducts. Air contributes to *provisioning* ecosystem services by enabling transportation (wind for sails, lift for airplanes) and providing energy (wind turbines). Especially important to humans are the *cultural* ecosystem services that air provides to society (delivery of aesthetically pleasing aromas).

Air quality has long been recognized as an important resource to protect on national forests. Not only does the public value the fresh air and sweeping views that national forests can provide, but forest health, water quality, and fisheries are also highly valued and can be negatively impacted by poor air quality as well.

The 2012 Planning Rule requires national forests and grasslands to consider air quality when developing plan components. The purpose of the air quality assessment is to evaluate available information about air quality. This section assesses air quality on, and affecting, the Cibola National Forest. This assessment will describe the current conditions and trends regarding air quality in the plan area. This information will be used to anticipate future conditions and to determine if trends in air quality pose risks to system integrity at the forest level. Additionally, this assessment will identify information gaps regarding air quality and any uncertainty with the data. The information contained in this assessment will be used to inform agency officials, whether current direction needs adjustment to protect air resources and the systems that rely on air quality on the forest.

Including in this assessment, the following components are identified, as specified by Forest Service Handbook, Chapter 10 Section 12.21 (FSH 1909.12 draft version 02/14/2013):

- Airsheds relevant to the plan area
- Location and extent of known sensitive air quality areas, such as Class I areas, non-attainment areas, and air quality maintenance areas
- Emission inventories, conditions, and trends relevant to the plan area
- Federal, state, and tribal governmental agency implementation plans for regional haze, non-attainment, or maintenance areas (including assessing whether Forest Service emission estimates have been included in the appropriate agency implementation plans)
- Critical loads

[34]For this assessment, the best available science was used that is relevant, accurate, and reliable. Uncertainty in the assessment has been appropriately documented where relevant. Government data that has met strict protocols for data collection was used to assess the current conditions and trends with regards to ambient air quality, visibility, emissions inventories, and deposition. The critical load information was based on multi-agency government research, analysis, and following Forest Service protocols.

Based on the above information, the assessment characterizes and evaluates the status of airsheds and air quality relevant to the plan area, assuming management is consistent with current plan direction.

Identification of Airsheds

Airsheds are similar to watersheds, in that they are defined geographic areas that because of topography, meteorology, or climate, they are frequently affected by the same air mass. The difference with airsheds is that air masses and air pollutants move between airsheds mostly based upon larger meteorological patterns, rather than primarily by topography, as with water flowing through a watershed.

The Cibola is spread out across 10 counties in New Mexico and has numerous airsheds. Figure 45 identifies the airsheds as classified by the New Mexico Environment Department. The Cibola is contained within the following counties: Bernalillo, Sandoval, McKinley, Cibola, Valencia, Torrance, and Socorro, with small portions within Catron, Sierra, and Lincoln. The Cibola lies primarily within the Middle and Lower Rio Grande and the Central Closed airsheds.

For the purpose of this assessment, the air quality and emissions will be limited to those counties and airsheds identified in Figure 45

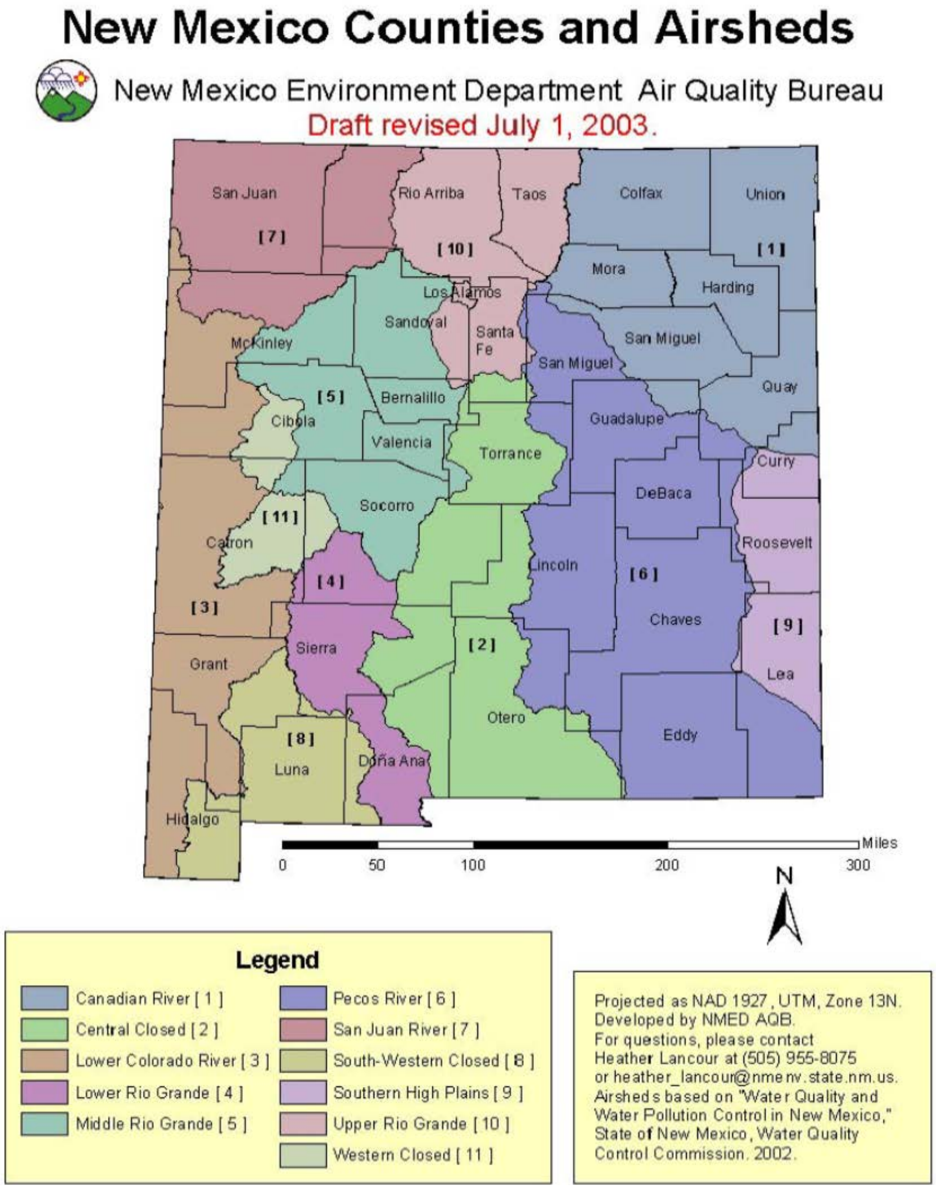


Figure 45. New Mexico counties and airsheds.

Identification of sensitive air quality areas

The basic framework for controlling air pollutants in the United States is mandated by the Clean Air Act (CAA), originally adopted in 1963, and amended in 1970, 1977, and 1990. The CAA was designed to "protect and enhance" air quality. Section 160 of the CAA requires measures "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreation, scenic, or historic value."

Congress classified 158 areas as Class I areas, including national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres, in existence on August 7, 1977 (42 U.S.C. 7472) (CAA Section 162). Class I areas have been designated within the Clean Air Act as deserving the highest level of air-quality protection. These “mandatory” Class I areas may not be re-classified to a less protective classification. The Cibola does not manage any Class 1 areas, however there are several nearby Class 1 areas that could be affected by projects and sources on or near the Cibola (Figure 46). They include the San Pedro Parks Wilderness, Bandelier National Monument, and the Pecos Wilderness to the North and East of the Mt. Taylor and Sandia Districts. The closest Class I areas to the south of the Magdalena and Mountainair ranger districts are the Gila Wilderness, the Bosque del Apache National Wildlife Refuge, and the White Mountain Wilderness.

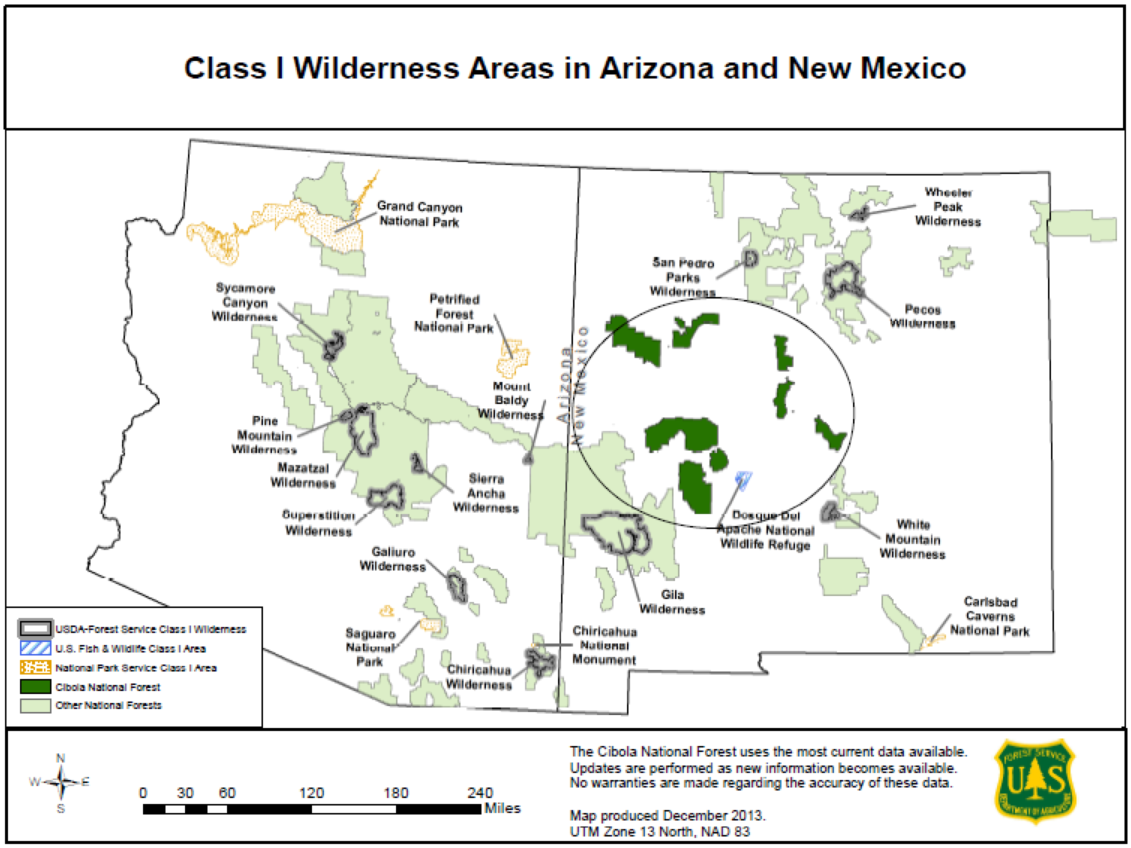


Figure 46. Class I areas in Arizona and New Mexico. (Circled area represents the Cibola plan area for the four mountain districts.)

The purpose of the CAA is to protect and enhance air quality, while at the same time ensuring the protection of public health and welfare. The Act established National Ambient Air Quality Standards (NAAQS), which represent maximum air pollutant concentrations which would protect public health and welfare. The pollutants regulated by an NAAQS are called criteria air pollutants and include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM_{10} and $PM_{2.5}$).

The US Environmental Protection Agency (EPA) established NAAQS for specific pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of NAAQS:

1. The primary standards represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare, and include a reasonable margin of safety to protect the more sensitive individuals in the population.
2. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

State agencies are given primary responsibility for air quality management as it relates to public health and welfare, and are further responsible for developing their State Implementation Plans (SIPs) to identify how NAAQS compliance will be achieved. If an area in a state has air quality worse than the NAAQS, that area becomes a non-attainment area. The state is then required to develop an SIP to improve air quality in that area. Once a non-attainment area meets the standards and that area can be designated as a maintenance area.

State standards, established by the New Mexico Environmental Improvement Board (EIB) and enforced by the New Mexico Environment Department, Air Quality Bureau (NMED-AQB), are termed the New Mexico Ambient Air Quality Standards (NMAAQS). The NMAAQS must be at least as restrictive as the National Ambient Air Quality Standards (NAAQS). NMAAQS also includes standards for total suspended particulate matter (TSP), hydrogen sulfide, and total reduced sulfur for which there are no National standards. Table 39 presents the national and state ambient air quality standards.

Table 39. National and New Mexico ambient air quality standards.

Pollutant	Averaging Time	New Mexico Standards	National Standards[a]	
			Primary[b,c]	Secondary[b,d]
Ozone	8-hour	—	0.075 ppm	Same as primary
Carbon monoxide	8-hour	8.7 ppm	9 ppm	—
	1-hour	13.1 ppm	35 ppm	—
Nitrogen dioxide	Annual	0.05 ppm	0.053 ppm	Same as primary
	24-hour	0.10 ppm	—	—
	1-hour		0.1 ppm	—
Sulfur dioxide	Annual	0.02 ppm	0.03 ppm	—
	24-hour	0.10 ppm	0.14 ppm	—
	3-hour	—	—	0.5 ppm
	1-hour		0.75 ppm	—
Hydrogen sulfide	1-hour	0.010 ppm	—	—
Total Reduced Sulfur	½-hour	0.003 ppm	—	—
PM_{10}	24-hour	Same as Federal	150 µg/m^3	Same as primary
$PM_{2.5}$	Annual (arithmetic mean)	Same as Federal	12 µg/m^3	Same as primary
	24-hour	Same as	35 µg/m^3	Same as primary

Pollutant	Averaging Time	New Mexico Standards	National Standards[a] Primary[b,c]	Secondary[b,d]
		Federal		
Total Suspended Particulates (TSP)	Annual (geometric mean)	60 μg/m^3	—	—
	30-day Average	90 μg/m^3	—	—
	7-day	110 μg/m^3	—	—
	24-hour	150 μg/m^3	—	—
Lead	Quarterly Average	—	1.5 μg/m^3	Same as primary

Notes:
(a) Standards other than the 1-hour ozone, 24-hour PM_{10}, and those based on annual averages are not to be exceeded more than once a year.

(b) To attain the 8 hour ozone standard the 3 year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm.

(c) Concentrations are expressed in units in which they were promulgated. μg/m^3 = micrograms per cubic meter and ppm = parts per million. Units shown as μg/m^3 are based upon a reference temperature of 25^{o}C and a reference pressure of 760 mm of mercury.

(d) Primary Standards: The levels of air quality necessary, with an adequate margin of safety to protect the public health.

(e) Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

μg/m^3 = micrograms per cubic meter; ppm = parts per million

The New Mexico Environment Department – Air Quality Bureau (NMED-AQB) enforces air pollution regulations and sets guidelines to attain and maintain the national and state ambient air quality standards within the state of New Mexico, except for tribal lands and Bernalillo County which maintain separate jurisdictions.

At the present time, the plan area attains all national and New Mexico ambient air quality standards. Dona Ana County is the only area in New Mexico that is currently in non-attainment for PM_{10}, which is approximately 45 miles south of the Magdalena ranger district (Figure 50).

Emissions Inventories, including current conditions and trends

This section presents current and historical data related to air quality in or near the Cibola. This data and any relevant trends in the data provide an understanding of the air quality conditions that could affect resources on the forest sensitive to air pollution. Included are a general description of baseline emissions inventories, ambient air quality measurements, visibility, and deposition measurements for sulfur, nitrogen, and mercury that define current air quality conditions of the plan area. Data are presented for the following parameters:

- Emission Inventory
- Ambient Air Quality

- Visibility
- Atmospheric Deposition (Acid Deposition and Mercury Deposition)

For emissions, the information presented in this section represents statewide totals for New Mexico. County-level emissions inventories were obtained and analyzed using the Western Regional Air Partnership (WRAP) Technical Support System (TSS) (WRAP 2012). Emissions inventories are useful tools for understanding regional sources of pollution that could affect the forest. Emissions inventories are created by quantifying the amount of pollution that comes from point sources (power plants, factories) and area sources (emissions from automobiles in a city or oil and gas development). Emissions can also originate from natural events like a wildfire.

The Western Regional Air Partnership is a voluntary partnership of states, tribes, federal land managers and the EPA. It tracks emissions data from states, tribes, and local air agencies, as well as emissions from wildland fire, in coordination with the EPA's National Emission Inventory (NEI). In addition, WRAP supports states by analyzing this data and models what future emissions maybe based on future trends, as part of the Regional Haze Rule. The Regional Haze Rule sets a 60-year timeline for states to improve visibility within mandatory federal Class I areas from baseline (2000-04) levels to natural conditions by 2064. States are required to show that reasonable progress is expected to be made toward this goal over the course of intermediary planning periods.

A summary of baseline emissions and projected emissions for 2018 for the state of New Mexico and the 10 counties that encompass the Cibola were analyzed (WRAP 2012). The following pollutants were included in the summary: carbon monoxide, nitrogen oxides, sulfur oxides, volatile organic compounds (VOCs), coarse particulate matter (surrogate for PM_{10}), and fine particulate matter (surrogate for $PM_{2.5}$). Nitrogen oxides and VOCs were included since they are precursors to the formation of ozone, which has both effects to human health but also has been shown to impact forested systems.

Emissions information is important, as adverse air quality impacts on the Cibola can usually be traced to air emissions. Knowing the magnitude of emissions and recognizing trends in emissions over time is important because emissions are usually correlated to the type and severity of air quality impacts. Often, adverse air quality impacts to air quality related values can be mitigated through programs that reduce associated air emissions. However, the Forest Service typically lacks direct authority to control air emissions that impact a particular ranger district.

While emissions play an important role in determining overall air quality for a given area, air quality evaluations are also based, in part, on ambient concentrations of pollutants in the air. The EPA is primarily concerned with air pollutants that result in adverse health effects. The Forest Service also uses these ambient concentrations to determine how pollutants such as ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2) impact forest resources. Because ambient air quality measurements provide quantitative information, they can also be meaningfully incorporated into air quality models. Ambient air quality data are presented in this section for a number of state, county, and federal monitoring stations in and around the air quality monitoring plan area.

Visibility data are presented for stations operated as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring program sponsored by the EPA and other government agencies. Visibility generally relates to the quality of visitors' visual experience on the forest and has been recognized as an important air quality related value in Class I wilderness areas dating back to the 1977 Clean Air Act Amendments. Generally, the presence of air pollution degrades the visual quality of a particular scene. In the Clean Air Act, a national visibility goal was established to return visibility to “natural background” conditions no later than 2064. IMPROVE monitoring data tracks the quality of visibility conditions and trends in visibility data and are specific to the wilderness areas of interest.

Deposition data are presented from the National Atmospheric Deposition Program (NADP). Deposition generally arises from the transformation in the atmosphere of air pollution to acidic chemical compounds (e.g., sulfuric acid, nitric acid), a portion of which are deposited into forested ecosystems. Excessive deposition may lead to adverse effects on ecosystems and on other resources (e.g., cultural). Acid deposition can lead to changes in the pH of stream runoff and adverse effects on aquatic species. Also, acidic depositions can accumulate in the wintertime snowpack. Research has demonstrated that when portions of the snowpack with high acid concentrations melt during spring thaw, the acids are often released as an acute pulse. The sudden influx of acid can alter the pH of high altitude lakes and streams for short periods, with dramatic consequences for respective aquatic communities.

Lastly, excessive nitrogen deposition can “over-fertilize” sensitive ecosystems, thereby promoting unnatural eruptions of native and nonnative plant species, invasions by noxious species and altering long-term patterns of nutrient cycling. National Atmospheric Deposition Program monitoring data collected in the plan area were chosen to best characterize these conditions in the wilderness areas of interest.

Where available, data on mercury deposition are also presented. Mercury is a neurotoxin which accumulates in plant and animal tissue, especially within the aquatic food chain. As birds, mammals, and humans consume fish and other aquatic organisms, the accumulated mercury is passed on to those species as well. Within human populations, mercury exposure is of particular concerns to pregnant women, as mercury can pass through the placenta to developing fetuses. Low-level mercury exposure is also linked to learning disabilities in children and interferes with the reproductive cycle in mammals that consume fish.

Emissions Inventory

Air quality effects on national forests are generally traceable back to the original source of emissions; therefore, air emissions information provides an overview of the magnitude of air pollution and is important in understanding air quality on the forest. Also, trends in precursor emissions would be expected to track with trends on the forest, e.g., visibility, acid deposition, etc. For example, improving visibility conditions in Class I areas would generally be associated with corresponding decreases in emissions for visibility precursor pollutants.

Emissions information is generally tracked for pollutants that have health-based air quality standards such as carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOCs), and particulate matter (PM). Volatile organic compounds emissions do not have a health-based standard, but are involved in the atmospheric chemical reactions that lead to ozone (O_3), which does. Ozone pollution is of added concern, because it can stress sensitive ecological systems. Particulate matter emissions are generally broken into two categories based on the size of the PM emissions: Fine PM (FPM) represents the particulate matter emissions sized at or below 2.5 microns in diameter. Coarse PM (CPM) represents the particulate matter emissions sized at or below 10 microns, but above 2.5 microns, in diameter. Smaller sized particles have greater health-related impacts because the smaller particles are more easily inhaled into the lungs.

Figure 47–Figure 49 show air emissions for the state of New Mexico for the criteria air pollutants of interest: CO, NOx, SO_2, VOC, CPM, and FPM.[35] Fine particulate matter (FPM) is analogous to $PM_{2.5}$ and course PM represents the PM_{10} emissions that are not $PM_{2.5}$. Each figure also depicts the relative magnitude of emissions from various source categories, such as mobile sources (vehicle exhaust), point sources (industrial and commercial operations), fire, biogenic sources etc. These figures represent statewide emissions for the baseline period (2000–2004) along with projected emissions for the 2018 time frame, based on information at the end of 2005. Since that time, additional regulations have been passed which should continue to reduce emissions. All of the emissions information in these figures has been taken from the WRAP Technical Support System (WRAP 2012).

For CO, NOx, and SO_2 emissions, the trend shows a projected decrease in statewide emissions through 2018. Most of the emissions reductions for CO and NOx emissions come from fewer mobile source emissions and are associated with the introduction of lower emitting vehicles over time, cleaner transportation fuels, and improvements in vehicle gas mileage. SO_2 emissions show improvement over time largely from reductions in stationary source emissions, such as coal-fired power plants, which are expected, in the near term, to install emission controls defined as Best Available Retrofit Technology (BART) under the regional haze regulations. Some of the decrease in SO_2 emissions occurs from mobile sources and is associated with cleaner transportation fuels, such as the introduction of low sulfur diesel fuel.

The expected increase in oil and gas industry activity through 2018 increases emissions of NOx and SO_2, which offsets some of the emissions decreases described above.

The VOC emissions in New Mexico are dominated by biogenic emission sources, (i.e., trees, agricultural crops, and microbial activity in soils). These emissions are projected to increase slightly through 2018, again due to increased oil and gas industrial activity.

Particulate emissions, both CPM and FPM, are expected to increase across New Mexico through 2018, consistent with the projected population growth in the state. Higher population translates to more vehicular traffic and the projected particulate emission increases generally occur in the "fugitive dust" and "road dust" categories.

Data analyzed using the WRAP TSS Emissions Review Tool shows similar emissions information for the pollutants of interest on a county-by-county basis (WRAP 2012). The seven counties of interest for this particular report are: Bernalillo, Cibola, McKinley, Sandoval, Socorro, Torrance, and Valencia. County-by-county distribution of emissions mostly follows the distribution of population across the counties of interest. Higher emissions for nearly all of the pollutants occur in Bernalillo County (Albuquerque) and McKinley County, which have larger population densities.

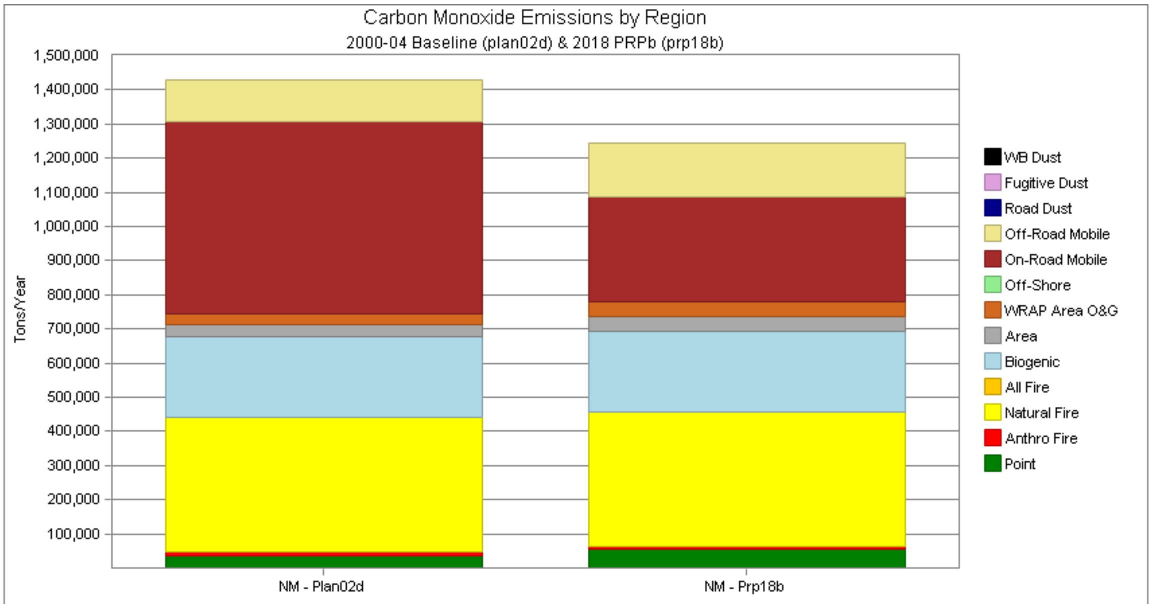
The general trend at state and county levels is for most of the emissions of CO, nitrogen oxides, and sulfur oxides to decrease through 2018. There are however, some notable exceptions. Nitrogen oxides and sulfur oxides are expected to increase in Bernalillo and Sandoval Counties from area sources primarily driven by industrial stationary source fuel combustion. Point source

[35] Products obtained from WRAP TSS Emissions Review Tool http://vista.cira.colostate.edu/TSS/Results/HazePlanning.aspx Plan02d data represent the 5-year baseline average period. PRP18b data represent WRAP's Preliminary Reasonable Progress Inventory. Blank entries represent instances where data categories are not applicable or data are not available.

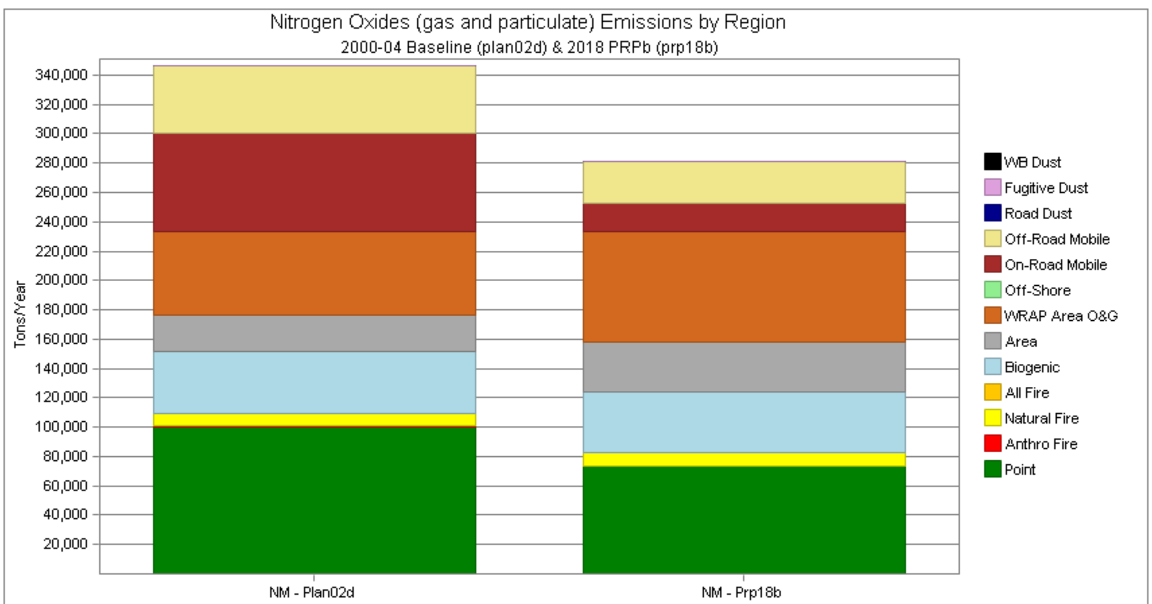
emissions of sulfur oxides are expected to increase in McKinley Country. Also of note is that wildfire emissions are a significant source of CO.

Particulate matter (PM) and VOCs are all expected to increase at state and county levels through 2018. The primary source of PM, both coarse and fine, is from windblown dust across the land and from fugitive dust from anthropogenic sources. Higher temperatures and persistent drought could exacerbate this trend (Prospero 2003). At the state level, VOCs are expected to increase primarily from oil and gas development in the Four Corners area and in the Permian Basin in eastern New Mexico. Biogenic sources of VOCs are a major source relative to the overall emissions in both New Mexico and in the counties where the Cibola is located.

The county-by-county emissions trends through 2018 generally share the patterns of decline described above.

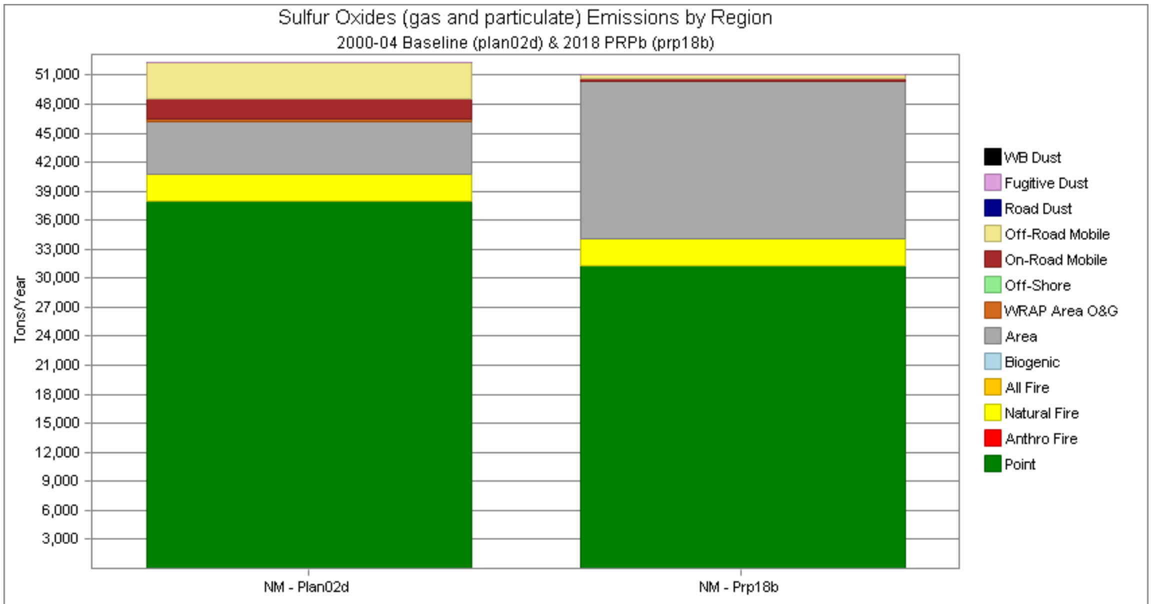


Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	36,589	9,937	393,865		238,478	34,426	31,628		561,611	124,063			
Prp18a	2,018	57,376	6,349	393,855		238,478	41,942	44,011		308,010	153,865			

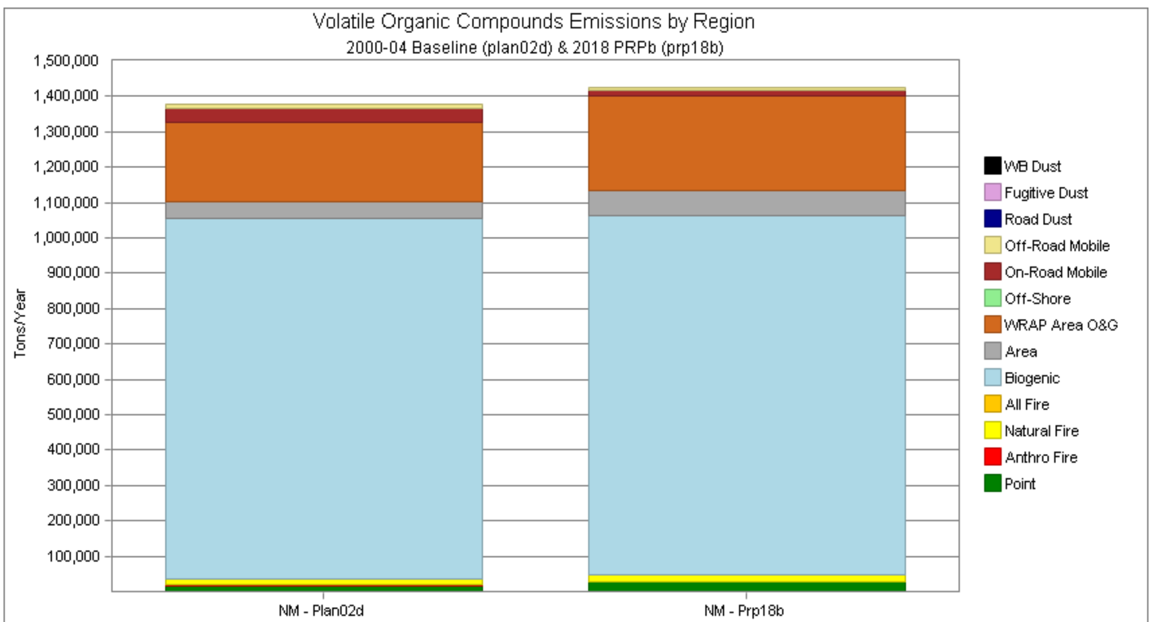


Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	100,387	394	8,570		42,139	25,130	56,210		67,835	45,311			
Prp18a	2,018	74,600	262	8,570		42,139	33,768	74,648		19,746	33,175			

Figure 47. New Mexico 2002 baseline and projected 2018 emission summaries, carbon monoxide (top) and nitrogen oxides (bottom).

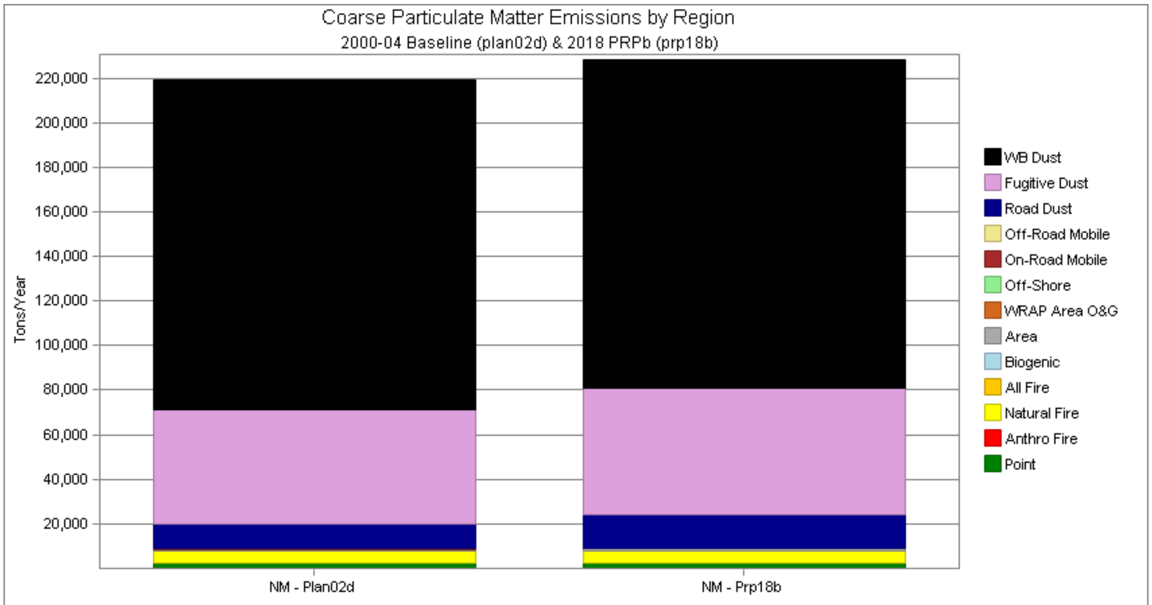


Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	37,918	94	2,729			5,433	250		2,066	3,846	4	6	
Prp18a	2,018	32,634	72	2,729			16,255	12		334	356	6	7	

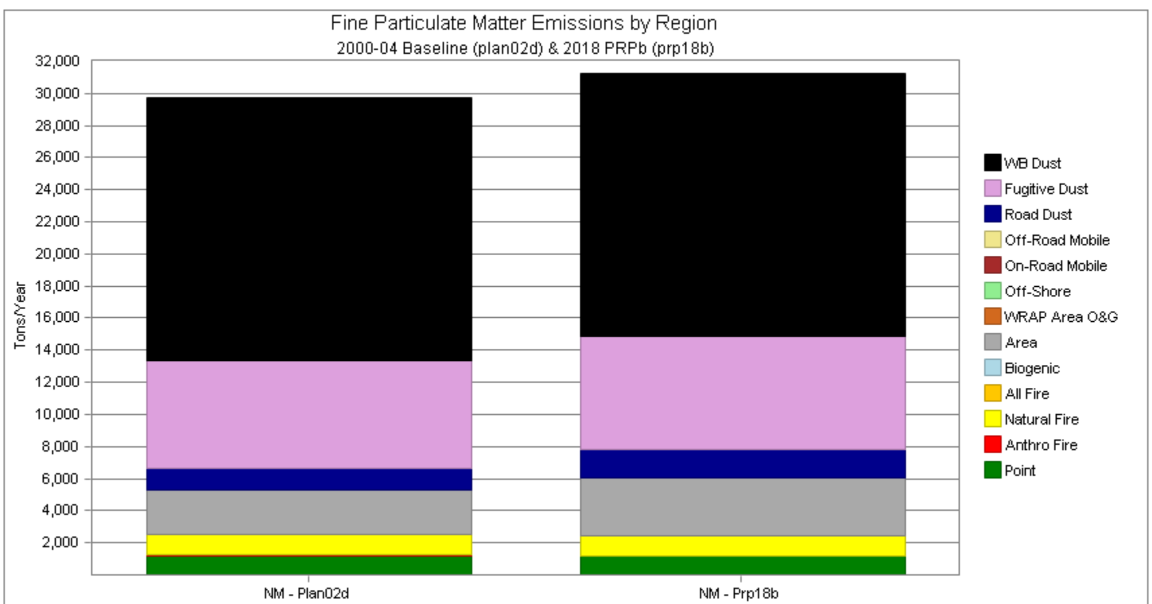


Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	17,574	608	18,846		1,016,487	49,010	224,268		38,768	13,850			
Prp18a	2,018	26,187	388	18,846		1,016,487	70,556	267,846		15,554	9,463			

Figure 48. New Mexico 2002 baseline and projected 2018 emission summaries, sulfur oxides (top) and volatile organic compounds (bottom).



Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	2,286	105	5,400			695			403		11,074	51,533	147,589
Prp18a	2,018	1,944	63	5,400			1,231			464		14,857	56,533	147,589



Scenario	Year	Point	Anthro Fire	Natural Fire	All Fire	Biogenic	Area	WRAP Area O&G	Off-Shore	On-Road Mobile	Off-Road Mobile	Road Dust	Fugitive Dust	WB Dust
Plan02d	2,002	1,180	87	1,223			2,821					1,305	6,751	16,399
Prp18a	2,018	1,144	44	1,223			3,644					1,751	7,026	16,399

Figure 49. New Mexico 2002 baseline and projected 2018 emission summaries, coarse particulate mass (top) and fine particulate mass (bottom).

Ambient Air Quality Measurements

This section summarizes the ambient air quality measurements collected between the years 2000 and 2010 at New Mexico monitoring sites in and near the Cibola. These monitoring data depict concentrations of air pollutants which have the potential to cause adverse health effects in the general population and/or adverse ecological effects. Additional discussion about the health and ecological effects of individual pollutants is provided below.

Figure 50 shows the location of the air quality monitoring sites that are relevant to the plan area. There are a variety of air monitoring stations throughout New Mexico that are operated by the state, Bernalillo County, the Navajo Nation, and by federal land management agencies that can be used to gauge ambient air quality, visibility, and deposition of pollutants. A summary of the pollutants monitored and available period of record for each site is provided in Table 40. The visibility monitoring data are described in next section.

For the Cibola, most of the nearby ambient air quality monitoring stations are located in the greater Albuquerque metropolitan area. Although air quality levels in an urban area are not likely to be totally representative of the Cibola, these data do provide for a reasonable upper bound on air quality concentrations within the plan area. Lacking other data collected in more remote settings, the reported data are the best available information to characterize exiting air quality conditions for the wilderness areas of concern.

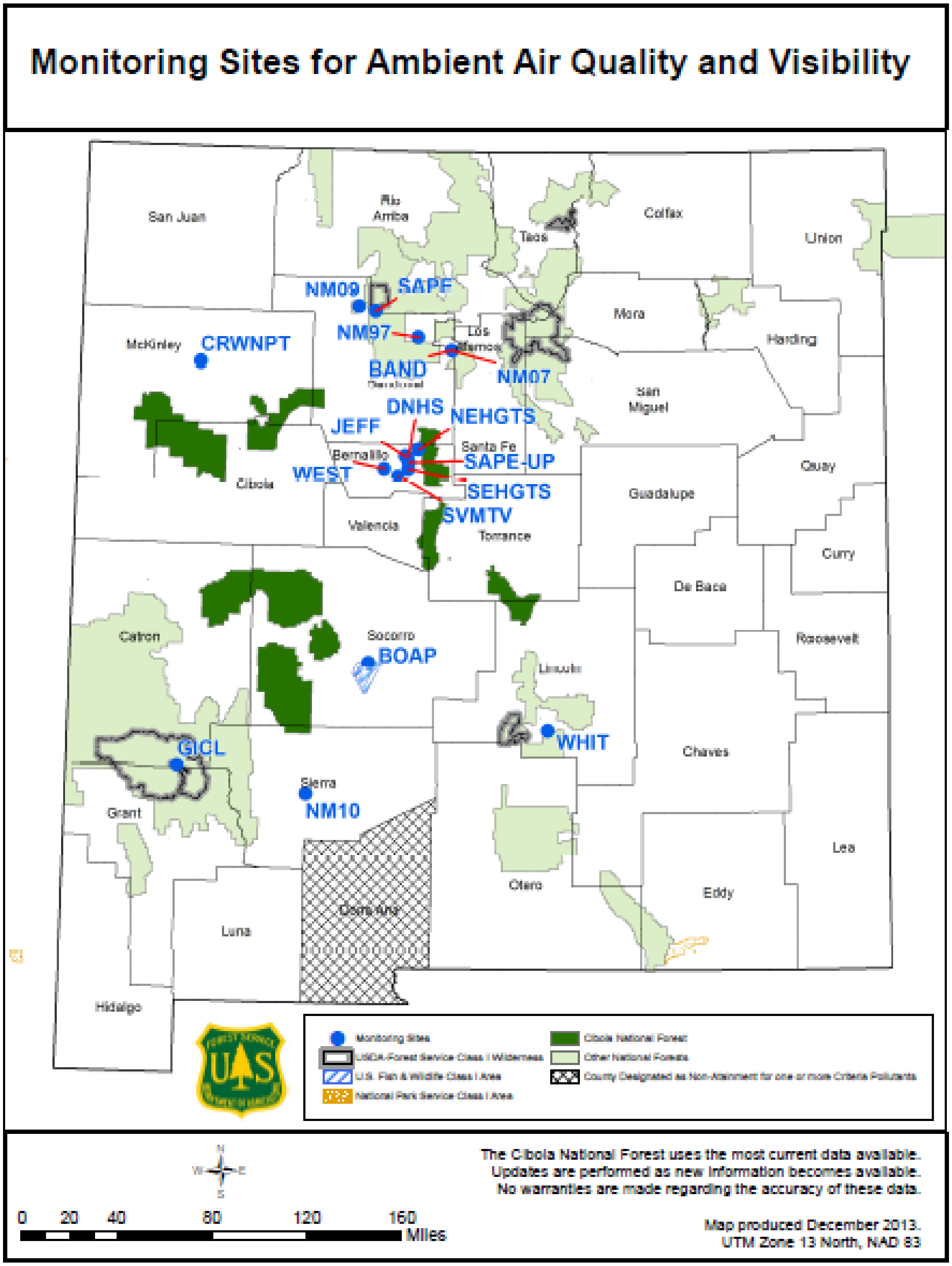


Figure 50. Map of air quality monitoring sites in the plan area.

Table 40. Air quality monitoring sites for the Cibola.

Monitoring Site	Site Label	Pollutants Monitored (review period)*
Bandelier	NM07	NADP/NTN (2000–2010)
Bandelier National Monument	BAND	IMPROVE Aerosol, dv (2000–2010)
Bosque del Apache	BOAP	IMPROVE Aerosol, dv (2000–2010)
Caballo	NM10	MDN (2000–2005)
Crownpoint	CRWNPT	PM_{10} (2008–2010)
Cuba	NM09	NADP/NTN (2000)
Del Norte High School	DNHS	CO (2000–2010), O_3 (2000–2010), NO_2 (2000–2010), $PM_{2.5}$ (2000-10), PM_{10} (2000–2010)
Far North East Heights	NEHGTS	O_3 (2000–2010)
Gila	GICL	IMPROVE Aerosol, dv (2000–2010)
Jefferson Corridor	JEFF	PM_{10} (2000–2010)
San Pedro Parks	SAPE	IMPROVE Aerosol, dv (2001–2010)
South East Heights	SEHGTS	O_3 (2003-10), $PM_{2.5}$ (2000–2010)
South Valley Mountain View	SVMTV	CO (2002–2010), O_3 (2002–2010), PM_{10} (2002–2010)
Uptown San Pedro	SAPE-UP	CO (2000–2010)
Valles Caldera National Preserve	NM97	MDN (2009–2010)
Westside	WEST	O_3 (2009–2010)
White Mountain	WHIT	IMPROVE Aerosol, dv (2002–2010)

*For the purposes of this assessment, only measurements collected between 2000 and forward were reviewed (dv=deciview).

Table 39 lists the current primary National Ambient Air Quality Standards (NAAQS), which represent ambient concentrations of air pollutants determined by the EPA to result in adverse health effects to the most sensitive population groups, such as: children, the elderly, and persons with breathing difficulties. The health effects of air pollution are discussed further in the subsequent sections that describe specifics of monitoring data for each pollutant.

Carbon Monoxide (CO) Concentrations

Carbon monoxide (CO) data have been collected at three sites in and near the wilderness areas of interest. Generally, CO emissions are caused by exhaust from fuel combustion in mobile sources (cars, trucks, etc.) and as such are generally monitored only in urban settings. All of the CO monitoring sites are in the Albuquerque metropolitan area, and as such, measured concentrations may not represent conditions on the Cibola. However, these data are the only available monitoring for CO concentrations.

Excessive CO concentrations can have a detrimental impact on human health and the environment. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. Exposure to CO can also reduce the oxygen-carrying capacity of the blood. People with several types of heart disease may experience reduced capacity for pumping oxygenated blood to the heart, which can cause lead to myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina). For these people, short-term CO exposure further affects their body's already compromised ability to respond to the increased oxygen demands of exercise or exertion (USEPA 2013).

Data representing the highest CO concentrations measured for the 1-hour and 8-hour average monitoring periods for calendar years 2000–2010 for the Del Norte, San Pedro, and South Valley monitoring stations were analyzed (WRAP 2012). These averaging periods correspond to the NAAQS. The data show a decrease in measured CO concentrations since 2000, generally attributable to improvements in the emissions profiles for passenger vehicles. Since after 2008, the peak 1-hour CO concentrations are generally less than 5 ppm and the peak 8-hour CO levels are generally around 2 ppm.

Based on the available monitoring data, CO concentrations are well below the applicable NAAQS.

Ozone (O_3) Concentrations

Ozone (O_3) data have been collected at five sites near the Cibola. All sites are located in the greater Albuquerque metropolitan area. Over 10 years of data are available for just two sites. The Westside monitoring station initiated monitoring in 2009 and has data available for only two years. The remaining sites having seven and eight years of data represented (USEPA 2012).

Ozone (O_3) is one of the major constituents of photochemical smog. It is not emitted directly into the atmosphere, but instead is formed by the reaction between nitrogen oxide (NOx) emissions and volatile organic compounds (VOCs) emissions in the presence of sunlight. The highest concentrations of O_3 typically occur in the summer months.

Excessive O_3 concentrations can have a detrimental impact on human health and the environment. Elevated O_3 levels can cause breathing problems, trigger asthma, reduce lung function, and lead to increased occurrence of lung disease. Ozone (O_3) also has potentially harmful effects on vegetation, which is usually the principal threat to forested ecosystems. It can enter plants through leaf stomata and oxidize tissue, causing the plant to expend energy to detoxify and repair itself at the expense of added growth. Damage to plant tissue can be more pronounced where the detoxification and repair does not keep up with the O_3 exposure. The mesophyll cells under the upper epidermis of leaves are particularly sensitive to O_3. Ozone (O_3) damage can generate a visible lesion on the upper side of a leaf, termed "oxidant stipple." Other symptoms of elevated O_3 exposure may include chlorosis, premature senescence, and reduced growth. These symptoms are not unique to ozone damage and may also occur from other stresses on plant communities such as disease and/or insect damage.

Data representing the 4^{th} highest 8-hour average O_3 concentrations for calendar years 2000–2010 for the Del Norte, Southeast Heights, South Valley, Westside, and Far North East Heights monitoring stations were analyzed (WRAP 2012). The applicable 8-hour National Ambient Air Quality Standards (NAAQS) is based on the annual fourth-highest daily maximum O_3 concentration averaged over three years. At some New Mexico monitoring sites, the annual 4^{th} highest concentration is at or near the NAAQS level (75 ppb). However, in the last three years, the 75 ppb level has not been exceeded based on the 4^{th} highest 8-hour average O_3 concentration. Note that given the form of the O_3 NAAQS, data analyzed does not allow for a strict comparison to the NAAQS as the data have not been averaged over three years as required for comparison to the NAAQS. However, it would appear that O_3 concentrations are below the applicable NAAQS although the margin of compliance is small.

Particulate Matter - $PM_{2.5}$/PM_{10}

$PM_{2.5}$ data are available from two monitoring sites over the period 200 – 2010. PM_{10} data have been collected at four sites in and near the forest areas of interest since 2008, with three sites having data prior to 2002, and only two sites prior to 2002 (USEPA 2012). Again, all monitoring sites except the Crownpoint PM_{10} site are located within the Albuquerque urban region. Crownpoint is located in McKinley County.

As shown by the emissions inventory data documented in the prior section, most PM emissions in New Mexico are associated with fugitive dust and other sources of dust (e.g., wind erosion and re-entrained dust from traffic on streets and roadways). Chronic exposure to elevated $PM_{2.5}$ and PM_{10} concentrations leads to an increased risk of developing cardiovascular and respiratory diseases (including lung cancer) where the PM emissions contain toxic constituents such as heavy metals (WHO 2011).

The annual average $PM_{2.5}$ concentration was approximately 6 micrograms per cubic meter at the Del Norte and South East Heights monitoring sites, compared to the NAAQS of 12 micrograms per cubic meter (WRAP 2012). On December 14, 2012, the EPA reduced the primary $PM_{2.5}$ NAAQS from 15 micrograms per cubic meter to 12 micrograms per cubic meter (annual mean, averaged over three years). The 15 micrograms per cubic meter standard was retained as the annual mean secondary $PM_{2.5}$ NAAQS. In most years, Del Norte showed the highest $PM_{2.5}$ levels, but differences between $PM_{2.5}$ concentrations at the monitoring sites were small.

The 98^{th} percentile 24-hour average $PM_{2.5}$ concentrations measured roughly 15–20 micrograms per cubic meter, with some minor year-to-year variability (WRAP 2012). The 24-hour NAAQS for $PM_{2.5}$ is 35 micrograms per cubic meter, based on the 98^{th} percentile concentration averaged over three years.

The PM_{10} data for the annual mean and the maximum 24-hour average concentration for the Del Norte and Southeast Heights from 2000–2010 were analyzed (WRAP 2012). The PM_{10} NAAQS exists only for the 24-hour average (150 micrograms per cubic meter). The 24-hour average PM_{10} concentrations show considerable variability from site-to-site and from year-to-year. At the Jefferson and South Valley monitoring sites, occasional samples exceed the 150 microgram per cubic meter NAAQS. Maximum 24-hour average PM_{10} concentrations are below the NAAQS at the Del Norte and Crownpoint monitoring locations.

Over the period of record, the annual mean PM_{10} concentrations have been as high as 50 micrograms per cubic meter at the Jefferson monitoring site and 40 micrograms per cubic meter at the South Valley monitoring site. At Crownpoint and Del Notre, the measured PM_{10} concentrations are mostly 20 micrograms per cubic meter or less (annual average). An applicable annual mean NAAQS no longer exists for PM_{10} concentrations, although PM_{10} is still regulated by an NAAQS for the 24-hour average as noted above.

Available $PM_{2.5}$ monitoring data show that concentrations within the plan area comply with the applicable NAAQS. Available PM_{10} monitoring data show occasional excursions with measured concentrations above the 24-hour average NAAQS of 150 micrograms per cubic meter. However, the greater Albuquerque metropolitan area is current designated as “attainment” for PM_{10}.

Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2)

Nitrogen oxides (NOx) and SO_2 emissions occur as a result of fuel combustion, either in industrial or commercial emission sources such as power generation facilities or in mobile sources (e.g., cars, trucks, busses, aircraft etc.). Sulfur dioxide (SO_2) emissions are linked to the quantity of sulfur in fuels that are combusted. These emissions may also result from smelting and refining of copper ores, due to the liberation of sulfur compounds contained in the ore body.

Nitrogen oxides (NOx) and SO_2 emissions are also linked to the formation of nitrate and sulfate aerosols, which have potential adverse effects on visibility. Also, NOx and SO_2 emissions are linked to increases in acid precipitation and acid deposition.

Nitrogen dioxide (NO_2) is the regulated form of NOx emissions. Nitrogen dioxide (NO_2) monitoring data are available for only one site in the area of interest (USEPA 2012), which is at Del Norte High School, within the greater Albuquerque metropolitan area. No SO_2 monitoring data have been collected at New Mexico monitoring sites near the forests of interest.

Health effects from exposure to elevated concentrations of NO_2 include inflammation of the airways for acute exposures and increases in the occurrence of bronchitis for children and other sensitive individuals chronically exposed to elevated NO_2 levels (WHO 2011).

The Del Norte High School 98th percentile 1-hour NO_2 concentration was generally in the range of 50–65 ppb and the annual mean NO_2 concentration was generally 15 ppb or less (WRAP 2012). These levels are substantially below the applicable 1-hour and annual NAAQS (100 and 53 ppb respectively) and demonstrate that ambient NO_2 concentrations comply with the NAAQS in the area of interest.

Visibility

Visibility has been recognized as an important value going back to the 1977 Clean Air Act (CAA) Amendments, which designated it as an important value for most wilderness areas that are designated as “Class I.” Visibility refers to the conditions that allow the appreciation of the inherent beauty of landscape features. This perspective takes into account the form, contrast, detail, and color of near and distant landscapes. Air pollutants (particles and gasses) may interfere with the observer’s ability to see and distinguish landscape features.

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program has been monitoring visibility conditions in Class I wilderness areas in New Mexico and nationwide since the late 1980s. The following five IMPROVE monitoring sites (mapped in Figure 50) are relevant to the Cibola:

1. Bandelier National Monument (BAND1)
2. Bosque del Apache (BOAP1)
3. Gila (GICL1)
4. San Pedro Parks (SAPE1)
5. White Mountain (WHIT1)

IMPROVE monitors concentrations of atmospheric aerosols (sulfates, nitrates, etc.) and uses these data to assess light “extinction,” or the degree to which light is absorbed and/or scattered by air pollution. Visibility is normally expressed in terms of “extinction” or by using the “deciview” index, which is calculated from the measured extinction value. The “deciview” index represents a measure of change in visibility conditions which is typically perceptible to the human eye. A deciview change in the range of 0.5 to 1.0 dv is generally accepted as being the limit of human perceptibility. Figure 51 illustrates the relationships among extinction, deciviews, and visual range.

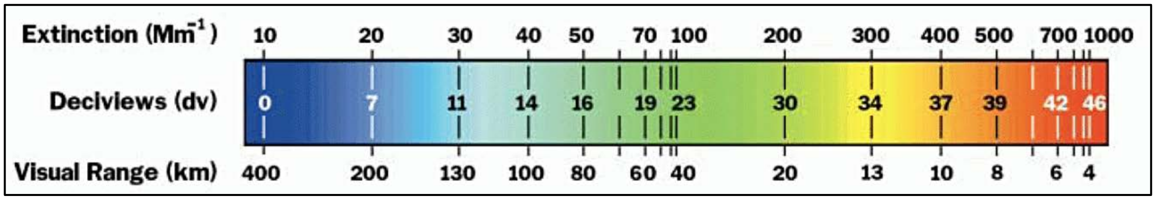


Figure 51. Relationship among extinction, deciview index, and visual range.

Measurements of annual mean visibility (as extinction) across the United States are shown in Figure 52 as taken from IMPROVE (Hand et al. 2011). These data show lower values of extinction (better overall visibility) across the western United States and high values of extinction in the eastern United States. Western areas in and around urban centers (e.g., Phoenix, Denver, Las Vegas, etc.) also show more degraded visibility.

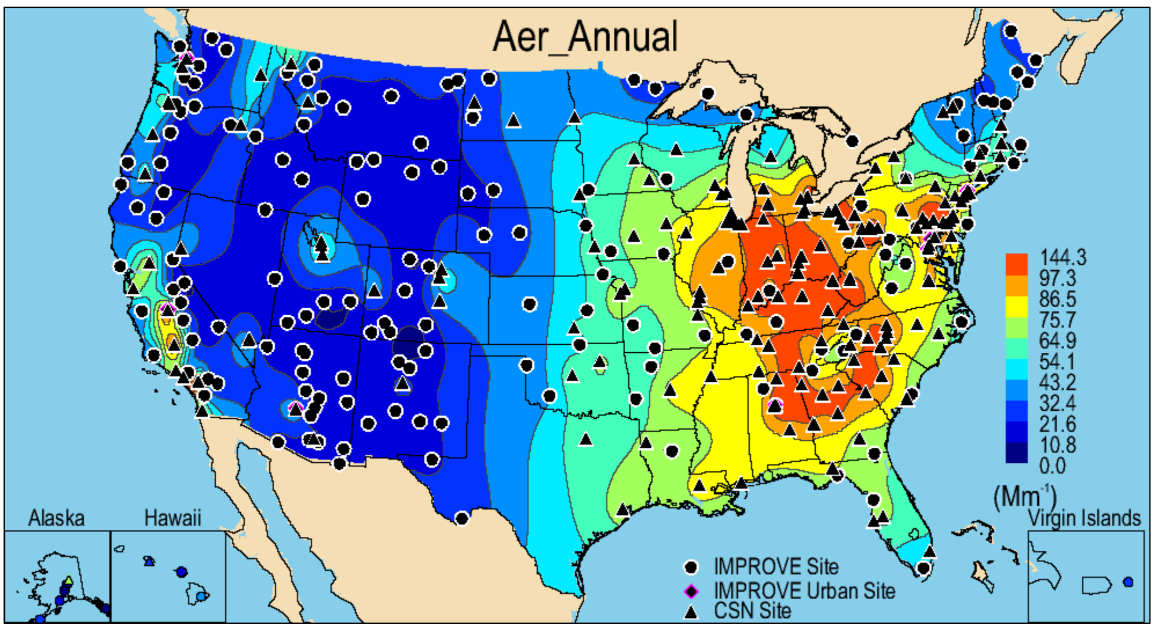


Figure 52. Reconstructed annual mean aerosol extinction from IMPROVE and other aerosol data (Hand et al. 2011).

Under the Clean Air Act (CAA), the national visibility goal is to return visibility in Class I areas to the “natural background condition” no later than 2064. To meet this goal, the CAA has instituted measures for emissions control at large stationary sources that contribute to visibility impairment.

Interagency Monitoring of Protected Visual Environments (IMPROVE) reconstructed extinction data for the Cibola were calculated from the IMPROVE aerosol measurements for the period 2000–2010 and are summarized in Table 41 for the 20 percent worst-case days (IMPROVE 2012). The IMPROVE measurements were sorted to provide the representative visibility conditions for the “worst 20%” visibility and the “average” visibility days, which are standard techniques for reviewing and assessing IMPROVE aerosol monitoring data. The visibility condition representing the 2064 goal for achieving “natural background” is also shown in Table 41. These data provide a measure of how much visibility improvement is required at each Class I area in order to achieve the 2064 National Visibility Goal (NMED 2011b).

The data in Table 41 are reported using the deciview metric described earlier. Higher values of deciview represent more degraded visibility conditions. Data are shown using the "baseline period" (2000–2004) along with the "progress period" (2005–2009) corresponding to the New Mexico regional haze SIP and the 2064 National Visibility Goal (natural background).

Table 41. Summary of IMPROVE visibility monitoring data, 20% worst-case days (dv).

Wilderness	IMPROVE Monitor	2000-04 Baseline Period		2005-09 Progress Period		2064 Goal Natural Background
		Average	Range	Average	Range	
Bandelier	BAND1	12.2	10.5–14.6	11.8	11.0–12.8	6.26
Bosque del Apache	BOAP1	13.8	12.9–14.6	13.4	11.9–14.3	6.73
Gila	GICL1	13.1	12.0–14.2	12.5	11.1–13.9	6.66
San Pedro Parks	SAPE1	10.2	9.3–11.6	9.9	8.2–10.8	5.72
White Mountain	WHIT1	13.7	12.4–14.8	13.2	12.4–14.3	6.8

These data show that based on the 20 percent worst days during the 2005–2009 "progress period," Bosque del Apache Wilderness and White Mountain have the most degraded visibility and San Pedro Parks has the least degraded visibility. Also, the general trend in visibility (based on the change in the worst 20 percent days between the baseline period and progress period) has been toward moderately improving visibility conditions. Table 41 also shows that the level of visibility improvement through the 2005–2009 "progress period," has been relatively modest compared to the visibility improvements needed by 2064 to achieve the goal of natural background conditions.

Interagency Monitoring of Protected Visual Environments (IMPROVE) measurements at each of the nearby Class I areas of interest can be found at http://views.cira.colostate.edu/fed/ (IMPROVE 2012). Data from this site show the reconstructed extinction at each IMPROVE monitoring site for each year (2000–2010 where data are available for the entire period of record). This site also produces pie charts showing the percent contribution to the reconstructed extinction for the different aerosol species. The percent contribution charts represent the 2000–2004 "baseline" and the 2005–2009 "reasonable further progress" periods described above. For these particular charts, the visibility is reported using units of inverse megameters, which is a direct measure of atmospheric light extinction. Again, higher values of extinction represent more degraded visibility.

- **Bandelier National Monument** (BAND1): The reconstructed extinction for the most impaired 20 percent days showed levels generally in the 30–40 Mm-1 range, except during 2000, when the extinction measured around 70 Mm-1. The conditions in Year 2000 at BAND1 appear somewhat anomalous, with very high extinction budgets for organics, strongly suggesting the presence of nearby wildfires. These conditions are not apparent in any other data year. Excluding the potential bias introduced by the Year 2000 measurements, the extinction budgets at Bandelier are roughly 25 percent Rayleigh scattering, 25–30 percent sulfate and nitrate (indicative of industrial source emissions), 20–25 percent organics, and 10–15 percent coarse mass and soils. There has been a steady improvement in the visibility conditions represented by the 20 percent most impaired days since about 2007, which is mostly reflected by reductions in sulfate and may be a result of emissions control technology improvements at coal-fired electric generating stations.

- **Bosque del Apache** (BOAP1): The reconstructed extinction for the most impaired 20 percent days showed levels generally in the 30–45 Mm-1 range. The extinction budgets at Bosque del Apache are roughly the same as described above for Bandelier: about 25 percent Rayleigh scattering, 25–30 percent sulfate and nitrate (indicative of industrial source emissions), 20 percent organics, and 15–20 percent coarse mass and soils. At Bosque del Apache, there has been a steady improvement in the visibility conditions represented by the 20 percent most impaired days since about 2007, which is mostly reflected by reductions the contributions from sulfate and nitrate and may be a result of emissions control technology improvements at coal-fired electric generating stations.
- **Gila** (GICL1): The reconstructed extinction for the most impaired 20 percent days also showed levels generally in the 30–45 Mm-1 range. Generally, any variability in the year-to-year extinction budget at Gila corresponds to variability in the organic species concentrations. However, the Gila extinction budgets show significantly more contribution from organic species compared to the other IMPROVE sites. At Gila, the extinction budget shows about 20 percent Rayleigh scattering, 20 percent sulfate and nitrate (indicative of industrial source emissions), 30–40 percent organics, and about 10 percent coarse mass and soils. Like the other IMPROVE sites above, there has been a slight improvement in the visibility conditions represented by the 20 percent most impaired days since about 2007. However, unlike the other IMPROVE sites discussed above, the year-to-year changes appear to be affected by the variability in the organics budget and not changes to sulfate and nitrate concentrations.
- **San Pedro Parks**: As mentioned above, the San Pedro Parks has the least degraded visibility, and this is also evident in the extinction data. For the 20 percent most impaired days, the reconstructed extinction ranges between 25–35 Mm-1. Because San Pedro Parks has the least impaired visibility, the Rayleigh contribution in the extinction budget is 30 percent, slightly larger than other IMPROVE sites. The sulfate and nitrate contribution is about 25–30 percent, the organics contribution is about 25 percent, and the coarse mass and soil contribution is about 15 percent. Similar to some of the other sites, the extinction data show some improvements in visibility conditions since 2007, generally reflecting less impact from sulfate, which might be indicative of regional SO_2 emission reductions.
- **White Mountain:** At this IMPROVE site, the extinction measurements for the most impaired 20 percent days range between 35–45 Mm-1. The extinction budgets at White Mountain are also different compared to the other IMPROVE monitoring sites discussed above. The White Mountain extinction budget shows greater visibility impacts from sulfate and nitrate (30–35%) and coarse mass and soil (20–25%) compared to the other IMPROVE monitoring sites discussed above. There is also no discernible trend in the IMPROVE data at White Mountain.

Atmospheric Deposition Information

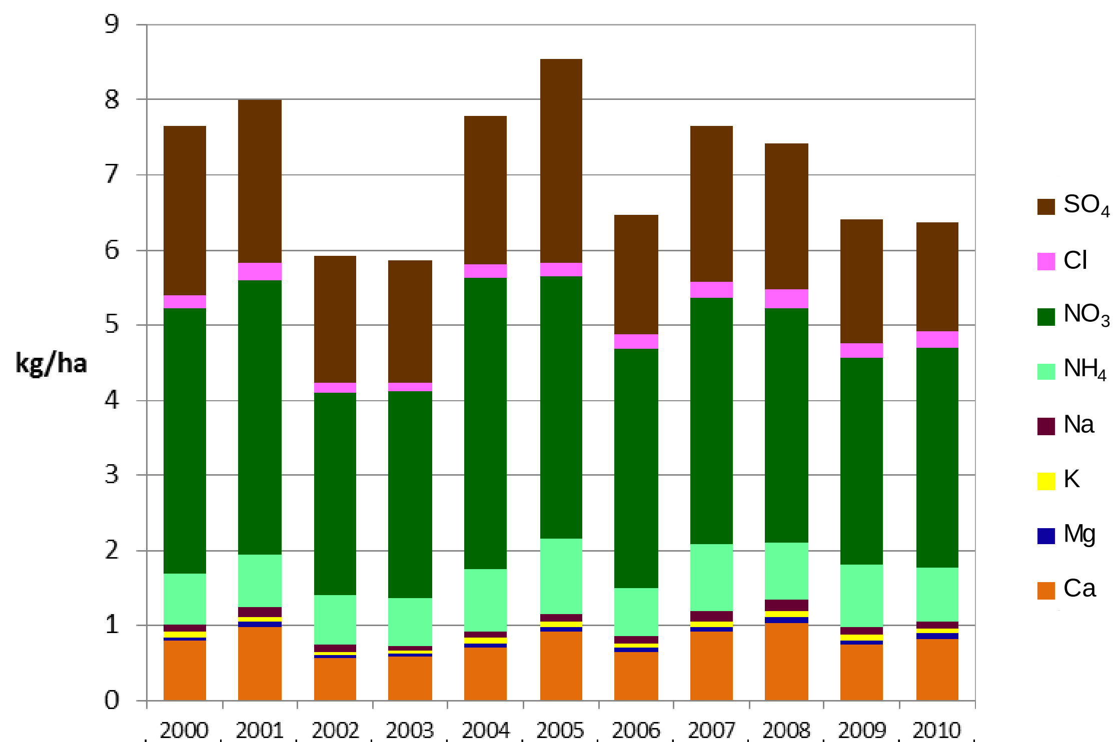
Sulfur and Nitrogen Deposition

Air emissions of nitrogen oxides (NOx) and sulfur dioxide (SO_2) can lead to atmospheric transformation of these pollutants to acidic compounds (e.g., nitric acid and sulfuric acid) and the resultant deposition onto land and water surfaces in forested ecosystems. Documented effects of nitrogen and sulfur deposition include acidification of lakes, streams and soils, leaching of nutrients from soils, injury to high-elevation forests, changes in terrestrial and aquatic species composition and abundance, changes in nutrient cycling, unnatural fertilization of terrestrial ecosystems, and eutrophication of aquatic ecosystems.

Deposition impacts are generally described in terms of the “critical load,” defined as “the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur based on present knowledge” (NADP 2009). In other words, the “critical load” determines the tipping point at which harmful effects attributable to deposition in a particular ecosystem start to occur. Critical loads have been established at some, but not all wilderness areas. For the New Mexico wilderness areas of interest, critical loads for nitrogen and acid deposition have been established based on a national assessment, although they lack some site-specific data for a more robust assessment (Pardo et al. 2011). This general approach has been applied to determine critical loads for nitrogen and sulfur deposition, for some sensitive receptors on the forest.

Figure 53 shows the sulfur and nitrogen deposition measurements collected at the Bandelier National Monument station operated for the National Trends Network (NTN) over the period 2000–2010 (CASTNET 2013). Totals are shown for wet deposition and dry deposition for both sulfur and nitrogen, along with other chemical species. Units of measurement are kilograms per hectare (kg/ha).

Deposition has remained relatively constant over the period of record, although some year-to-year variability is noted. Generally, the observed deposition at Bandelier ranges between 6.0-8.5 kg/ha-yr. Nitrogen deposition makes up the bulk of the deposition and typically constitutes about 3 kg/ha-yr, while sulfur deposition is typically closer to 2 kg/ha-yr.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
SO_4	2.25	2.17	1.68	1.62	1.98	2.71	1.598	2.078	1.95	1.64	1.45
Cl	0.19	0.24	0.15	0.12	0.17	0.19	0.191	0.229	0.25	0.20	0.21
NO_3	3.53	3.63	2.69	2.76	3.88	3.49	3.195	3.262	3.12	2.76	2.94
NH_4	0.67	0.70	0.66	0.64	0.84	1.00	0.638	0.898	0.76	0.83	0.71
Na	0.106	0.144	0.09	0.052	0.086	0.101	0.092	0.13	0.156	0.104	0.108
K	0.067	0.067	0.037	0.045	0.075	0.073	0.062	0.081	0.067	0.064	0.06
Mg	0.053	0.062	0.043	0.036	0.053	0.059	0.048	0.067	0.078	0.057	0.067
Ca	0.79	0.98	0.57	0.59	0.70	0.92	0.649	0.912	1.04	0.75	0.82

Figure 53. Chemical deposition (Bandelier Station, 2000–2010).
(Data obtained from http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=NM07&net=NTN)

Mercury Deposition

Mercury is a persistent bioaccumulative toxin which can stay in the environment for long periods of time, cycling between air, water and soil. Mercury deposits on the earth's surface through wet or dry deposition, which can accumulate in the food chain and bodies of water. Toxic air contaminants like mercury, are emitted primarily by coal-fired utilities, and may be carried thousands of miles before entering lakes and streams as mercury deposition. Mercury can bioaccumulate and greatly biomagnify through the food chain in fish, humans, and other animals. Mercury is converted to methylmercury by sulfur reducing bacteria in aquatic sediments, and it is this form that is present in fish. Methylmercury is a potent neurotoxin, and has been shown to have detrimental health effects in human populations as well as behavioral and reproductive impacts to wildlife. Eating fish is the main way that people are exposed to methylmercury. However, each person's exposure depends on the amount of methylmercury in the fish they eat, how much they eat, and how often. Typically, larger fish that are higher up the food chain (eat lots of little fish rather than algae) will have a greater amount of methylmercury in them.

Almost every state (including New Mexico) has consumption advisories for certain lakes and streams warning of mercury-contaminated fish and shellfish. Bluewater Lake, which has its headwaters on the Mt. Taylor ranger district, has a mercury advisory for Tiger Muskie; however, the fish consumption advisory is only for fish greater than 30 inches (NMED 2011a). Often lakes have advisories for fish less than 10 inches, which is some indication of the level of impairment.

The Mercury Deposition Network collects and provides a long-term record of mercury concentrations and deposition in precipitation. As a result of coal-fired utilities in the Southwest, and the limited levels of mercury pollution controls at those sites, the total concentration of mercury in the air is fairly high relative to elsewhere in the United States (Figure 54) (MDN 2011). However, due to the relatively low precipitation rates (except at higher elevations), the mercury from wet deposition is comparatively low (Figure 55) (MDN 2011).

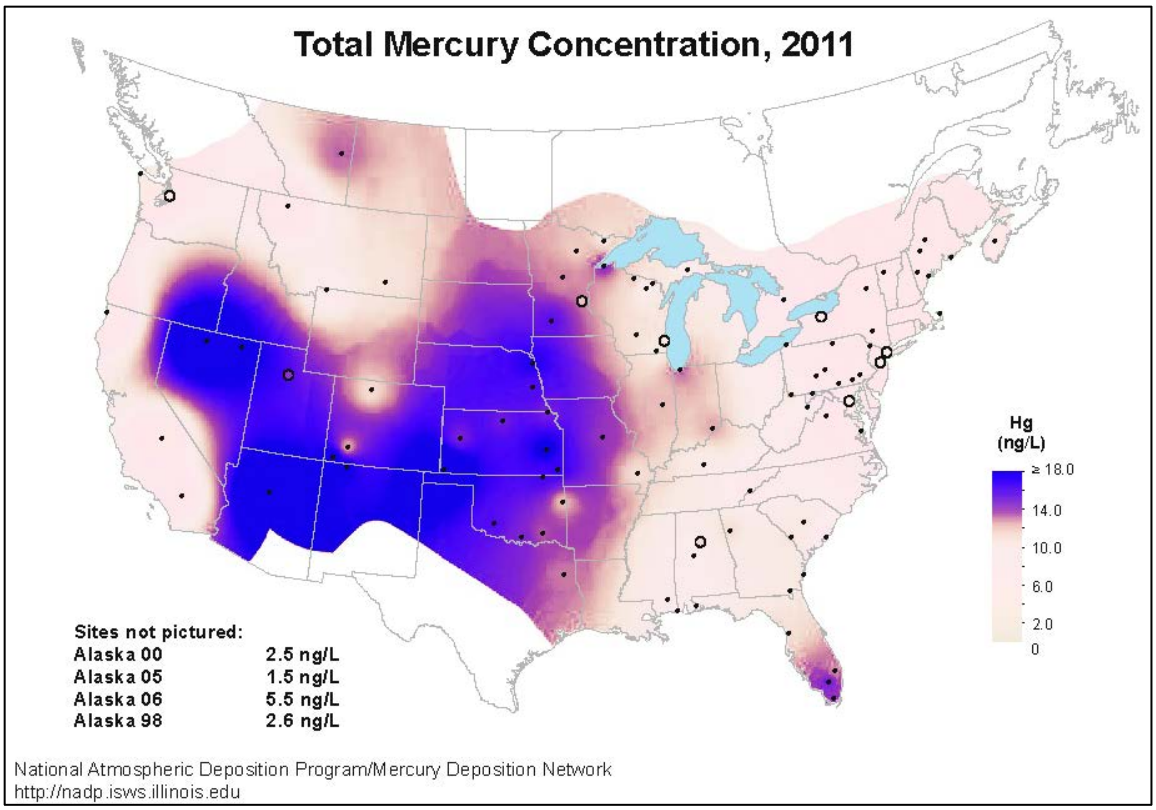


Figure 54. Total mercury concentration, 2011.
(Data obtained from: http://nadp.sws.uiuc.edu/maplib/pdf/mdn/hg_Conc_2011.pdf)

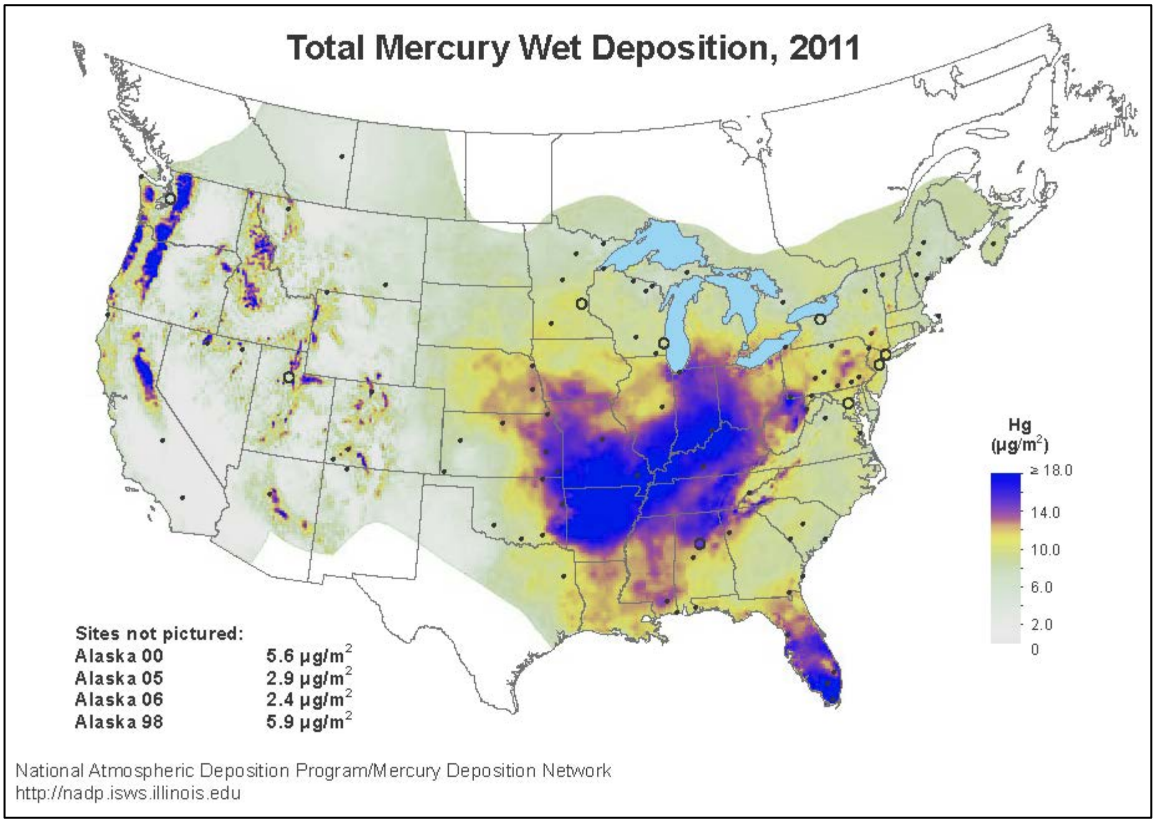


Figure 55. Total wet mercury deposition, 2011.
(Data obtained from: http://nadp.sws.uiuc.edu/maplib/pdf/mdn/hg_dep_2011.pdf)

Some sites also are now collecting total deposition, both wet and dry. One site is located on the Valles Caldera National Preserve. Although it is not on the Cibola, it can provide some indication of the conditions on the Cibola. While it has only been operating for two years, initial results suggest that dry deposition adds significantly to the total deposition (Sather et al. 2013).

Figure 56 shows the mercury deposition measurements collected at the Mercury Deposition Network (MDN) Caballo site (Sierra County) over the period 2000–2005. No data are available for this site after 2005. Annual totals are shown for wet deposition in nanograms per square meter (ng/m^2) and concentration in nanograms per liter (ng/L) for the period of record. The mercury deposition at Caballo shows considerable year-to-year variability, with measurements ranging between 2,000 and 6,000 ng/m^2.

Figure 56 and additional mercury deposition data for the MDN monitoring site at Valles Caldera National Preserve (Sandoval County) can be accessed on the NADP/MDN network (NADP 2013). The Valles Caldera MDN site has data only for 2009 and 2010 and shows mercury deposition values greater than the Caballo site (about 7,000 ng/m^2).

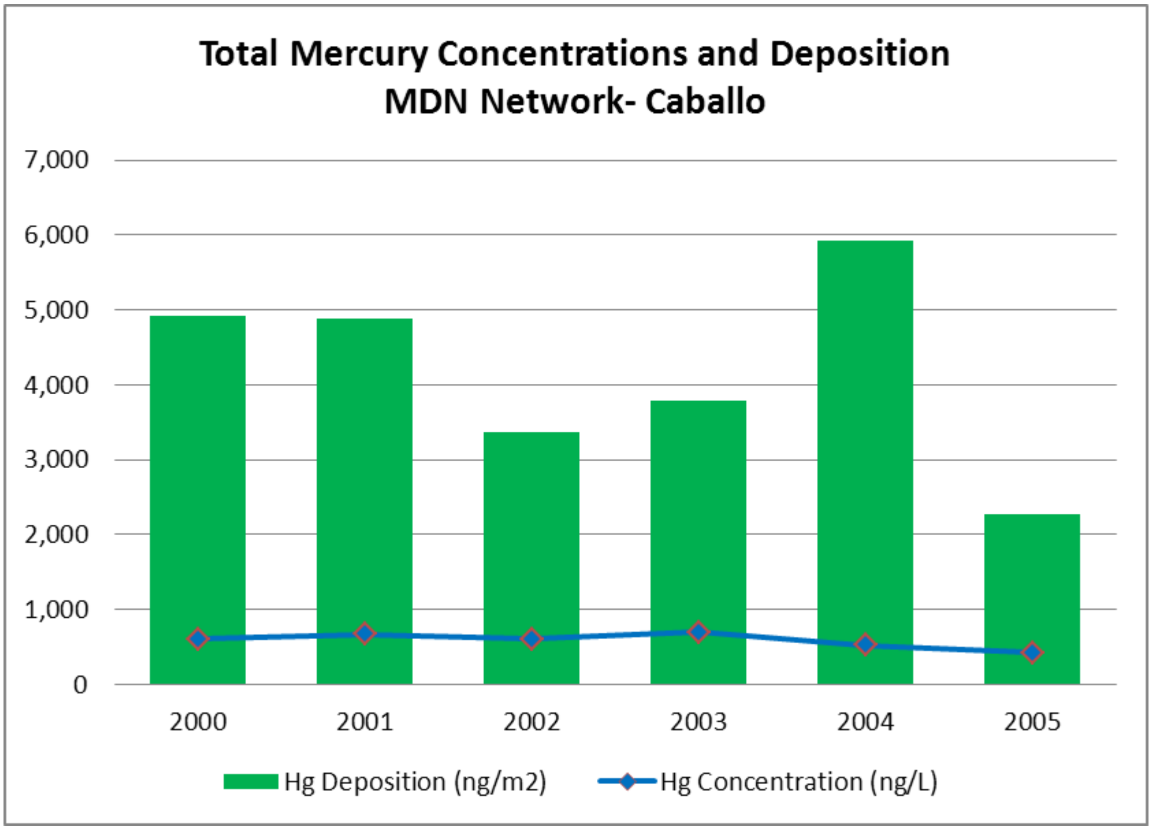


Figure 56. Total mercury concentrations and deposition, MDN Network, Caballo Station, 2000–2005. (Data obtained from http://nadp.sws.uiuc.edu/MDN/)

While it is difficult to assess the current effects that mercury deposition is having on the Cibola, trends in two areas suggest that overall mercury effects will decline. First, new regulatory controls at a couple regional coal fired power plants should reduce the total mercury emissions over the next several years. In addition, sulfur emissions are also expected to decline, due to new sulfur fuel standards and pollution controls at the coal fired utilities. The link between sulfur-reducing bacteria and biotic mercury concentrations has led researchers to establish that reductions in sulfur dioxide emissions and a resulting reduction in sulfate deposition will abate mercury concentrations in wildlife. As a result, as sulfates are reduced in aquatic systems, sulfur reducing bacteria will reduce less sulfur, and this will lead to less inorganic mercury being methylated.

Federal, State & Tribal State Implementation Plans

As stated previously, the federal Clean Air Act (CAA) provides the basic framework for controlling air pollution, but the states are primarily responsible for implementing and enforcing CAA requirements. Within this framework, there are a couple tools particularly relevant to protecting air quality related to national forests. Typically, air pollution that occurs off national forests is the primary concern for causing impacts on national forests. Pollution can result from either new or existing sources.

The primary tool for addressing air quality impacts from new sources is the Prevention of Significant Deterioration (PSD) program. The 1977 CAA amendments established the PSD program to preserve the clean air usually found in pristine areas, while allowing controlled economic growth. The PSD permitting program applies to new, major sources of air pollution or modifications to existing major sources which have the potential to emit certain amounts of air pollution regulated by the Environmental Protection Agency (EPA). The purpose of the PSD program is to prevent violations of NAAQS and to protect the environment including visibility and air quality is pristine areas such as Class 1 wilderness areas managed by the Forest Service. The PSD program can apply to non-criteria pollutants and can require analyses to assess the impacts of pollution on soils, vegetation, visibility and water resources managed by the Forest Service.

For existing sources of air pollution, the Federal Regional Haze Rule (RHR) requires states to develop programs to assure reasonable progress toward meeting the national goal of preventing any future, and remedying any existing, impairment of visibility in mandatory Class I federal areas. The RHR addresses requirements for SIPs, plan revisions, and periodic progress reviews to address regional haze and achieve natural haze conditions in each of the Class I areas by the year 2064.

Regional Haze Rule, 40 CFR 51.308 and 40 CFR 51.309

On July 1, 1999, the Environmental Protection Agency (EPA) issued regional haze rules to comply with requirements of the Clean Air Act. Under 40 CFR 51.308, the rule requires the state of New Mexico to develop SIPs which include visibility progress goals for each of the nine Class I areas in New Mexico, as well as provisions requiring continuing consultation between the state and Federal Land Managers (FLM) to address and coordinate implementation of visibility protection programs. Under 40 CFR 51.309, the rule also provides an optional approach to New Mexico and eight other western states to incorporate emission reduction strategies issued by the Grand Canyon Visibility Transport Commission (GCVTC) designed primarily to improve visibility in 16 Class I areas on the Colorado Plateau, including the San Pedro Parks Wilderness Area in New Mexico (NMED 2011b).

New Mexico Environmental Department-State Implementation Plan

On December 31, 2003, the state of New Mexico submitted a visibility SIP to meet the requirements of 40 CFR 51.309 (309 SIP). The 2003 309 SIP and subsequent revisions to the 309 SIP, address the first phase of requirements, with an emphasis on stationary source sulfur dioxide (SO_2) emission reductions and a focus on improving visibility on the Colorado Plateau. In the 2003 submittal, New Mexico committed to addressing the next phase of visibility requirements and additional visibility improvement in New Mexico's remaining eight Class I areas by means of an SIP meeting the requirements in 309(g). The regional haze SIP describes the Class I areas where visibility protections are in place, monitors existing visibility conditions and trends, defines the cause in terms of source emissions of visibility impairment at each Class I area, projects future trends in visibility conditions based on implementation of various emission control measures, and provides a long-term strategy to meet the stated national visibility goal of reducing all man-made visibility impairment by 2064.

Since the 2003 submittal of the 309 SIP, the EPA has revised both 40 CFR 51.308 and 309 in response to numerous judicial challenges. The latest SIP petition was filed by the New Mexico Environmental Department on February 28, 2011, revised March 31, 2011 (NMED 2011b). The February 2011 revision was made to satisfy New Mexico’s obligations under the “Good Neighbor” provision of the CAA at §110(a)(2)(D)(i). Included is a Best Available Retrofit Technology (BART) determination and proposed reductions for the San Juan Generating Station to achieve visibility reductions relied upon by other states in setting their visibility goals (NMED 2013). This SIP was challenged by San Juan Generating Station and the U.S. EPA, which is currently still pending appeal. On February 15, 2013, a tentative settlement was announced between the state of New Mexico, the U.S. EPA, and San Juan Generating Station (USEPA 2013). The agreement will shut down two of the plant's coal fired units and install selective non-catalytic reduction technology on the remaining two coal fired units. The two units being shut down will be replaced by less polluting natural gas-fueled units.

Grand Canyon Visibility Transport Commission – 1996 Findings and Recommendations

In 1990, amendments to the Clean Air Act under 40 CFR 51.309 established the Grand Canyon Visibility Transport Commission to advise the EPA on strategies for protecting visual air quality on the Colorado Plateau. The GCVTC released its final report in 1996 and initiated the WRAP, a partnership of state, tribal and federal land management agencies to help coordinate implementation of the Commission's recommendations (GCVTC 1996). Issues addressed by the GCVTC and WRAP are summarized below:

- Air pollution prevention
- Clean air corridors
- Stationary sources
- Areas in and near parks and wilderness areas
- Mobile sources
- Road dust
- Emissions from Mexico
- Fire

Forest Service Policy and Actions

Regional Forest Service Air Resource Management (ARM) staff act as the point of contact to receive and review permit applications filed with state and local regulatory agencies by new/modified emission sources and provide comments back to the state agency. Unless a specific issue arises, individual national forests are typically not responsible for conducting reviews of new/modified sources via the state-level air quality applications process. The Forest Service regional office provides air quality analysis to determine if proposed actions are likely to cause, or significantly contribute to, an adverse impact to visibility or other air quality related values within the national forest system.

Additionally, the Forest Service complies with the New Mexico State Smoke Management Programs (SMP), which is described in Section 12.7.14 of the February 2011 New Mexico Section 309(g) Regional Haze SIP (NMED 2011b). New Mexico's administrative code (20.2.65 NMAC-Smoke Management) stipulates that all burners must comply with requirements of the Clean Air Act and Federal Regional Haze Rule (RHR), as well as all city and county ordinances relating to smoke management and vegetative burning practices. For prescribed fires and wildfires managed for resource benefit that exceed 10 acres, additional requirements include: registering the burn, notifying state and nearby population centers of burn date(s), visual tracking, and post-fire activity reports (NMAC 2013).

Unique to the Sandia ranger district is that Bernalillo County is the primary regulatory authority in terms of air quality, while the other districts fall under the jurisdiction of the New Mexico Environmental Department.

As indicated previously, the Forest Service typically lacks direct authority to control air emissions that impact a particular ranger district of the Cibola. The primary role that Air Resource

Management (ARM) staff can provide the New Mexico Environmental Department (NMED) staff as they prepare Prevention of Significant Deterioration (PSD) permits or develop the Federal Regional Haze Rule (RHR), is to provide information about potential impacts that could occur on national forest land, particularly in Class I areas.

The primary tool federal land managers (FLM) use is the critical load concept described in the next section on atmospheric deposition. Currently the Cibola has critical loads based on a national assessment developing empirical critical loads for major ecoregions across the United States. However there are no forest specific critical loads developed for the Cibola, and therefore they have not been included in the New Mexico SIP.

Critical Loads

Air pollution emitted from a variety of sources is deposited from the air into ecosystems. These pollutants may cause ecological changes, such as long-term acidification of soils or surface waters, soil nutrient imbalances affecting plant growth, and loss of biodiversity. The term critical load is used to describe the threshold of air pollution deposition below which harmful effects to sensitive resources in an ecosystem begin to occur. Critical loads are based on scientific information about expected ecosystem responses to a given level of atmospheric deposition. For ecosystems that have already been damaged by air pollution, critical loads help determine how much improvement in air quality would be needed for ecosystem recovery to occur. In areas where critical loads have not been exceeded, critical loads can identify levels of air quality needed to maintain and protect ecosystems into the future.

U.S. scientists, air regulators, and natural resource managers have developed critical loads for areas across the United States through collaboration with scientists developing critical loads in Europe and Canada. Critical loads can be used to assess ecosystem health, inform the public about natural resources at risk, evaluate the effectiveness of emission reduction strategies, and guide a wide range of management decisions.

The Forest Service is incorporating critical loads into the air quality assessments performed for forest plan revision. There are no published critical loads in the Southwest United States. For this assessment, national scale critical loads were used to determine if critical loads were exceeded for nutrient nitrogen (Pardo et al. 2011), acidity to forested ecosystems (McNulty et al. 2007), and for acidity to surface water (Lynch et al. 2012). In addition, mercury deposition was analyzed based on data from the mercury deposition network (MDN 2011), however no critical loads have been developed for mercury on the forest service. Ozone deposition was not assessed, due to lack of data availability and analysis in the Southwest United States. No critical loads have been developed for ozone on the Cibola National Forest.

Nitrogen Saturation/Eutrophication

Nitrogen air pollution can have an acidifying effect on ecosystems as well as cause excess input of nitrogen in the ecosystem and nitrogen saturation. This excess nitrogen initially will accumulate in soil and subsequently be lost via leaching. While increased nitrogen may increase productivity in many terrestrial ecosystems (which are typically nitrogen limited) this is not necessarily desirable in protected ecosystems, where natural ecosystem function is desired. Excess nitrogen can lead to nutrient imbalances, changes in species composition (trees, understory species, nonvascular plants (lichens), or mycorrhizal fungi), and ultimately declines in forest health.

Based on research by Pardo and others (2011), national scale critical loads were developed for nitrogen deposition for lichen and herbaceous plants and shrubs. Pardo and others (2011) also developed critical loads for mycorrhizal fungi, forests, and nitrate leaching in soils, although they are not available for the Cibola. Summary results of this assessment are in Table 42.

Table 42. Critical load exceedance summary for nitrogen deposition on the Cibola (109 grid cells).

	# grid cells	% of total	Minimum Exceedance (kg-N/ha)	Maximum Exceedance (kg-N/ha)	95% Exceedance level (kg-N/ha)
Lichens					
Exceedance	94	86%	1.953771	6.131773	4.868832
No Exceedance	7	6%			
Critical Loads Not Available	8	7%			
Herbaceous Plants & Shrubs					
Exceedance	32	29%	0.002616	3.621773	2.254738
No Exceedance	35	32%			
Critical Loads Not Available	42	39%			
Mycorrhizal Fungi					
Exceedance		0%			
No Exceedance	8	7%			
Critical Loads Not Available	101	93%			
Forests					
Exceedance		0%			
No Exceedance		0%			
Critical Loads Not Available	109	100%			
Nitrate Leaching					
Exceedance		0%			
No Exceedance	8	7%			
Critical Loads Not Available	101	93%			

Lichens

Lichens, which add significantly to biodiversity of ecosystems, are some of the most sensitive species to nitrogen deposition (Pardo et al. 2011). Unlike vascular plants, lichens have no specialized tissues to mediate the entry or loss of water or gases. They rapidly hydrate and absorb gases, water and nutrients during periods of high humidity and precipitation. They dehydrate and reach an inactive state quickly, making them slow growing and vulnerable to contaminate accumulation. As such, they are an important early indicator of impacts from air pollution.

Pardo and others (2011) used the major ecoregion types adapted from the Commission for Environmental Cooperation (CEC 1997), of which the Cibola is within the Temperate Sierras and North American Deserts ecoregions. The critical loads for lichens in these two ecoregions are based on research for North American Deserts and the Temperate Sierras, with minimum levels between 3–4 kg-N/ha-yr (Pardo et al. 2011, Geiser et al. 2010). Based on these values, 86 percent of the Cibola exceeds critical loads to protect lichens, where 6 percent showed no exceedance and critical loads were not available for 7 percent or the area encompassing the Cibola. The minimum amount that the Cibola exceeded nitrogen deposition by was 1.95 kg-N/ha and the maximum was by 6.13 kg-N/ha. Almost all (95%) of the grid cells exceeded the critical loads for lichens by less than 4.87 kg-N/ha.

Herbaceous Plants and Shrubs

Herbaceous plants and shrubs comprise the majority of the vascular plants in North America (USDA NRCS 2009). They are less sensitive to nitrogen deposition than lichens; however, they are more sensitive than trees due to rapid growth rates, shallow roots, and shorter life span (Pardo et al. 2011). Herbaceous plants are the dominant primary producers, contributing significantly to forest litter biomass and biodiversity (Gilliam 2007). The shorter lifespan of some species can result in a rapid response to nitrogen deposition and can result to rapid shifts (1–10 years) in community composition sometimes resulting in an increase in invasive species compared to native species (Pardo et al. 2011).

Based on the national scale empirical critical loads for nitrogen deposition for herbaceous plants and shrubs (Pardo et al. 2011), 29 percent of the Cibola is potentially exceeding critical loads, 32 percent does not exceed, and critical loads are not available for 39 percent of the Cibola. The areas exceeding critical loads for nitrogen deposition range from a slight exceedance of 0.002 kg-N/ha to 3.62 kg-N/ha, with 95 percent of the grid cells exceeding the critical loads by less than 2.25 kg-N/ha. The critical loads were based empirical data developed for the North American Desert ecoregion, which noted increased biomass of invasive grasses and a decrease of native forbs at 3 kg-N/ha-yr (Allen et al. 2009, Rao et al. 2010). Critical loads for nitrogen deposition were not available for the Temperate Sierra ecoregion for herbaceous herds and shrubs.

Acid Deposition

The potential for impacts from acid deposition on forests has been recognized for more than 30 years in the United States. Research has shown that deposition of nitrogen and sulfur has resulted in acidifying effects, which has had negative impacts on ecosystem health, including impacts to aquatic resources, forest sustainability, and biodiversity (McNulty et al. 2007). Acidifying effects can lead to mortality of tree species, reduced forest productivity, reduced biological diversity, and increased stream acidity (Driscoll et al. 2001).

The following section presents critical acid load for soils and surface water on the Cibola. McNulty and others (2007) estimated critical loads and exceedances for forested soils across the

United States. The surface water critical acid loads were based on research from Lynch and others (2012).

Soils

Many factors contribute to an exceedance of critical acid loads in forested ecosystems. Key factors include the composition of the soil, including how weathered it is, the amount of organic matter present, and the amount of base cations (i.e., calcium, potassium, magnesium, and sodium), which all play a role in how well the soil is buffered against acid deposition (how well the soil can neutralize the acid). For example, sandy soils are typically low in base cations, which make them more vulnerable to acid deposition. Also important are the types of tree species present due to the various rates that they uptake nitrogen, and base cations, which can either counter act the effects of acid deposition or reduce soils buffering capacity. In conifer forests, as the needles break down, the soil is naturally acidified, which can also increase the system's vulnerability to acidification. Also important is the rate at which sulfur and nitrogen compounds fall to the ground through either wet or dry deposition, which is related to what sort of emissions are occurring that are adding these compounds to the airshed. Elevation also plays a role, since more precipitation tends to occur at higher elevations increasing the rate of acid deposition.

Estimates that factor all the parameters described above show that there are no exceedances of acid critical loads on the Cibola (Figure 57). This is primarily a result of low amount of acid gases in the airsheds in New Mexico and the western United States.

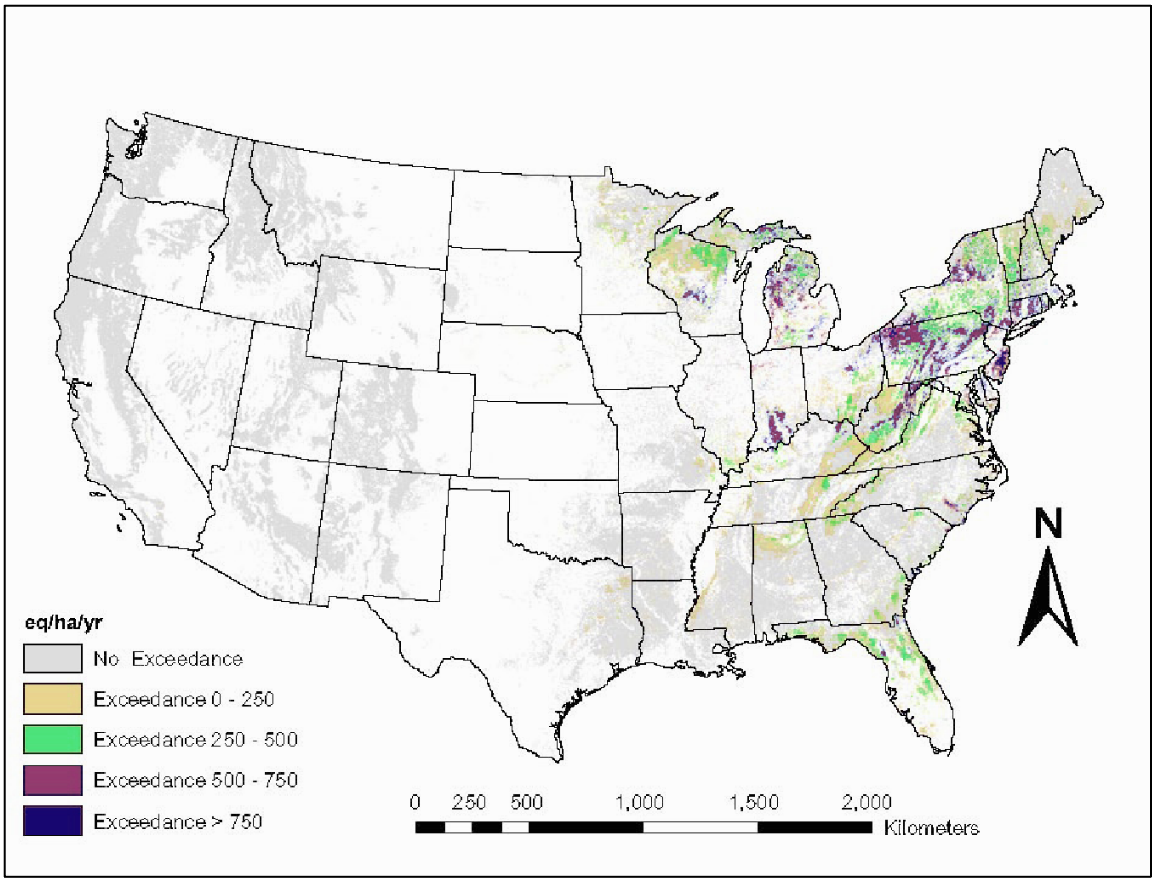


Figure 57. Average annual exceedance of the critical acid load for forest soils expressed in eq/ha-yr for the coterminous US for the years 1994–2000 at a 1-km² spatial resolution. (adapted from McNulty et al. 2007).

Surface Water Impacts

Stream and lake acidification can be a result of deposition of acid gases, which can reduce the pH of surface water resulting in reduced diversity and abundance of aquatic species. As described in the previous section, many of the same factors contribute to the susceptibility of aquatic ecosystems to the effects of acid deposition. Surface water acidification begins with acid deposition in adjacent terrestrial areas (Pidwirny 2006) and the system's ability to neutralize the acid before it leaches into the surface water.

There are no critical loads available for the Cibola to assess acid deposition to surface water, however acidification of surface water on the forest does not appear to be an issue. A national analysis by Lynch and others (2012) that was conducted using the Steady-State Water Chemistry model (SSWC) used a mass-balance approach to assess acid critical loads for surface water. This assessment did not include any surface water sites on the Cibola. However, every two years the New Mexico Environment Department is required by the Clean Water Act to submit an assessment of the surface waters in New Mexico to the U.S. EPA. Based on the current list of impaired water in New Mexico, there are no impaired waters as a result of pH on the Cibola (NMED 2011a).

Ozone

Ground-level ozone interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, drought, and higher temperatures. Some plants have been identified as particularly sensitive to the effects of ozone and are reliable indicators of toxic levels of the pollutant on plant growth.

Ozone damages the appearance of leaves on trees and other plants. The most common visible symptom of ozone injury on broad-leaved bioindicator species is uniform interveinal leaf stippling. As a gaseous pollutant, ozone enters the stomata of plant leaves through the normal process of gas exchange, damaging the tissue. Elevated levels of ozone have not been directly measured on the Cibola, nor has an assessment of the forest's vegetation been conducted in terms of looking for impacts from ozone. The effects of ozone on tree growth on the Cibola are not well understood.

Uncertainty

There are many factors that contribute to the reliability and confidence of an assessment. Typically a sufficient amount of direct measurements taken over time, provide the greatest level of confidence regarding the current state and trends of forest health as it applies to air quality impacts. In the absence of direct measurements, modeled data can be used to assess relative risk of systems to the impacts for air pollution; however this creates a greater degree of uncertainty in the assessment. To understand the level of confidence in the modeled results, it is important to understand the assumptions in the models as well as how they perform in a given environment. In this case, how do they perform assessing the potential impacts that air pollution has on various indicators, such as lichens, on the Cibola.

While there are direct measurements that have been taken over time, for ambient air quality and visibility, there have been no studies performed on the Cibola to directly measure the impacts from air pollution on forest health. The modeled results that are available, indicate that lichens and to a lesser degree herbaceous plants and shrubs are at risk of being impacted by nitrogen deposition. There is a fair amount of uncertainty with these estimates, however. The critical loads were developed based on lichen studies in western Oregon and Washington for the Temperate Sierras and based on research in Hells Canyon for the North American Desert ecoregion (Pardo et al. 2011). In addition, atmospheric nitrogen deposition estimates and critical loads are influenced by several other factors, including the difficulty of quantifying dry deposition on complex mountainous terrain in arid climates with sparse data (Pardo et al. 2011), all of which are significant factors on the Cibola. At this time, there is a fair amount of uncertainty with the critical load estimates to have a high level of confidence in the assessment.

Summary of Condition, Trend, and Risk

The ecosystem services provided by air are generally stable and not at risk. Air quality on the Cibola is within regulatory levels for National Ambient Air Quality Standards (NAAQS), and the trend based on projected emission inventories appears to be stable or is improving for most pollutants (Table 43). This is also true regarding visibility conditions. The main challenge could be with regards to both coarse and fine particulate matter, which can affect both the ambient air quality and visibility on the forest. Land-use both on and off the forest, as well as climate change and drought can contribute to windblown and fugitive dust. Wildfires can also be a significant source of particulate matter.

Table 43. Summary of conditions, trends, and reliability of assessment.

Air Quality Measure	Current Conditions	Trend	Reliability
NAAQS*			
CO	Good	Improving	High
NO_2	Good	Improving	High
SO_2	Good	Stable	High
Pb	Good	Stable	High
O_3	Good	Stable	High
$PM_{2.5}$	Good	Stable to Declining	High
PM_{10}	Good	Stable to Declining	High
Visibility†			
Visibility	Departed	Stable to Improving	High
Critical Loads- Deposition			
Nitrogen Eutrophication			
Lichens	Potentially at risk	Improving	Low
Herbaceous Plants & Shrubs	Potentially at risk	Improving	Low
Mycorrhizal Fungi	Unknown	Unknown	N/A
Forests	Unknown	Unknown	N/A
Nitrate Leaching	Unknown	Unknown	N/A
Acid Deposition			
Soils	Good	Improving	Low
Surface Water	Good	Improving	Low
Deposition (other)			
Mercury	Potentially at risk	Improving	Low
Ozone	Unknown	Unknown	N/A

*Relative to NAAQS
†Relative to 2064 Regional Haze Goal

There is some indication that current levels of nitrogen deposition have exceeded critical loads and are significant enough to have resulted in impacts to lichen diversity and community structure and to a lesser degree impacts to herbaceous plants and shrubs. However, these results were based on modeled critical loads and have not been verified on the forest. The rate of deposition of nitrogen, which can lead to impacts affecting forest health, appear to be decreasing based on projected emissions at the state level.

Modeled results also indicate that the levels of acid gases are not at levels significant enough to result in impacts to either soils or surface water. There are no direct measurements on the forest that indicate otherwise.

There is some indication that mercury deposition at higher elevations on the forest may be significant, but there are not any studies to verify any impacts. Atmospheric mercury, based on regional emissions, is also expected to decrease.

Key Message

The air on the Cibola is in good condition; however, visibility and air quality may decline if particulate matter increases—a likely result of larger, more severe wildfires as the effects of climate change are realized.

Chapter 6. Carbon[36]

Introduction

The emission of greenhouse gases (GHGs) by human activities and natural processes contribute to the warming of the Earth's climate. Warming could have significant ecological, economic, and social impacts at regional and global scales (IPCC 2007). In 2005, U.S. forests were estimated to be sequestering nearly 200 Tg[37] of carbon (Cameron et al. 2013), suggesting that southwest ecosystems could play a significant role in sequestering carbon and mitigating climate change. The U.S. Forest Service has directed the assessment of carbon (36 CFR 219.6) for purposes of considering issues associated with climate change as well as the influences on carbon stocks that are under Forest Service management authority.

We estimated the major carbon components of Southwest ecosystems including biomass, carbon emissions, and soil organic carbon. Some estimates are provided for *biomass* and *soil* carbon on the Cibola. Carbon *emissions* have been characterized by using a case study synthesis from the Apache-Sitgreaves National Forest (Vegh et al. 2013), relevant to forested ecosystems of the Southwest in terms of natural processes and common management activities. The study provides a surrogate solution for emissions assessment in lieu of emissions data and analysis specific to the Cibola. Also, we acknowledge that the description of other carbon components, such as forest products, would provide a fuller accounting of carbon stocks and flux. However, inclusion of the major components of biomass, emissions, and soil carbon will suffice for strategic purposes of Forest planning.

Biomass (vegetative carbon)

Biomass is an integral component of carbon (C) cycles. Through photosynthesis, plants convert atmospheric carbon dioxide (CO_2) to carbohydrates (C fixation). These carbohydrates (sugars) are used by plants to grow aboveground biomass (stems, leaves) and belowground biomass (roots, tubers). Conversely, soil microorganisms slowly release CO_2 into the atmosphere as they decompose plant material. Total carbon stored in vegetative biomass is referred to as the biomass carbon stock—a value that changes over time.

The primary influences on biomass carbon stock are plant growth (which increases biomass carbon stock), decomposition (which decreases biomass carbon stock), and disturbance (fire, harvest). The effect of harvest on carbon emissions depends largely on the use of the wood products. For example, wood products utilized in construction provide long-term carbon storage (with slow release) while wood products burned as fuel quickly release CO_2 into the atmosphere. As forest and grassland ecosystems are constantly changing through succession and disturbance, so does the carbon stock. This section will focus on biomass carbon stocks on forest system lands of the Cibola. For the purpose of this section, biomass carbon stock includes aboveground live biomass, standing dead biomass , downed woody debris, litter, duff, and belowground live biomass (belowground nonliving plant material is considered in soil organic carbon).

[36] Adapted from Wahlberg et al. 2013b.
[37] 1 teragram (Tg) = 1 milllion metric tons (2.2×10^9 pounds).

Existing Conditions

Each Ecological Response Unit (ERU) contributes differently to carbon stocks based on area, vegetative structure, and current conditions. Generally speaking, relative contributions to carbon stocks are lowest in grassland ERUs, with a steady increase in relative contribution for shrubland, woodland, and forested ERUs, respectively.

The figures and tables presented below represent the Cibola biomass carbon stock for current conditions, reference conditions, and modeled future conditions under current management for major ERUs.

The current Cibola carbon stock (about 39 million tons/acre) is 11 percent higher than the carbon stock under reference conditions (about 35 million tons/acre). The balance of carbon stock has decreased in woodland ERUs while increasing in most forested ERUs (Figure 58). The increase in forested ERUs is likely from overstocking due to fire suppression and reduced harvest. Conversely, the reduction in woodland ERUs may have resulted from thinning of pinyon-juniper (Howard et al. 1987).

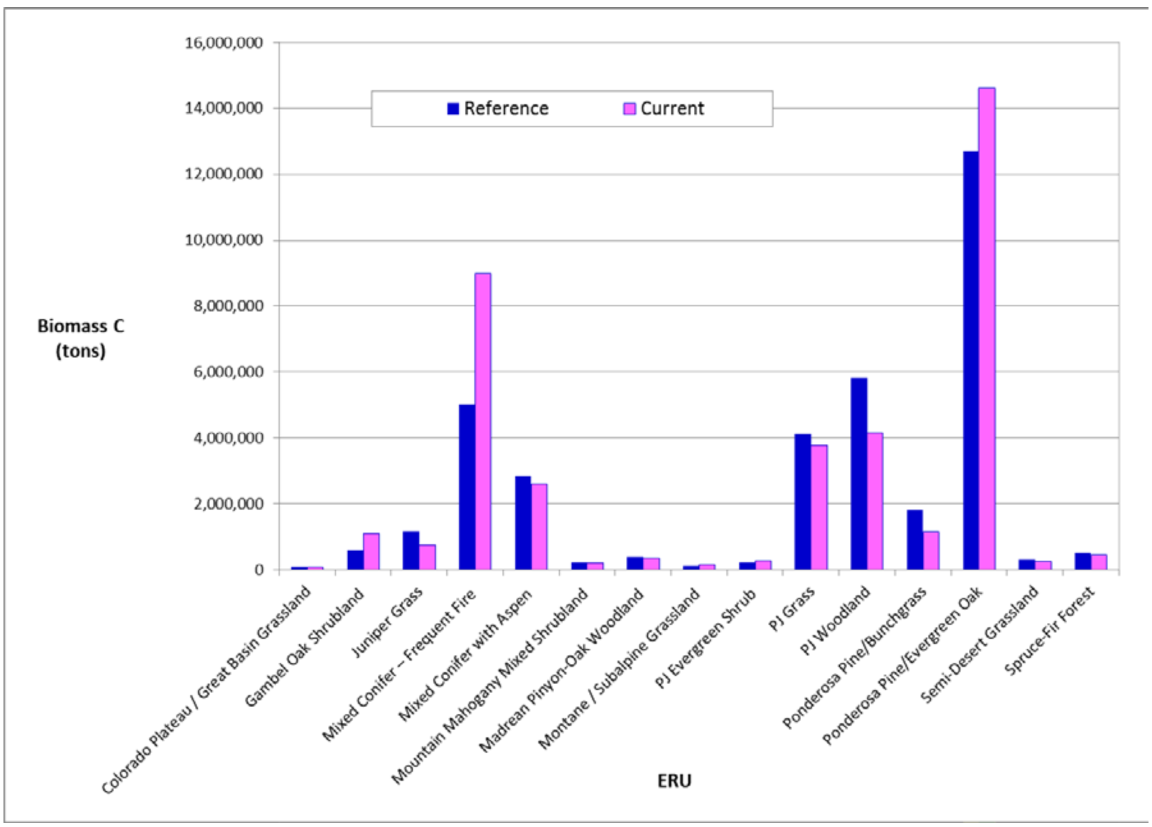


Figure 58. Total carbon stocks for major Cibola ERUs (and PPF subsections) under reference and current conditions.
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Trends

General ecosystem dynamics in southwestern forest systems are fairly well understood and provide a good starting point for assessing trends in biomass carbon stocks; however, factors such as climate, fire frequency and severity, and management budgets vary, so only broad generalizations can be made. Forest and woodland conditions on the Cibola have been projected into the future using state-and-transition modeling and assumptions based on current management and disturbance patterns (ESSA 2006). Using assumptions of past stand development dynamics and management applications for future projections are inherently problematic in light of projected climate changes. Assuming continuation of current management intensities and a suitable climate envelope for each ERU, the general pattern of projected biomass carbon stock on the Cibola is for an increase in total carbon storage in nearly all modeled ERUs (Figure 59).

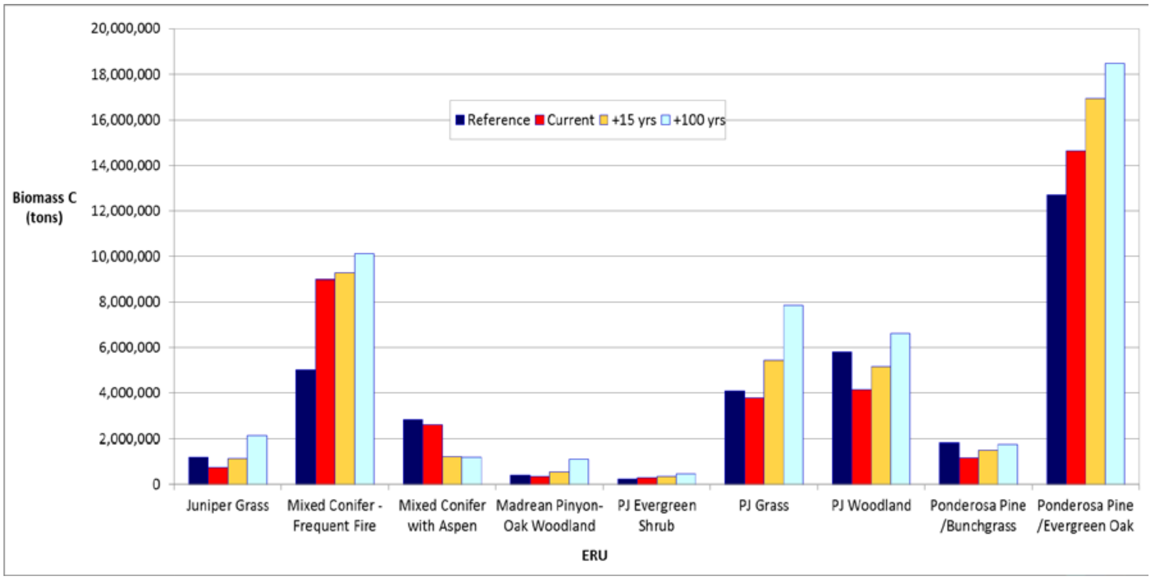


Figure 59. Reference, current, and projected biomass carbon stocks for major Cibola ERUs (and PPF subsections).
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

Soil Organic Carbon

Existing Conditions

Soil organic carbon (SOC) is the energy source for soil organisms which, through their activity and interactions with mineral matter, impart the structure to soil that affects its stability and its capacity to provide water, air, and nutrients to plant roots. The amount and kind of soil organic carbon reflects and controls soil development and, ultimately, ecosystem productivity (Van Cleve and Powers 1995).

Globally, SOC contains more than three times as much carbon as either the atmosphere or terrestrial vegetation (Schmidt et al. 2011). Forest soils are the largest active terrestrial carbon pool and account for 34 percent of the global soil carbon (Bucholtz, et al. 2013). Accurate quantification of SOC stocks is key to modeling atmospheric CO_2, soil productivity, and global climate. Soils represent a significant portion of the active carbon cycle, with estimates of organic

C ranging from 1,500–2,000 Pg[38] C, or roughly two thirds of the terrestrial organic C stocks (Rasmussen 2006).

Attempts to characterize regional soil carbon stocks include both ecosystem- and soil taxa-based approaches. The ecosystem approach involves averaging soil C data within a specific plant community or biome and multiplying the average soil C content by the estimated biome land area (Rasmussen 2006). This approach does not account for soil spatial heterogeneity and results in large variability of soil C estimations within an ecosystem or biome. The soil taxa approach has been extensively described in the soil science literature (Rasmussen 2006) and includes segregating landscapes by soil taxa (instead of biomes) and using average taxa soil C and estimated land area to calculate soil C stocks.

Because of its extensive area (over 26% of the Cibola), the Ponderosa Pine/Evergreen Oak ERU contains the most (over 18 million tons) SOC on the Cibola (Figure 60**).** However, the Mixed Conifer with Aspen ERU contains the highest average (over 136 tons/acre) SOC—the cool (not cold), moist conditions that support this ERU are highly favorable to plant production and subsequent SOC accumulation. The SOC values by ERU represent data collected and analyzed during the Cibola NF Terrestrial Ecosystem Survey (Strenger et al. 2007). Considerable SOC variation exists between ERUs due to the variable numbers of soils sampled, different kinds of soil taxa per ERUs, and sampling scale.

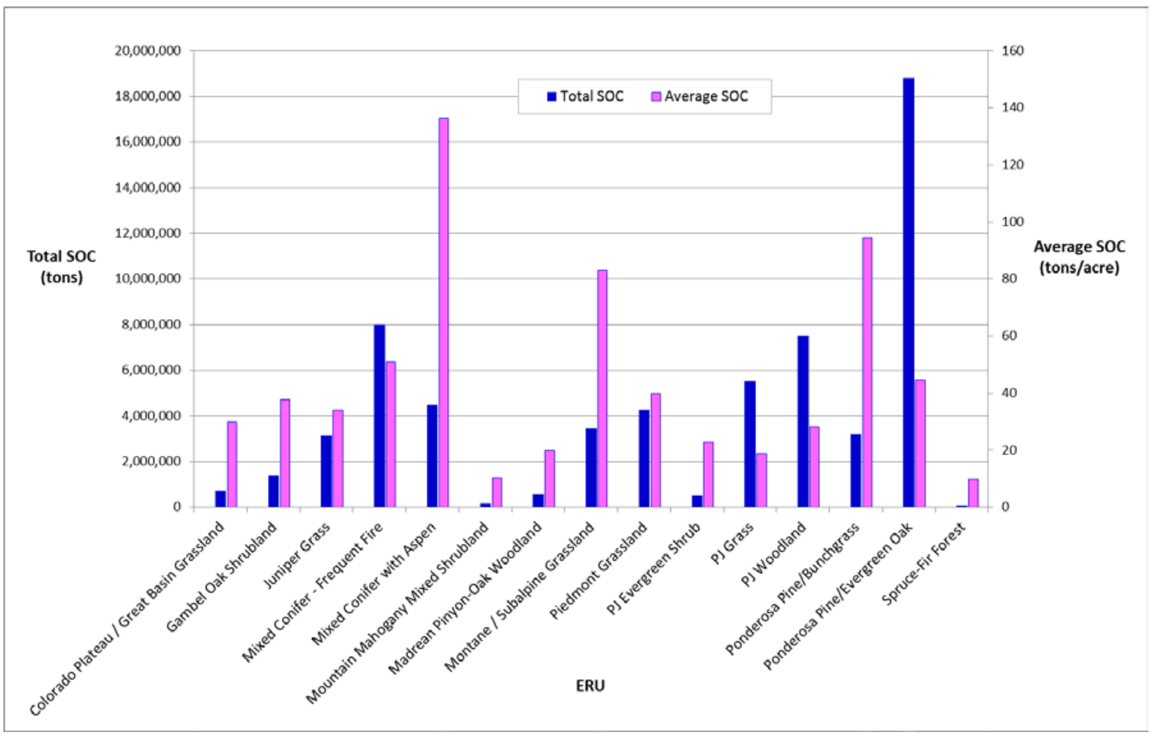


Figure 60. Total and average soil organic carbon (SOC) for major Cibola ERUs (and PPF subsections).
Regional Corporate Spatial Database: gdb04a_r03_default_(Region)

[38] One petagram (Pg) equals one billion metric tons (2.2×10^{12} pounds).

Trends

The current trend of sustaining SOC is strongly influenced by vegetation growth and by activities that remove biomass; including climatic factors that influence the rates of weathering and decomposition of above- and belowground biomass. Given the projection that biomass carbon will increase into the future, it is logical to assume that SOC will remain the same, or potentially increase, under current rates of decomposition. Current Forest Service Southwestern Region soil quality technical guidance is to maintain surface coarse woody material in woodlands and forests to ensure microbial populations for nutrient cycling (Graham et al. 1994). The exception to this would be the Grassland and Shrubland ERUs where surface biomass has decreased due to consumptive harvesting by ungulates, erosion (wind and water) and other disturbances (e.g., fire).

Carbon Emissions

Similar to implications of biomass conditions and resource management, the research synthesis on carbon emissions conveys significant trade-offs among potential carbons strategies. Although the total C emissions were higher for the harvest alternatives in the study considered here (Vegh et al. 2013), thinning and fuels reduction did reveal lower wildfire emissions and reduced risk of uncharacteristic wildfire. The study also suggests that, in the long term, systematic thinning and burning will ultimately lead to greater live, aboveground sequestration. It's also important to keep in mind, that like the Cibola, the Apache-Sitgreaves National Forest is starting with uncharacteristically high levels of biomass on the heels of a century of fire suppression, and that strategies to maximize carbon sequestration and sustain carbon stores are not necessarily compatible (Hurteau and Wiedinmyer 2010). The indirect goal of contemporary management is to reduce, at least in part, current C stocks to pre-European settlement levels.

In the future, the benefits to reduced emissions and increased C sequestration may be more pronounced. First, because live trees continually sequester C and are a more stable C sink than dead biomass (particularly that generated by uncharacteristic fire), insect outbreaks, drought, and other stresses, proactive management and broad-scale fuel reduction may be preferable for the long-term mitigation of atmospheric C. Second, there is the related issue of trees regenerating poorly or not at all following uncharacteristic fire in some forest types (Savage and Mast 2005). Others investigators (Dore et al. 2008) also show that poor regeneration after stand-replacement fire in ponderosa pine can render plant communities as C sources for many years after the fire, casting further doubt on the sustainability of a strategy that intends to maximize sequestration while indirectly promoting uncharacteristic fire and reduced ecosystem productivity (Hurteau and Wiedinmyer 2010).

The Apache-Sitgreaves National Forest study by no means represents a comprehensive analysis of the carbon emissions involved with forest management scenarios. A full accounting would include emissions involved in the harvest, transfer, and processing of any wood products, along with the sequestration and decomposition of those products and other forest residues, and the emissions involved with the associated energy consumption of processing (Cameron et al. 2013). Cameron and others (2013) determined, on a 100-year model simulation, that even with an industrial forestry theme, that the ratio of storage to emissions was 0.58. They also showed that if wood destined for paper and pulp was instead redirected to less lucrative biomass consumption, the storage ratio could increase substantially to 2.7.

Finally, it is worth mentioning the effects of increased CO_2 levels on ecosystem productivity and the potential for negative feedback by emissions on climate. Such a feedback loop would involve C-emitting processes and increased atmospheric CO_2 levels followed by an increase in vegetation production and increased C capture and sequestration (mitigation). Some research indicates that vegetation productivity increases with elevated atmospheric CO_2 levels, but productivity rates soon level off as other factors appear to compete with the growth benefits (Archer 2011, Penuelas et al. 2011).

Key Message

Carbon stocks on the Cibola are largely stable or improving.

Chapter 7. Identifying and assessing at-risk species in the plan area

This chapter of the assessment focuses on identifying at-risk species—federally recognized as threatened, endangered, proposed and candidate species as well as potential species of conservation concern (SCC). This chapter also documents information gaps relevant to at-risk species that may be filled through inventories, plan monitoring, or research. Other species of interest on the Forest such as popular game species are addressed in Volume II, Chapter 4, Multiple Uses.

Under the National Forest Management Act (NFMA, 16 U.S.C. 1604(g)(3)(B)), the Forest Service is directed to "provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet multiple-use objectives, and within the multiple-use objectives of a land management plan adopted pursuant to this section [of this Act], provide, where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan." To meet this objective, the 2012 Planning Rule adopts a complementary ecosystem and species-specific approach known as a coarse-filter/fine-filter approach to maintaining species diversity (36 CFR 219.9).

The premise behind the coarse-filter approach is that native species evolved and adapted within the limits established by natural landforms, vegetation, and disturbance patterns prior to extensive human alteration. Therefore, maintaining or restoring ecological conditions and functions similar to those under which native species have evolved, offers the best assurance against losses of biological diversity and maintains habitats for the vast majority of species in an area. However, for some species, this approach may not be adequate, either because the reference condition is not achievable or because of non-habitat risks to species viability.

The fine-filter approach recognizes that for many species, additional specific habitat needs or ecological conditions are required and these may not be met by the coarse-filter approach. To determine which wildlife and plant species may require this fine-filter approach, the Cibola National Forest has identified federally threatened, endangered, proposed and candidate species and developed a list of potential SCC that occur within the plan area. This list will be used at later stages of the plan revision process to ensure that specific plan components are developed to ensure species diversity in the plan area. Maintaining species that are vulnerable to decline within the planning unit will maintain the diversity of the planning unit and will therefore comply with the National Forest Management Act diversity requirement.

Plant and animal species are frequently a function of ecosystems; specific conditions created by local soil, air, water, aspect, elevation, precipitation, etc. create areas that are favorable or unfavorable for a particular species. The most important direct drivers of biodiversity loss and ecosystem service changes are habitat change (such as land use changes, physical modification of rivers or water withdrawal from rivers), climate change, invasive species, overexploitation, and pollution (MEA 2005).Therefore, this chapter builds on the reference and current conditions for the other resources assessed in this volume. It also relies very heavily on the description of vegetation types (Ecological Response Units, ERUs) on the Cibola and associated risk assessment performed. Additional information can be found in the Vegetation chapter in Volume I of this assessment report.

The Cibola's four mountain districts are home to hundreds of animal, plant, and fungi species. Because of the sky island nature of the mountain districts, many of these species are found only on the Cibola. For other species, changing land use patterns outside of the forest has reduced potential habitat availability and increased their reliance on Cibola-managed lands. These species provide many ecosystem services that in turn benefit society as a whole. This includes *supporting* ecosystem services such as nutrient cycling (by both plants and animals), soil formation and manipulation (burrowing insects and mammals), primary production (plants), and seed dispersal (animals). *Regulating* services including carbon sequestration (plants), pollination (both forest plants and adjacent croplands by both vertebrates and invertebrates), and erosion control (plants) are additional key ecosystem services provided. Species also provide *provisioning* services such as food (forage, game, wild foods), fiber, medicine, and forest products. And finally, species provide *cultural* services including recreation (hunting, fishing, bird-watching), opportunities for scientific discovery and education, and cultural, intellectual, or spiritual inspiration. Because this chapter focuses on at-risk species that occur in the plan area, it follows that the ecosystem services provided by these species are decreasing and/or at risk.

Federally Recognized Species on the Cibola

The Endangered Species Act (16 U.S.C. Sec. 1531-1544), administered by the U.S. Fish and Wildlife Service (USFWS), recognizes imperiled species and provides for their protection and recovery. There are four federally endangered, three threatened, and two proposed species relevant to the plan area and to the planning process (Table 44; USFWS 2013). Not all of these species are known to exist on the Cibola. For example, the Chiricahua Leopard Frog and the Alamosa Springsnail have been recorded immediately off the forest boundary, but are within the same watershed as the forest and are affected by management actions on the forest. Likewise the Southwestern Willow Flycatcher is not currently occupying any territories on the Cibola but it has been documented here in the past. The Western Yellow-Billed Cuckoo potentially uses the Cibola only as migrant and has not been documented here. Other species, including the Mexican Wolf and the Northern Aplomado Falcon are not presently documented to den or breed on the Cibola, but they routinely use the forest for foraging. Mexican Spotted Owl, Zuni Fleabane, and Zuni Bluehead Sucker are known residents on the Cibola and there are long-standing records documenting their presence here.

Section 4 of the Act requires the USFWS to identify and protect all lands, water, and air necessary to recover an endangered species; this is known as critical habitat. Critical habitat includes areas that have been determined to be needed for life processes for a species including space for individual and population growth and for normal behavior; cover or shelter; food, water, air, light, minerals, or other nutritional or physiological requirements; sites for breeding and rearing offspring; and habitats that are protected from disturbances or are representative of the historical geographical and ecological distributions of a species.

Section 7 of the Endangered Species Act requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to destroy or adversely modify designated critical habitat. Mexican Spotted Owl, Chiricahua Leopard Frog, Zuni Bluehead Sucker all have designated or proposed critical habitat either on or within close proximity to the Cibola and these are described in more detail in Volume II, Assessing Designated Areas. Section 7 of the Act also requires that any federal agency that carries out, permits, licenses, funds, or otherwise authorizes activities that may affect a listed species must consult with the Fish and Wildlife Service to ensure that its actions are not likely to jeopardize the continued existence of any listed species.

Table 44. Federally listed threatened or endangered species, species proposed for federal listing, and candidate species that are relevant to the plan area and planning process

Scientific Name	Common Name	Federal Status
Mammals		
Canis lupus baileyi	Mexican Wolf	Endangered
Birds		
Coccyzus americanus occidentalis	Western Yellow-Billed Cuckoo	Threatened
Empidonax traillii extimus	Southwestern Willow Flycatcher	Endangered
Falco femoralis septentrionalis	Northern Aplomado Falcon	Endangered
Strix occidentalis lucida	Mexican Spotted Owl	Threatened
Fish		
Catostomus discobolus yarrow	Zuni Bluehead Sucker	Endangered
Amphibian		
Rana chiricahuensis	Chiricahua Leopard Frog	Threatened
Invertebrate		
Pseudotryonia alamosae	Alamosa Springsnail	Endangered
Plant		
Erigeron rhizomatus	Zuni Fleabane	Threatened

Potential Species of Conservation Concern

A species of conservation concern (SCC) is defined in the Rule as "a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The Cibola National Forest followed the guidance provided in the proposed directives for the Rule (Forest Service Handbook [FSH] 1909.12 – Land Management Planning, Chapter 10) in developing this list. As stated in the proposed directives:

A. All potential SCCs *must meet* the following mandatory requirements for their identification as SCC:

   1. The species must be a native species in the plan area, with a plan area occurrence record for the species within the last 10 to 15 years; and

   2. The best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area. This information may be derived from the scientific literature, species studies, habitat studies, analyses of information obtained from a local area, and/or the result of expert opinion or panel consensus.

B. A species *should not* be identified as a potential SCC if:

1. The species is secure and its continued long-term persistence in the plan area is not at risk based on knowledge of its abundance, distribution, lack of threats to persistence, trends in habitat, and responses to management.
2. There is insufficient scientific information available to conclude that there is a substantial concern about the species capability to persist in the plan area over the long term.
3. Its occurrence is thought to be “accidental,” well outside its current range.

More detailed guidance for selecting SCC is presented in Chapter 10 of the proposed directives (FSH 1909.12, pp 35-37).

Evaluating Relevant Information for At-Risk Species

The Cibola used a Microsoft Access database (Risk Assessment Database) developed for determining risk to species expressly for the forest plan revision process to store and evaluate relevant information collected. Both the Rule and proposed directives mandate the use of best available scientific information (BASI) for each of the resource parameters evaluated in this assessment.

The Cibola accessed a wide variety of sources to compile the BASI for species considered. According to NatureServe (NatureServe 2012), there are more than 7,000 unique animal, plant, and fungi species found in New Mexico. To form the list of potential SCC, A(2) above, was considered. Species records were exported from NatureServe for all species occurring in New Mexico that had status ranks of G or T 1, 2, or 3 and S 1 and 2.[39] These are species that have been identified by state natural heritage programs, The U.S. Fish and Wildlife Service, the International Union for Conservation of Nature, the Canadian Wildlife Service, and others as facing imminent risk of extinction.

To this list were added:

- Species that are identified as recently delisted or have a positive 90-day finding in New Mexico by the USFWS (77 FR 69994);
- Species listed as threatened or endangered by New Mexico Department of Game and Fish (BISON-M 2013) and State Forestry Division (NMSFD 2013b);
- Species on the Region 3 Regional Forester’s Sensitive Species List (USFS 2013);

[39] NatureServe conservation status ranks are based on a scale of one to five, ranging from critically imperiled (G1) to demonstrably secure (G5). Status is assessed and documented at three distinct geographic scales -global (G), national (N), and state/province (S). Infraspecific taxa (subspecies or other designations below the level of species) are indicated by “T rank”. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G = Global, N = National, and S = Subnational), or infraspecific (T) where appropriate. The numbers have the following meaning:

1. Is equal to critically imperiled
2. Is equal to imperiled
3. Is equal to vulnerable
4. Is equal to apparently secure
5. Is equal to secure

- Species listed as threatened or endangered by adjacent Tribes (Navajo Nation, Division of Natural Resources 2008);
- Species identified as those of greatest conservation need by the New Mexico Comprehensive Wildlife Conservation Strategy (NMDGF 2006); and
- Rare plants as identified by the New Mexico Rare Plants Technical Council (NMRPTC 1999).

This list of approximately 1,350 species formed the basis of the Potential SCC list and was comprised of 694 vascular and non-vascular plants, 11 fungi, 332 invertebrates, and 321 vertebrates including 13 amphibians, 26 reptiles, 52 fish, 99 mammals, and 131 birds.

The next phase of this process involved identifying which of these species occur on any of the Cibola's four mountain districts and of these which had records or observations in the last 15 years (since 1998; A(1) above). Where possible, published location information was used to filter out species that were not reported in one of the ten counties encompassing the mountain districts.

The(Natural Resource Information System (USFS NRIS 2013) and unpublished breeding bird survey data (USFS Cibola 2012) were queried for Forest-specific observations. Museum databases, including Arctos Collection Management Information System (Arctos 2013), Biological Information Serving Our Nation (BISON 2013), Biota Information System of New Mexico (BISON-M 2013), Natural Heritage New Mexico (NHNM 2013), New Mexico Biodiversity Collections Consortium (NMBCC 2013), Southwest Environmental Information Network (SEINet 2013), were queried to determine which species had records that met the location and time requirements.

Subject matter experts at the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, New Mexico Department of Forestry, Natural Heritage New Mexico, researchers and others who were able to consult internal records and databases or rely on expert knowledge to further filter the list were consulted.

In addition to the databases and lists cited above, Forest Service biologists at the supervisor's office and each of the four mountain districts and the Southwestern Regional Office consulted closely in the development of the potential SCC list. Subject matter experts were consulted via personal communications and included staff at Angelo State University (M. Burt); Natural Heritage New Mexico (R. McCollough); New Mexico State Forestry Division (D. Roth); New Mexico Department of Game and Fish (J. Stuart, C. Painter, E. Gilbert, R. Hansen, J. Caldwell, A. Monie, M. Neal, K. Madden, B. Lang, E. Heilhecker); New Mexico Museum of Natural History (P. Gegrick, A. Burdett); New Mexico State University (J. Frey); University of New Mexico (L. Snyder, D. Lightfoot); U.S. Fish and Wildlife Service (M. Mata, M. Christman, P. Zenone, B. Millsap, G. Dennis); U.S. National Park Service (A. Chung-MacCoubrey); and the U.S. Geological Survey (E. Valdez).

While compiling relevant species information, several sources of data that appeared to fill gaps in the BASI were encountered. Citizen science is a growing movement in conservation and allows volunteers to collect and submit data to online databases including eBird (eBird 2013), iNaturalist (iNaturalist 2013), and BugGuide.Net (BugGuide.Net 2013). These resources were used where it was possible to verify observations, but for many records this was not possible.

For highly visible and high-interest species (e.g., birds), reliable collection and observation data were readily available. In addition, the current Forest Plan requires monitoring for management indicator species and federally listed species. However, for many other species, this information was simply not available. In many cases, it was not possible to determine if this was because surveys had been conducted but the species were not found (negative surveys) or surveys had not been conducted at all. No fungi or lichen species were carried forward because it is not known which of those identified as potentially at-risk occur on the Forest. This is a data gap that should be addressed through future inventories, plan monitoring, or research. Several fish species included on the Region 3 Regional Forester's Sensitive Species List (USFS 2013) have not been documented on the Cibola but have been documented off-Forest. They were included on the Sensitive Species List because they have the potential to be affected by Forest management activities; however, this alone does not merit inclusion on the potential SCC list. From the initial 1,350 potential SCC identified, only 60 species had been reliably documented on the Cibola National Forest. Of those 60 species, only 35 have been documented on the Cibola since 1998, or in the last 15 years (Table 45).

Another potentially valuable source of BASI is the recently released New Mexico Crucial Habitat Assessment Tool, or NM CHAT (NMCHAT 2013). This web-based map tool provides spatial information on the conservation of animals, plants, and their habitats across New Mexico. This tool calculates a Crucial Habitat Rank (a score between 1, most crucial, and 6, least crucial) for the entire state of New Mexico at a resolution of 1 square mile. This rank considers a number of factors when assigning rank scores, including presence species of concern (determined by a number of state and federal agencies, similar to but not duplicative of the SCC process described here), wildlife corridors (using models generated in a least-cost path analysis for cougars [Benke 2008]), terrestrial and aquatic species of economic and recreational importance (habitat models developed by NMDGF, wetland and riparian areas, large natural areas (areas greater than 1000 hectares that are minimally fragmented by roads, power lines, railroads, pipelines, and other human impacts) and a number of other data sources. Much more information can be found at www.nmchat.org. Much of the Cibola's mountain districts ranks high in terms of overall crucial habitat in most part because of presence of species of concern and presence of large natural areas. Wetland and riparian areas, where present, also contribute to making a given cell more crucial. While the wildlife corridor layer is promising, at this point in time the only information contained within it is the cougar model described above. It is expected that the NM CHAT will be an important resource in the upcoming phases of plan revision.

Table 45. Species known to historically occur in the plan area and carried forward for consideration as species of conservation concern

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
Mammals					
Cynomys gunnisoni	Gunnison's Prairie Dog	CN, N, RF	2013 (Cibola bio. observ.)	Yes	
Corynorhinus townsendii pallescens	Pale Townsend's Big-Eared Bat	NN, RF	2012 (Corbett)	Yes	
Euderma maculatum	Spotted Bat	CN, RF, S	1995 (Chung-MacCoubrey)	No	No known surveys
Idionycteris phyllotis	Allen's Big-Eared Bat	CN, N, RF	1996 (NHNM)	No	No known surveys
Myotis occultus	Arizona Myotis	N, CN	2002 (NHNM)	Yes	
Ovis anadensis Canadensis	Rocky Mountain Bighorn Sheep	CN	~2000 (Cibola bio. observ.	Yes	
Sorex merriami	Merriam's Shrew	N	1963 (NHNM)	No	No known surveys
Sorex nanus	Dwarf Shrew	N	Pre-1975 (Hafner and Stahlecker 2002)	No	No known surveys
Spermophilus tridecemlineatus monticola	White Mountains Ground Squirrel	N	unknown[40] (Frey 2004)	No	No known surveys

[40] Species has been observed on the Cibola but no reliable date could be found.

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
Sylvilagus cognatus	Manzano Mountain Cottontail	N	1997 (ARCTOS)	No	No known surveys
Thomomys bottae paguatae	Cebolleta Southern Pocket Gopher	N, RF	1980 (USGS BISON)	No	No known surveys
Birds					
Accipiter gentilis	Northern Goshawk	CN, NN, RF	2013 (Cibola bio. observ.)	Yes	
Aquila chrysaetos	Golden Eagle	CN, NN	2011 (BBS)	Yes	
Athene cunicularia hypugaea	Burrowing Owl	CN, NN, RF	2013 (Cibola bio. observ.)	Yes	
Baeolophus ridgwayi	Juniper Titmouse	CN	2013 (BBS)	Yes	
Buteo regalis	Ferruginous Hawk	CN, N, NN	2008 (BBS)	Yes	
Cardellina rubrifrons	Red-Faced Warbler	CN	2012 (BBS)	Yes	
Circus cyaneus	Northern Harrier	N, CN	unknown (Cibola bio. observ.)	Yes	
Dendroica graciae	Grace's Warbler	CN	2012 (BBS)	Yes	
Dendroica nigrescens	Black-Throated Gray Warbler	CN	2012 (BBS)	Yes	
Dendroica petechia	Yellow Warbler	CN, NN	1995 (BBS)	No	Not found during regular surveys
Falco peregrinus anatum	American Peregrine Falcon	CN, N, NN, RF, S	2006 (BBS)	Yes	
Gymnorhinus	Pinyon Jay	CN	2012 (BBS)	Yes	

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
cyanocephalus					
Haliaeetus leucocephalus	Bald Eagle	F, NN, RF	unknown (Cibola bio. observ.)	Yes	
Lanius ludovicianus	Loggerhead Shrike	CN	2012 (BBS)	Yes	
Leucosticte australis	Brown-Capped Rosy-Finch	N	2013 (Cibola bio. observ.)	Yes	
Melanerpes lewis	Lewis's Woodpecker	CN	2004 (BBS)	Yes	
Melospiza lincolnii	Lincoln's Sparrow	N	2012 (BBS)	Yes	
Pandion haliaetus	Osprey	CN, N	1999 (USGS BISON)	Yes	
Riparia riparia	Bank Swallow	CN, N	mid-1990s (Cibola bio. observ.)	No	Not found during regular surveys
Spinus tristis	American Goldfinch	N	unknown (Cibola bio. observ.)	No	Not found during regular surveys
Toxostoma bendirei	Bendire's Thrasher	CN	2008 (BBS)	Yes	
Vireo vicinior	Gray Vireo	CN, NN, RF, S	2011 (BBS)	Yes	
Wilsonia pusilla	Wilson's Warbler	N	2005 (BBS)	Yes	
Reptiles and Amphibians					
Crotalus lepidus klauberi	Banded Rock Rattlesnake	CN, N	unknown (Degenhardt et al. 1996)	No	No known surveys
Rana pipiens	Northern Leopard Frog	CN, N, NN, RF,	2010 (NHNM)	Yes	

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
		S			
Fish					
Catostomus plebeius	Rio Grande Sucker	CN, N, RF	1986 (NHNM)	No	Not found on recent surveys
Gila pandora	Rio Grande Chub	CN, N, RF	1986 (NHNM)	No	Not found on recent surveys
Invertebrates					
Oreohelix magdalenae	Magdalena Mountainsnail	N, RF	Pre1982 (Metcalf and Smartt 1997)	No	No known surveys
Oreohelix neomexicana	Oscura Mountain Land Snail	CN, N	unknown (B Lang, pers. comm.)	No	No known surveys
Oreohelix strigosa depressa	Rocky Mountainsnail	CN, N, NN	unknown (B Lang, pers. comm.)	No	No known surveys
Radiodiscus millecostatus	Ribbed Pinwheel	N	unknown (B Lang, pers. comm.)	No	No known surveys
Streptocephalus henridumontis	Dumont's Fairy Shrimp	RF	2001 (B Lang, pers. comm.)	Yes	
Speyeria nokomis nitocris	Nokomis Fritillary	N	~1970 (S. Carey, pers.	No	No known surveys

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
			comm.)		
Plants					
Apacheria chiricahuensis	Cliff Brittlebush	N	1982 (NHNM)	No	No known surveys
Astragalus accumbens	Zuni Milkvetch	N, RF, RP	1985 (NHNM)	No	No known surveys
Astragalus feensis	Santa Fe Milkvetch	N, RP	1998 (NHNM)	Yes	
Astragalus humistratus var. crispulus	Villous Groundcover Milkvetch	RF, RP	1981 (SEINet)	No	No known surveys
Astragalus micromerius	Chaco Milkvetch	N, RF, RP	1983 (SEINet)	No	No known surveys
Clematis hirsutissima var. hirsutissima	Clustered Leather-flower	RF	1991 (SEINet)	No	No known surveys
Draba mogollonica	Mogollon Whitlow-grass	N, RP	1993 (NHNM)	No	No known surveys
Erigeron sivinskii	Sivinski's Fleabane	N, NN, RF, RP	1995 (SEINet)	No	No known surveys
Euphorbia brachycera	Horned Spurge	N	2002 (USGS BISON)	Yes	
Heuchera pulchella	Sandia Mountain Alumroot	N, RF, RP	2004 (SEINet)	Yes	
Hymenoxys brachyactis	Tall Bitterweed	N, RF, RP	2006 (NHNM)	Yes	
Packera cynthioides	White Mountain Groundsel	N	2001 (NMBCC)	Yes	
Penstemon oliganthus	Apache Beardtongue	N	2009 (SEINet)	Yes	

Scientific Name	Common Name	Rationale for Consideration	Year Last Observed in the Plan Area (Source)	Presence in the Plan Area Documented since 1998?	Rationale for No Documentation
Penstemon pseudoparvus	San Mateo Penstemon	RF, RP	2002 (SEINet)	Yes	
Silene plankii	Plank's Catchfly	N, RP	1998 (NHNM)	Yes	
Tetraneuris argentea	Perkysue	N	1998 (USGS BISON)	Yes	

Codes for rationale:

CN = Identified as a species of greatest conservation need in the New Mexico Comprehensive Wildlife Conservation Strategy Report;

F = Federally delisted within last 5 years;

N = NatureServe Global, Taxonomic, National, or State Ranking;

NN = Navajo Nation Endangered;

RF = Regional Forester's Sensitive Species List;

RP = Rare Plant; and

S = State-listed as threatened or endangered.

Scales of Analysis

Three scales of analysis were used for the assessment of at-risk species: context, plan, and local. These roughly correspond with evaluating species within the state of New Mexico (context), those species that occur somewhere on the Cibola (plan) and finally associating species with individual mountain units (local). Because of the sky island nature of the Cibola's individual mountain ranges and the unique habitat needs of many species considered, this approach worked well for this resource area. However, other relevant resource areas used different scales of analysis (e.g., vegetation, see Chapters 1 and 2 of this Volume) and inconsistencies will be noted and addressed later in this chapter.

Habitat Associations

Species cannot be managed apart from their habitats and thus much of the assessment of species on the Cibola focused on potential and actual habitat available on the forest. To make the species risk assessment relevant to other ecological risk assessments presented in this assessment, habitat types were categorized following Ecological Response Units (ERUs), as was done in Chapter 2, Vegetation. The ERU system (formerly Potential Natural Vegetation Type or PNVT) is a stratification of units that are each similar in plant indicator species, succession patterns, and disturbance regimes that, in concept and resolution, are most useful to management.

The ERU framework represents all major ecosystem types of the region and a coarse stratification of biophysical themes. The ERUs are map unit constructs, i.e., technical groupings of finer vegetation classes with similar site potential (Daubenmire 1968) and disturbance history; that is, the range of plant associations, along with structure and process characteristics, that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006).

For this reason, ERUs do not necessarily reflect the vegetation currently present in a particular map unit but rather reflect the unit's site potential given the natural range of variation and historical disturbance regime. ERUs are described in much more detail in the Vegetation chapter of Volume 1 of this assessment report. Average patch size for each ERU under reference and current conditions are presented in Table 13. A discussion of seral stage under reference and current conditions as well as at the context scale is also presented in that chapter of the assessment.

Wildlife and plant species were associated with up to four dominant ERU types (Table 46). These associations were informed by a number of different sources including the Biota Information System of New Mexico (BISON-M 2013), the New Mexico Rare Plants website (NMRPTC 1999), NatureServe Data Explorer (NatureServe 2012) and personal communications with species experts and agency biologists.

In many cases, species' habitat needs were not represented solely by ERUs (e.g., raptors requiring snags for perching or nesting, or snails requiring dense leaf litter to retain moisture). In these cases, those special habitat features were recorded and assessed separately from the ERU model (Table 47). Overall, an effort was made to associate species with ERU types whenever possible because later stages of forest plan revision and development will center on the management of ERUs. This relationship between species and ERUs is the premise of the coarse-filter approach discussed above and appropriate management of ERUs is expected to benefit not only at-risk species, but those that remain common and abundant. The relationship between species and special habitat features will help to identify fine-filter approaches necessary for preserving species diversity on the Cibola.

Table 46. Federally listed and potential species of conservation concern (SCC) currently known to occur in the plan area and associated ecological response unit types. *Denotes Federally listed species; all others are potential SCC

Common Name	Chihuahuan Desert Scrub	Colorado Plateau / Great Basin Grassland	Juniper Grass	Mixed Conifer – Frequent fire	Mixed Conifer – Aspen	Montane / Subalpine Grassland	Mountain Mahogany Mixed Shrubland	PJ Woodland	Ponderosa Pine Forest	Riparian	Sagebrush Shrubland	Semi-Desert Grassland	Spruce-Fir Forest	Unspecified Aquatic
Mammals														
Arizona Myotis									X	X				
Gunnison’s Prairie Dog (prairie population)	X		X								X	X		
Pale Townsend’s Big-Eared Bat	X							X						
Rocky Mountain Bighorn Sheep				X	X	X				X				
Mexican Wolf*					X			X	X				X	
Birds														
American Peregrine Falcon					X			X	X				X	
Bald Eagle										X				
Bendire’s Thrasher	X	X												
Black-throated Gray Warbler								X		X				
Brown-capped Rosy-Finch													X	
Burrowing Owl	X		X								X	X		
Ferruginous Hawk	X		X			X					X			
Golden Eagle								X	X					
Grace's Warbler				X					X					

Common Name	Chihuahuan Desert Scrub	Colorado Plateau / Great Basin Grassland	Juniper Grass	Mixed Conifer – Frequent fire	Mixed Conifer – Aspen	Montane / Subalpine Grassland	Mountain Mahogany Mixed Shrubland	PJ Woodland	Ponderosa Pine Forest	Riparian	Sagebrush Shrubland	Semi-Desert Grassland	Spruce-Fir Forest	Unspecified Aquatic
Gray Vireo			X				X	X						
Juniper Titmouse			X					X	X					
Lewis’s Woodpecker				X					X	X				
Lincoln’s Sparrow										X				
Loggerhead Shrike	X	X	X								X			
Mexican Spotted Owl*				X					X	X				
Northern Aplomado Falcon*	X													
Northern Goshawk				X	X				X				X	
Northern Harrier		X				X					X	X		
Osprey										X				X
Pinyon Jay	X		X					X			X			
Red-faced Warbler				X					X	X				
Southwestern Willow Flycatcher*										X				
Western Yellow-Billed Cuckoo*										X				
Wilson's Warbler										X				X
Amphibians														
Chiricahua Leopard Frog*										X				X
Northern Leopard Frog										X				X

Common Name	Chihuahuan Desert Scrub	Colorado Plateau / Great Basin Grassland	Juniper Grass	Mixed Conifer – Frequent fire	Mixed Conifer – Aspen	Montane / Subalpine Grassland	Mountain Mahogany Mixed Shrubland	PJ Woodland	Ponderosa Pine Forest	Riparian	Sagebrush Shrubland	Semi-Desert Grassland	Spruce-Fir Forest	Unspecified Aquatic
Fish														
Zuni Bluehead Sucker*										X				X
Invertebrates														
Alamosa Springsnail*										X				X
Dumont’s Fairy Shrimp														X
Plants														
Apache Beardtongue						X								
Horned Spurge								X	X					
Perkeysue								X						
Plank’s Catchfly								X						
San Mateo Penstemon						X			X				X	
Sandia Mountain Alumroot					X									
Santa Fe Milkvetch								X						
Tall Bitterweed								X						
White Mountain Groundsel				X										
Zuni Fleabane*								X						

Table 47. Federally listed and potential species of conservation concern (SCC) known to currently occur in the plan area and associated special habitat features. *Denotes federally listed species, all others are potential SCC.

Special Habitat Feature	Associated Species
Tree features (cavities, snags, leaves, bark, downed logs, leaf or forest litter)	• Arizona Myotis • Bald Eagle • Golden Eagle • Juniper Titmouse • Lewis's Woodpecker • Mexican Spotted Owl* • Northern Goshawk • Red-faced Warbler
Rock Features (Canyons, cliffs, crevices, outcrops)	• American Peregrine Falcon • Arizona Myotis • Rocky Mountain Bighorn Sheep • Golden Eagle • Mexican Spotted Owl* • Apache Beardtongue • Pale Townsend's Big-Eared Bat • Perkysue • Plank's Catchfly • Sandia Mountain Alumroot • Santa Fe Milkvetch • White Mountain Groundsel • Zuni Fleabane*
Aquatic Features (Riparian areas, springs, permanent water)	• Alamosa Springsnail* • Arizona Myotis • American Goldfinch • Bald Eagle • Bank Swallow • Black-Throated Gray Warbler • Dumont's Fairy Shrimp • Lincoln's Sparrow • Mexican Spotted Owl* • Osprey • Rocky Mountain Bighorn Sheep • Southwestern Willow Flycatcher* • Western Yellow-Billed Cuckoo* • Red-faced Warbler • Wilson's Warbler • Yellow Warbler • Chiracahua Leopard Frog* • Northern Leopard Frog • Zuni Bluehead Sucker*
Meadows and Small Openings	• Apache Beardtongue • San Mateo Penstemon

Special Habitat Feature	Associated Species
Soil Features	• Red-faced Warbler • Perkysue • Plank’s Catchfly • Sandia Mountain Alumroot • Santa Fe Milkvetch • White Mountain Groundsel • Zuni Fleabane*

During the assessment, numerous data gaps were found and attributed mainly to inadequate survey data. For example, the Magdalena Mountainsnail (*Oreohelix magdalanae*) meets two of the criteria for inclusion on the list of potential SCC as described in FSH 1909.12. It has a NatureServe G-rank of 1, implying that it is critically imperiled. While it does not have an S-rank for New Mexico, it is identified on the Region 3 Regional Forester’s Sensitive Species List (USFS 2013). The species was first described in 1939 and was reportedly collected in several localities prior to 1982 (Metcalf and Smartt 1997), but it is not known if there have been any surveys since that time. This was not uncommon and approximately half of the species initially identified as potential SCC that had at one time been documented on the Cibola were excluded from further consideration because there were no recorded observations in the last 15 years. It was very difficult to determine whether surveys had been conducted but they were negative or if surveys had simply not been conducted at all so unless there was specific knowledge, it was assumed that no surveys had been conducted.

Grouping of Species

Species can be grouped a number of different ways that are useful for identifying broad threats to their continued existence on the Cibola. For efficiency during the risk assessment portion of this evaluation, species were grouped according to their associated ERUs, described above and presented in Table 46. This information is summarized by taxonomic group below (Table 48). This paired well with the risk assessment process that was conducted on the ERU types and presented in the Vegetation chapter of this document. It is acknowledged that grouping species in this manner will not accurately capture all of their specific habitat needs, and so they have also been sorted by special habitat features (Table 47).

Table 48. Federally listed and potential species of conservation concern and their associated ecological response units (ERUs). Note that species are typically associated with more than one ERU.

	Riparian	PJ Woodland	Ponderosa Pine Forest	Juniper Grass	Mixed Conifer – Frequent Fire	Chihuahuan Desert Scrub	Mixed Conifer – Aspen	Unspecified Aquatic	Sagebrush Shrubland	Spruce-Fir Forest	Montane / Subalpine Grassland	Colorado Plateau / Great Basin Grassland	Semi-Desert Grassland	Mountain Mahogany Mixed Shrubland
Mammals	4	2	3	2	2	1	3		1	1	1		1	
Birds	12	6	9	7	6	6	2	2	5	3	2	3	2	1
Amphibians	2							2						
Fish	1							1						
Invertebrate	1							1						
Plants		6	2		1		1			1	2			
Total	**20**	**14**	**14**	**9**	**9**	**7**	**6**	**6**	**6**	**5**	**5**	**3**	**3**	**1**

It was also useful to group species by individual mountain range unit of occurrence during the data-gathering and risk assessment portions of this assessment (Figure 2, located in the Introduction of Volume I). This corresponds with the local scale of analysis and for the endemic or specialized nature of many species was an appropriate approach. It is expected that this may also benefit other planning purposes. However, caution should be exercised when making comparisons between mountain range units. The Gallinas Mountains of the Mountainair RD have only six federally listed and potential SCC species associated with them, whereas the Sandia Mountains of the Sandia RD have 30 species. The Gallinas Mountains on Mountainair District are remote (Figure 2) whereas the Sandia Mountains are adjacent to the state's largest metropolitan area. While the two mountain ranges contain differing amounts and types of habitat from one another and likely host different species, it is assumed that relatively more effort is spent surveying and assembling species observation data in the Sandia Mountains than in the Gallinas Mountains.

Table 49. Federally listed and potential species of conservation concern and associated mountain range unit. Note that species are often associated with more than one mountain range unit.

	Mt Taylor	Zuni Mtns	Bear Mtns	Datil Mtns	Magdalena Mtns	San Mateo Mtns	Gallinas Mtns	Manzano Mtns	Sandia Mtns
Mammals	2	3	2	3	4	4	1	4	3
Birds	8	19	10	6	16	16	3	10	22
Amphibians	1	1				1			1
Fish		1							
Invertebrate						1			
Plants	2	2		2	2	3	2	4	5
Total	**13**	**26**	**12**	**11**	**22**	**25**	**6**	**18**	**31**

Evaluation Process for Assessing At-Risk Species

The Cibola used a Microsoft Access Database (Species Risk Assessment Database) that was designed as a two-phase process to review, screen, and analyze risk to potential SCCs on the Cibola. The first phase involved reviewing and screening species that meet one or more of the criteria described above for at-risk species and determining which of those species have been documented on the Cibola in the last 15 years (since 1998). Federally recognized species (Table 44) are also tracked in the Risk Assessment Database, but in a parallel process to potential SCC. Of the initial 1,350 species known to exist in New Mexico, 84 met one or more of the criteria for potential SCC as outlined in the proposed directives. Of those 84 species, 60 had been documented at some point in time on the Cibola National Forest; however only 35 of those had been documented on the Cibola since 1998 (Table 45, in accordance with proposed directives).

Also during the first phase, it was determined which of the potential SCCs were directly threatened by Cibola/Forest Service management activities. Some threats are not under agency jurisdiction (e.g., development of private land immediately off the Cibola boundaries or development of water resources on the Cibola when the water rights are held by other entities). Some species have been documented to use the Forest only during the winter or as migrants (e.g., Wilson's Warbler) and would not likely be affected by Cibola management actions during other seasons. Additionally, sometimes portions or all of a given ecosystem characteristic may be altered so that recovery is not possible even if threats are controlled or reduced (e.g., loss of topsoil from historical juniper tree pushing and chaining). And in some cases, the response from the reduction of the threat may be so slow that current departures will essentially be present for hundreds of years (e.g., restoring fire in spruce-fir forest when the historical fire return interval is several hundred years).

Eighteen of the 35 species identified as potential SCC were found to not be directly affected by management under the current forest plan and these were removed from further analysis. Species were determined to either be animals that are only occasional users of the plan area, plants that grow in areas not affected by management activities, or species for which specific threats have not been identified.[41] The rationale for removing them included species that were not known to nest or breed on the Cibola but rather just use the Cibola for occasional foraging (Bald Eagle, Ferruginous Hawk, Golden Eagle, Northern Harrier, Osprey, Wilson's Warbler). Under current plan direction, the occasional stop-over use of Cibola habitat by and important to these species is not anticipated to be affected by management activities. Plant species that are found on rocky outcrops or other areas not suitable for typical forest-management activities such as timber harvest or cattle grazing (Plank's Catchfly, Santa Fe Milkvetch, Tall Bitterweed,) were also excluded from further analysis. Species for which specific threats were not identified in the literature (Apache Beardtongue, Black-Throated Gray Warbler, Brown-Capped Rosy Finch, Horned Spurge, Lincoln's Sparrow, Perkysue, Pinyon Jay, San Mateo Penstemon, White Mountain Groundsel) were not considered either because they could not be tied to specific management actions. Several species (Black-Throated Gray Warbler, Pinyon Jay) have declines that have been associated with legacy management actions that are no longer practiced by the Cibola.

The second phase of the process involved performing risk assessment analysis on the species remaining from phase one screening. The Risk Assessment Database has been designed to assess habitat, population, and threat factors for each of the species in terms of historical, current, and future trends. These are described in detail below. Numerical values (1, 2, or 3) were assigned to each of the habitat, population, and threat factors analyzed. The Risk Assessment Database calculates an overall numerical ranking of risk to each species. The Risk Assessment Database assesses risk for each species within each habitat type on each mountain district. For example, a bird documented on all four districts and known to use 3 different ERUs would undergo 12 separate risk assessments. By and large, that degree of resolution in population or habitat factors is not available, but if it were the Risk Assessment Database would allow us to tease out these subtleties.

The dual coarse-filter and fine-filter approach described earlier was used to assess risk to species on the Cibola National Forest. The coarse-filter approach considered habitat (ERUs) associated with species and current condition and future trends were modeled using a variety of methods (Chapter 2, Vegetation). For forest and woodland ERUs, the Vegetation Dynamics Development Tool (VDDT) (ESSA 2006) was used. This tool simulates stand structure 15, 100, and 1,000 years into the future under current management. The data presented in the Vegetation chapter of this assessment is modeled at the plan-level of analysis, or Cibola-wide. Additional VDDT modeling for departure at current conditions was performed at the ranger district level (between plan- and local-scales of analysis) and this finer scale of resolution was used for the species risk assessment. Some of the results of that modeling are presented here (Table 50) and the rest is available in the Forest Plan Revision Project Record.

[41] An earlier draft of this document included Red-faced Warbler with species for which specific threats had not been identified, but during the public review period, more data became available regarding threats to this species.

Table 50. Results of Vegetation Dynamics Development Tool modeling for Ecological Response Unit (ERU) departure of current conditions by ranger district and of conditions 100 years into the future forest-wide. N/A indicates that ERU is not present on that ranger district. N/M indicates that there was not enough data to model departure for spruce-fir forest in the future.

ERU	Current Departure by Ranger District (%) Mt. Taylor	Magdalena	Mountainair	Sandia	Modeled departure in 100 years forest-wide (%)
Juniper Grass	64	67	53	65	80
Mixed Conifer – Frequent fire	80	71	68	84	63
Mixed Conifer – Aspen	n/a	55	51	49	44
PJ Evergreen Shrub	n/a	71	87	n/a	82
PJ Grass	51	55	61	65	72
PJ Woodland	53	69	39	22	20
Ponderosa Pine Grassland	100	100	100	100	89
Ponderosa Pine Forest	100	100	100	100	94
Spruce-Fir	44	64	n/a	46	n/m

Trend was not calculated for ERUs whose Cibola acreages were too small to adequately model in VDDT or whose stand structure is not appropriate for VDDT modeling (specifically grassland and shrubland types). This included several of the ERUs associated with at-risk species in this chapter: Chihuahuan Desert Scrub, Colorado Plateau/Great Basin Grassland, Montane/Subalpine Grasslands, Mountain Mahogany Shrubland, Riparian, Semi-Desert Grassland, and Unspecified Aquatic habitats. For shrubland and grassland ERUs, litter cover and plant basal cover (Terrestrial Ecosystem Unit Inventory [TEUI] data) were used to indicate the understory structure and its departure from reference conditions. For these ERUs, only information on current condition was available from the TEUI data, future conditions are not modeled. Current departure for those ERUs are as follows: Chihuahuan Desert Scrub 0%, Colorado Plateau/Great Basin Grassland 34%, Montane/Subalpine Grasslands 48%, Mountain Mahogany Shrubland 28%, Sagebrush Shrubland 93%, and Semi-Desert Grassland 17%.

Nearly all of the ERUs modeled are currently departed from reference and are predicted to be departed from reference 100 years from now. An extensive discussion of that analysis is presented in Chapter 2, Vegetation and is only briefly summarized here. Fire regimes are disrupted in nearly half of the ERUs present on the Forest, typically from historical fire suppression activities. Fire suppression has led to an overall change in seral stage proportion in most of the woody ERUs modeled in VDDT (Chapter 2, Figure 7-Figure 15) and many stands are currently characterized by smaller diameter trees with a denser distribution whereas in reference conditions these stands were characterized by more widely spread trees of medium or larger diameters. Many wildlife species are dependent on shrub and forb species that once grew in the understory of various ERUs but in many cases are now crowded out by this overall shift in seral structure and density. Additionally, years of prolonged drought combined with overstocked stands increases the risk of higher-intensity, more severe fires that could further eliminate habitat.

Other features important to wildlife and plants, such as coarse woody debris (e.g., downed logs) that provide shelter, food, and moisture retention and standing snags of sufficient size for roosting, nesting, or foraging are also departed from reference conditions. See the section on Snags and Coarse Woody Debris in Chapter 2, Vegetation for more information. These features are somewhat more transient on the landscape and as snags fall down and eventually decay, standing live trees die becoming new snags. If the seral stage proportions of most ERUs trend towards smaller diameter trees, future may not be large enough to provide the habitat required by species such as Mexican Spotted Owl or Northern Goshawk.

For all modeled ERU types, current departure from reference condition and modeled departure for 100 years into the future were entered into the Risk Assessment Database. Qualitative determinations for those ERU types not modeled were made using knowledge of current condition and expert opinion. The Risk Assessment Database calculates an overall risk rating for each ERU-ranger district combination entered based on the parameters described below. The italicized words are the way each parameter is identified in the Risk Assessment Database. Each qualitative ranking selected is assigned a numerical value between 1 and 3 and then an overall habitat ranking value is calculated. All parameters below are evenly weighted in this calculation. A number of assumptions were made while performing the species' risk assessments using the Risk Assessment Database. They are summarized as follows:

1. The *extent of habitat available* to a species does not change from reference to current to future conditions. As stated above, ERU map units reflect the potential of a site and the historical disturbance regime. These are not expected to change at the time scales used. Therefore, the amount of habitat available in historical/reference conditions does not change as one moves to current or future trend. Those ERUs that make up less than 5 percent of the total area of all four mountain districts are considered as providing low amounts of habitat. Moderate amounts of habitat are those ERUs that range from 6–50 percent, and high amounts of habitat make up 51–100 percent of the area. There are no ERUs that make up more than 50 percent of the total plan area.

2. *Quality of habitat* represents ERU departure from reference. It is assumed that during reference conditions, all habitat was sufficient to maintain viability. Current condition of habitat ERUs in low departure (0–33% departed from reference) are considered high quality; ERUs in moderate departure (34–66% departed from reference) are moderate quality; and ERUs in high departure (67–100% departed from reference) are low quality. The future trend in quality of habitat reflects ERUs modeled for 100 years from now. While it is acknowledged that ERUs that are highly departed from reference are not necessarily low quality habitat for wildlife, for the purpose of this risk assessment, that is the assumption. The VDDT modeling for ERUs on the Cibola represents the most comprehensive habitat data available but where more detailed habitat information is available for SCC it was noted.

3. *Distribution* is a qualitative measure that indicates the representativeness and redundancy of ERU types across the four mountain districts. ERUs were determined to be either even (habitat dispersed broadly), restricted (habitat restricted to certain areas) or highly fragmented (habitat isolated and separated by distance or barriers). As in number 1 above, these ratings were assessed to be consistent across historical, current, and future trends.

4. *Processes* refers to ecological processes including herbivory, fire, and flooding and were evaluated using ERU departure. As in number 2 above, processes are assumed to have been functioning in historical conditions. ERUs that are 0–50 percent departed are considered to be functioning in both current and future conditions. ERUs that are 51–100 percent are considered to be disrupted. The future trend in quality of habitat reflects ERUs modeled for 100 years from now.

5. Not all ERU types were modeled by VDDT in Chapter 2, Vegetation. Only the 10 forested ERUs with the largest acreages in the plan area were evaluated. An exception was made for spruce-fir forest which was determined to be of importance to other resource areas (see ERU descriptions in Chapter 2, Vegetation). Those that were not modeled but are important to species include those listed below. These ERUs are rated qualitatively (low, medium, high) for current condition using TEUI data and future trend is assumed to be consistent with current condition.

    a. Chihuahuan Desert Scrub – current: low; 100 years: low
    b. Colorado Plateau/Great Basin Grassland – current: moderate; 100 years: moderate
    c. Montane/Subalpine Grasslands – current: moderate; 100 years: moderate
    d. Mountain Mahogany Shrubland – current: low; 100 years: low
    e. Riparian – current: high; 100 years: high
    f. Sagebrush Shrubland – current: high; 100 years: high
    g. Semi-Desert Grassland – current: low; 100 years: low
    h. Unspecified Aquatic habitats

Once the risk to habitats (ERUs and special habitat features) had been evaluated and entered into the Risk Assessment Database, historical, current, and trend of populations of potential SCCs on the Cibola were then evaluated. The Risk Assessment Database steps the user through a similar analysis of historical, current, and future population trends. Qualitative rankings are assigned a numerical value of 1-3 and then overall risk to the populations is calculated and all parameters are weighted equally. As with the analysis of habitats, a number of assumptions were made regarding population trends. Data informing these trends were gathered from a number of places including NatureServe (NatureServe 2012) BISON-M (2013), and North American Breeding Bird Survey Data (Sauer et al. 2012).

1. *Distribution* refers the species occurrence on the Cibola with respect to the overall range for that species. Detailed distribution maps for breeding birds were available from Sauer et al. (2012) and NatureServe (2012) provided distribution maps for many non-avian species. Distribution of the species on the Cibola was considered by evaluating the availability and location of suitable habitat. Species were determined to be either in high isolation, moderate isolation, or high interaction.
2. *Size* refers to the overall population size across the species' range. Detailed information about populations of each species on just the Cibola was not available in most cases. Population sizes were categorized as small, moderate, or large.
3. *Stability* refers to a population's relative trend towards increasing, decreasing, or remaining the same. In nearly all cases, population trend information specific to the Cibola National Forest was not available; this constitutes a data gap in the analysis. For these instances, trend was inferred from regional or state information where possible. If it was not clear whether or not populations were declining or increasing, or if in the case of the Breeding

Bird Survey Data the trends were not significant, it was assumed that they were stable. All species were ranked as either in decline, stable, or gaining.

4. *Diversity* refers to phenotypic, ecological, and genetic diversity. There was no information available regarding diversity for any of the species considered; however, the risk assessment calculations would not properly function without assigning a ranking. For that reason, moderate diversity was selected for every species analyzed.

Once population factors have been evaluated, the Risk Assessment Database allows for other threats to species to be accounted for, including harassment (by humans), invasive species, diseases, parasitism, obstructions (e.g., collisions with wind turbines, cars), or predation (Table 51). The severity of each threat is determined to be low, moderate, or high and the likelihood of that threat is also determined to be low, moderate, or high. Unlike the habitat or population factors which require assessment, these other threats do not require assessment if no data is available. Again, numerical values are assigned to both the severity and likelihood ratings. The Risk Assessment Database then calculates overall numerical risk (1-3) to each species and assigns a qualitative rank (high, moderate, low).

Table 51. Additional threats to federally listed and potential species of conservation concern.
***Denotes federally listed species, all others are potential SCC.**

Additional Threats	Affected Species
Harassment (e.g., Human presence disrupting species during sensitive life stages, dogs, disturbance from mining activities)	• Arizona Myotis • American Peregrine Falcon • Burrowing Owl • Mexican Spotted Owl* • Northern Goshawk • Pale Townsend’s Big-Eared Bat • Rocky Mountain Bighorn Sheep • Sandia Mountain Alumroot • Zuni Fleabane*
Invasive Species	• Chiricahua Leopard Frog* • Dumont’s Fairy Shrimp • Lewis’s Woodpecker • Northern Leopard Frog • Rocky Mountain Bighorn Sheep • Western Yellow-Billed Cuckoo* • Zuni Bluehead Sucker*
Disease (e.g., White-Nose Syndrome, chytrid fungus, sylvatic plague)	• Arizona Myotis • Chiricahua Leopard Frog* • Dumont’s Fairy Shrimp • Gunnison’s Prairie Dog • Mexican Wolf* • Northern Leopard Frog • Pale Townsend’s Big-Eared Bat • Rocky Mountain Bighorn Sheep

Additional Threats	Affected Species
Parasitism (including nest parasitism from Brown-Headed Cowbirds)	• Gray Vireo • Southwest Willow Flycatcher*
Obstruction (e.g., collisions with wind turbines or vehicles)	• American Peregrine Falcon • Arizona Myotis • Burrowing Owl • Loggerhead Shrike • Pale Townsend's Big-Eared Bat • Western Yellow-Billed Cuckoo*
Predation (including both predation from other wildlife as well as indiscriminate shooting)	• Gunnison's Prairie Dog (prairie) • Chiricahua Leopard Frog* • Burrowing Owl • Mexican Spotted Owl* • Mexican Wolf* • Northern Goshawk • Northern Leopard Frog • Zuni Fleabane* • Zuni Bluehead Sucker*

In summary, the process used to determine potential SCC started with 60 species that met the criteria outlined in the proposed directives, FSH 1909.12, pp 35-37. Of those 60 species, 25 have not been documented on the Cibola in the last 15 years or since 1998. Of the 35 remaining potential SCC, 18 were determined to not be affected by current Forest Plan management direction, namely they were animal species that were only occasional users of the plan area, they were plant species that grew in areas outside of management activities, or that were species for which specific threats have not been identified in the literature and therefore could not be tied to specific management activities. Therefore, 17 potential SCC remain.

Table 52. Potential list of species of conservation concern for the Cibola National Forest.

Scientific Name	Common Name
Mammals	
Corynorhinus townsendii pallescens	Pale Townsend's Big-Eared Bat
Cynomys gunnisoni	Gunnison's Prairie Dog
Myotis occultus	Arizona Myotis
Ovis canadensis Canadensis	Rocky Mountain Bighorn Sheep
Birds	
Accipiter gentilis	Northern Goshawk
Athene cunicularia hypugaea	Burrowing Owl
Baeolophus ridgwayi	Juniper Titmouse
Cardellina rubrifrons	Red-faced Warbler

Scientific Name	Common Name
Dendroica graciae	Grace's Warbler
Falco peregrinus anatum	American Peregrine Falcon
Lanius ludovicianus	Loggerhead Shrike
Melanerpes lewis	Lewis's Woodpecker
Toxostoma bendirei	Bendire's Thrasher
Vireo vicinior	Gray Vireo
Amphibian	
Rana pipiens	Northern Leopard Frog
Invertebrate	
Streptocephalus henridumontis	Dumont's Fairy Shrimp
Plant	
Heuchera pulchella	Sandia Mountain Alumroot

Federally Listed Species and Species of Conservation Concern and Current Cibola Management Direction

All of the federally listed species and potential SCC can be affected by current Forest Plan-authorized management activities on the Cibola National Forest, especially that which pertains to timber management, watershed protection and improvement, and specific wildlife. Risk was not assessed for ERUs or other habitat factors not on Cibola-owned lands and therefore it is not possible to state with certainty the overall risk to the species at the context scale. However, for many of these species, habitat provided on the Forest represents the majority or in some cases, the only habitat available. Changing land use patterns, habitat degradation and loss, or simply the lack of suitable habitat off-Forest place a particular emphasis on the Cibola to maintain these species.

Federally Listed Species

Mexican Wolf (*Canis lupus baileyi*) was historically extirpated from nearly all its range in the United States and has been reintroduced to the American Southwest since 1998. It is federally endangered. Though the species does not currently breed or den on the Cibola, it has been documented on Magdalena RD. The Mexican Wolf uses a variety of different ERU types and feeds almost exclusively on elk and deer. Threats include loss of prey, collisions with vehicles, disease, and illegal shooting.

Western Yellow-Billed Cuckoo (*Coccyzus americanus occidentalis*) is proposed for federal listing as threatened. The species occurs in dense riparian habitats in the western U.S. although it has not been documented on the Cibola. It is possible that the species uses the Forest as migratory habitat. The major threat faced is the loss of riparian habitat because of invasive species and changing land use. They are also susceptible to tower and turbine strikes.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is federally listed as endangered and relies on dense riparian areas, usually dominated by willow species. The species has been historically documented on Mt. Taylor and Mountainair RDs although it has not been observed on the Cibola since 1994. Threats include loss of riparian habitat due to altered hydrology or unmanaged grazing and nest parasitism by the Brown-Headed Cowbird.

Northern Aplomado Falcon (*Falco femoralis septentrionalis*) is a federally endangered species that was extirpated from the United States. Reintroduction efforts and dispersal from Mexico have allowed the bird to slowly return to the southern part of New Mexico. It does not nest on the Cibola but has been documented foraging for prey (primarily other birds but also to a lesser extent invertebrates, small mammals, and reptiles) on the Forest. Threats are not well understood but are expected to include habitat loss, specifically the conversion of grasslands to crops.

Mexican Spotted Owl (*Strix occidentalis lucida*) are well known on Mt. Taylor, Magdalena, Mountainair, and Sandia RDs where it is federally threatened. This species is apparently nonmigratory and feeds primarily on small mammals. There are 176,073 hectares (435,100 acres) of designated critical habitat on the Cibola and this is described in more detail in Volume 2 Chapter 6, Designated Areas. The Mexican Spotted Owl requires a variety of mixed conifer habitats, proximity to riparian areas, standing snags for roosting and nesting, and typically rocky outcrops. Timber harvest, prescribed burning, and other management activities are designed around Mexican Spotted Owl critical habitat.

Zuni Bluehead Sucker (*Catostomus discobolus yarrowi*) is federally endangered with critical habitat on the Cibola. This fish is known to Mt. Taylor RD and is endemic to five semi-stable populations in western New Mexico. It feeds on invertebrates and organic matter on the bottom and threats include altered hydrology, predation, and invasive species.

The Chiricahua Leopard Frog (*Rana chiricahuensis*) is a federally threatened species not known to occur on the Cibola; however, a small population is located just off the Forest boundary on Magdalena RD. A small section of Magdalena RD is included in one of the Recovery Units within designated critical habitat for the species. More information can be found in Volume 2 Chapter 6, Designated Areas. It feeds primarily on invertebrates and threats include habitat loss from unmanaged grazing or other activities that alter hydrology, predation by invasive bullfrogs, and disease including chytrid fungus.

Alamosa Springsnail (*Pseudotryonia alamosae*) is a federally endangered species, that like the Chiricahua Leopard Frog is not known to exist on the Cibola but rather can be found just off the Forest boundary on Magdalena RD. It is found in thermal springs and is endemic to a single spring system with several populations known. The primary threat is altered hydrology but the species is also susceptible to invasive species and disease.

Zuni Fleabane (*Erigeron rhizomatus*) is a rare, regional endemic and is found on Mt. Taylor and Magdalena RDs. It is federally threatened and has three metapopulations range-wide. It is found in nearly barren habitats and is threats include disturbance to these areas by off-highway vehicle use and potentially uranium mining.

Potential Species of Conservation Concern

Information on the species below indicates substantial concern about the species' capability to persist over the long term in the plan area, as evidenced by one or more of the following criteria:

1. Habitat is limited or rare within the plan area,
2. Current management activities are negatively impacting habitat within the plan area,
3. Available monitoring indicates a decline in population, range, or both within the plan area.

All species listed met one or more of the initial requirements for SCC (Table 45) and a number of sources were consulted to determine whether the above criteria were met (see the section titled Evaluating Relevant Information for At-Risk Species above).

Pale Townsend's Big-Eared Bat (*Corynorhinus townsendii pallescens*) have been recorded on Mt. Taylor, Mountainair, and Sandia RDs. They hibernate and roost in caves and abandoned mine features, which are rare on the Cibola (criteria #1 above). Ongoing activities known to impact habitats used by the bats include recreational caving, vandalism, renewed mining (Finch 1992, Kunz and Martin 1982, USFS 2013, WBWG 2005b; all meet criteria #2), and potentially White Nose Syndrome, a lethal fungal infection in some species of hibernating bats in the eastern and midwestern U.S. (USDI BLM et al. 2010, Cryan 2014). Past activities, such as improper cave and mine closures, have led to a reduction in the number of available hibernacula for this species, particularly on Sandia RD (criteria #3).

Gunnison's Prairie Dog (*Cynomys gunnisoni*) are known to Mt. Taylor RD but have historically been on Magdalena RD (criteria #3). Threats include recreational shooting (Finch 1992, USFS 2013; criteria #2) and sylvatic plague (USFS 2013). Sylvatic plague could be affected by management because the Cibola could elect to "dust" prairie dog burrows with the insecticide Deltamethrin, which controls fleas infected with the plague bacterium (criteria #2).

Arizona Myotis (*Myotis occultus*) have been documented on Mt. Taylor, Magdalena, and Sandia RDs where they are found in ponderosa pine forests and riparian areas. This species roosts under loose bark on standing snags and in natural rock crevices (criteria #1). The Western Bat Working Group has identified a medium regional priority for this species, indicating that it warrants a closer evaluation (WBWG 2005a). Current threats include loss of roosting snags. While snag recruitment may occur through natural disturbance patterns such as drought and insects and disease, resulting snags may be concentrated in certain areas or aspects and not be uniformly distributed across the landscape. Prescribed fire may influence snag recruitment as well; while post-treatment abundance of logs and snags is frequently lower than desired, these elements will accumulate over time (Reynolds et al. 2013). Ongoing vegetation management activities include fire-suppression in ponderosa pine habitat which does not allow for the creation of new snags, and firewood collection in some areas which could reduce existing snags (Chung-MacCoubrey 1995, Rabe 1997; criteria #2). Magnitude of vegetation management activity acres and firewood sales volume are discussed in Volume II (Chapter 4, Timber and Special Forest Products section). White Nose Syndrome, a lethal fungal infection in some species of hibernating bats in the eastern and Midwestern U.S., is another potential threat (USDI BLM et al. 2010, Cryan 2014).

Rocky Mountain Bighorn Sheep (*Ovis canadensis canadensis*) can be found on Mountainair RD. The species was historically wide-ranging in northern New Mexico but was extirpated and then reintroduced around the state, including in the Manzano Mountains (NMDGF 1991). Population estimates for the Manzano herd were relatively stable, although very low for several years and the herd was augmented with transplanted bighorn sheep from the Pecos Wilderness (1997) and Wheeler Peak (2012) areas (Goldstein and Rominger 2013). Approximately half of the sheep transplanted in 2012 died between 2012 and 2013 (Goldstein and Rominger 2013; criteria #3). Rocky Mountain Bighorn Sheep use a variety of habitats but require rocky outcrops and cliffs for escape from predators and lambing; these escape habitats are overgrown in many areas and therefore rare (Tesky 1993; criteria #1). This species feeds on forbs and shrubs located near these rocky areas, and management actions including prescribed fire, or tree thinning is needed to improve movement corridors, escape routes, and reduce predation is difficult in the Manzano Mountain Wilderness (Tesky 1993; criteria #2). The current rate of these activities is not high enough to improve habitat given ongoing vegetation encroachment.

The Northern Goshawk (*Accipiter gentilis*) is a forest habitat generalist that uses a wide variety of forest ages, structural conditions and successional stages, most of which are departed from reference because of fire suppression activities and in some cases, stand-replacing fire (Reynolds et al. 1992, Reynolds and Squires 1997; criteria #2). This species can be found Mt. Taylor, Magdalena, Mountainair, and Sandia RDs where post-fledgling family areas (PFAs) are identified and managed. Several of these PFAs have been lost of abandoned because of stand-replacing fires and annual monitoring within the plan area has documented this decline (USFS Cibola 2012; criteria #3).

Burrowing Owls (*Athene cunicularia hypugaea*) are known to grassland habitats on Magdalena and Sandia RDs. They nest and roost in recently abandoned burrows dug by mammals including ground squirrels, prairie dogs, and badgers; these burrows may soon become unsuitable for nesting (Green and Anthony 1989; criteria #1). For this reason, viability of Burrowing Owls is inextricably linked to that of burrowing mammals including prairie dogs. Threats to this species on the Cibola include threats to burrowing mammals, such as Gunnison's Prairie Dogs, recreational shooting and sylvatic plague (Finch 1992, USFS 2013; criteria #2).

Juniper Titmouse (*Baeolophus ridgwayi*) have been recorded on Mt. Taylor, Magdalena, Mountainair, and Sandia RDs. They can be found in nearly all habitats that include juniper and prefer those with a mature, high juniper overstory. They nest in natural cavities or abandoned woodpecker holes and feed on insects and spiders during summer months and seeds and berries during the winter (Cicero 2000). Cavity use for night roosting in winter increases fasting endurance and may be critical to annual survival. These cavities have become limited because of a lack of older trees with decadent features and the loss of snags from activities such as firewood collection in some areas (Cicero 2000; criteria #1). Declines have been recorded on 4 of the 7 currently active USGS Breeding Bird Survey routes on the Cibola (Sauer et al. 2012; criteria #3). The main threats to Juniper Titmouse are loss of mature and senescent trees in pinyon-juniper habitat (which provide nesting cavities), potentially linked to firewood removal, lack of integrated planned woodland thinning and tree removal efforts, including the removal of dead or dying trees (Cicero 2000; criteria #2).

Red-faced Warbler (*Cardellina rubrifrons*) is a short-distance migrant that has been documented on Magdalena and Sandia RDs where they are found in ponderosa pine, dry mixed conifer, and riparian habitats. They primarily eat insects which they glean from the foliage of trees. Areas on the Cibola where Red-faced Warblers have been documented are at the northern limit of this specie's range (Martin and Barber 1995; criteria #1). Red-faced Warblers nest on the ground in a small hole or scrape (frequently sheltered by downed wood, rock, or clump of grass) and are sensitive to any timber harvesting activities, including selective management (Martin and Barber 1995; criteria #2). Because of this specie's reliance on Ponderosa Pine Forest and Mixed Conifer-Frequent Fire ERUs, and because these ERUs are where much silvicultural activity takes place (Figure 23) they are at risk on the Cibola.

Grace's Warbler (*Dendroica graciae*) is a diurnal songbird known to Mt. Taylor, Magdalena, Mountainair, and Sandia RDs. This species uses the upper canopy layer of late seral mixed conifer and ponderosa pine forests; habitats which are rare because they departed from reference because of disrupted fire regimes (Stacier and Guzy 2002; criteria #1). Declines have been recorded on 4 of the 7 currently active USGS Breeding Bird Survey routes on the Cibola (Sauer et al. 2012; criteria #3). Because of its specific habitat requirements, the species is threatened by continuing habitat loss associated with vegetation management projects, fire suppression and stand-replacing fires which can result (criteria #2). While current science on vegetation management in frequent fire forests such as ponderosa pine and mixed conifer includes management recommendations to avoid thinning old tree groups and increase large tree recruitment, it also recommends avoiding arbitrary constraints such as diameter limits for tree cutting and increasing open grass-forb-shrub interspaces thereby decreasing the amount of forested areas (Reynolds et al. 2013).

American Peregrine Falcon (*Falco peregrinus anatum*) is known to Mt. Taylor, Magdalena, Mountainair, and Sandia RDs where it nests in cliffs and rock outcrops (criteria #1). Threats include disturbance from recreation, especially rock climbers (White et al. 2002; criteria #2). Of the known eyries on the Cibola National Forest, about a quarter are monitored each year; of those monitored most recently most were abandoned or failed to fledge any young (USFS Cibola 2012; criteria #3).

Loggerhead Shrike (*Lanius ludovicianus*) are known to Mt. Taylor, Magdalena, Mountainair, and Sandia RDs. This species uses a variety of shrubland and grassland habitats (criteria #1) where it preys on insects and small vertebrates (Yosef 1996). Wherever it is encountered on USGS Breeding Bird Survey routes on the Cibola the trend is declining (criteria #3). Threats on the Cibola likely include loss of grasslands used for foraging due to unmanaged grazing and shrub encroachment in these habitats (Yosef 1996; criteria #2). While pesticides are not applied on the Cibola, declines in Loggerhead Shrike populations elsewhere have been linked to consumption of contaminated prey (Anderson and Duzan 1978).

Lewis's Woodpecker (*Melanerpes lewis*) have been recorded on Mt. Taylor, Mountainair, and Sandia RDs. They can be found in mixed conifer, ponderosa pine, and riparian habitats where they rely on large snags for nesting (criteria #1). The species also prefers recently burned to moderately recently burned areas (Vierling et al. 2013). Diet varies by season and includes free-living insects, fruit, acorns, and other nuts (Vierling et al. 2013). Acorns and other nuts are typically cached in standing snags. Threats on the Cibola include processes that result in permanent loss of large snags such as fire suppression that has led to dense forest dominated by smaller trees and does not allow for the recruitment of new snags (Vierling et al. 2013), or stand-replacing fire that destroys all snags, or grazing that results in a degradation of riparian habitat (criteria #2). See the description of Arizona Myotis, above, for more discussion of snags. These changes may have led to increased reliance on riparian cottonwood forests for breeding, which account for less than one half of one percent of the Cibola (criteria #1). Wherever the Lewis's Woodpecker is encountered on USGS Breeding Bird Survey routes on the Cibola, they are declining (Sauer et al. 2012; criteria #3) and have not been sighted on the Forest since 2007.

Bendire's Thrasher (*Toxostoma bendirei*) have been observed on Magdalena and Sandia RDs where they inhabit shrub and scrub habitats which are rare and make up less than 5% of the plan area (criteria #1). This species prefers open desert and grasslands where it forages for insects in the soil. Threats may include loss of suitable habitat caused by shrub encroachment (England and Laudenslayer, Jr. 1993). Where it is encountered on Breeding Bird Survey routes on the Cibola, the species is declining and has not been observed since 2008 (Sauer et al. 2012: criteria #3).

Gray Vireo (*Vireo vicinior*) is a short-distant migrant which can be found on Mt. Taylor, Magdalena, Mountainair, and Sandia RDs where it inhabits juniper grassland and mountain mahogany shrublands in rocky hills. Primary threats to Gray Vireos are the loss or alteration of suitable nesting habitat and wintering habitat, possibly by firewood collecting (Barlow et al. 1999; criteria #2). They have also been observed in areas with tall, herbaceous vegetation which suggests that recently grazed areas may not be suitable habitat (criteria #2). There is also some evidence to suggest that nest parasitism by Brown-headed Cowbirds, which often occur in higher densities where livestock graze, also threaten Gray Vireos (Barlow et al. 1999) Gray Vireos are also subject to disturbance prior to incubation, when discovery of the nest by humans or other wildlife (primarily jays) could lead to abandonment of the site and delay nesting.

Northern Leopard Frog (*Rana pipiens*) are found on Mt. Taylor RD. This aquatic species requires springs, slow streams, or other perennial water for habitat for overwintering; during warmer months they may be found in wet meadows or other habitats near standing water and these habitats are extremely limited on the Cibola (criteria #1). Current threats include degradation of these habitats caused by grazing, poor road management or other activities that alter hydrology, and disease including chytrid fungus (Christman 2010, Finch 1992; criteria #2). This species is known to have disappeared from parts of its historical range on Mt. Taylor RD (Christman 2010; criteria #3).

Dumont's Fairy Shrimp (*Streptocephalus henridumontis*) is a recently described species known to only a few locations including two dirt stock tanks on Mt. Taylor RD, but are assumed to have been common in vernal pools, seasonal/ephemeral wetlands, and wet meadows, which are all rare habitats (criteria #1). Threats include anything that would alter surface water flow patterns at wet meadows or other parts of its current habitat such as stock tank maintenance, degradation caused by grazing, or poor road management (Lang 2002; criteria #2).

Sandia Alumroot (*Heuchera pulchella*) is known to Mountainair and Sandia RDs where it is limited to limestone cliff habitats along the crests of both the Manzano and Sandia Mountain ranges (criteria #1). It is locally abundant where it occurs but its very limited distribution makes it sensitive to recreation (specifically trampling by hang gliders, rock climbers, NMRTC 1999; criteria #2).

Additional threats for special habitat features used by potential SCC and federally listed are presented in (Table 53).

Table 53. Primary threats to special habitat features and their associated species. *Denotes federally listed species; all others are potential SCC.

Habitat Feature	Primary Threats	Associated Species
Tree features (cavities, snags, leaves, bark, downed logs, leaf or forest litter)	• Fire not only creates but can also consume tree features directly resulting in the loss of nesting, breeding, and roosting habitat. Smoke from fire can displace species and cause direct mortality. • Trampling can cause mortality to individuals occupying leaf litter. • Timber harvest activities may result in direct damage/loss of trees and snags. • Large-scale outbreaks of insects or disease could threaten large areas of habitat.	• Arizona Myotis • Red-faced Warbler • Grace's Warbler • Juniper Titmouse • Lewis's Woodpecker • Mexican Spotted Owl* • Northern Goshawk
Rock Features (Canyons, cliffs,	• Activities including recreational rock climbing, caving, mining, construction	• American Peregrine Falcon • Arizona Myotis

Habitat Feature	Primary Threats	Associated Species
crevices, outcrops)	and vandalism, can disturb or damage habitat. • Removal of surface rock causes direct mortality and damages habitat. • Alterations of the rock surfaces such as removing rock through excavation or rock climbing, can alter the habitat enough to prevent plant establishment. • Trampling of plants in crevices causes direct mortality.	• Mexican Spotted Owl* • Pale Townsend's Big-Eared Bat • Sandia Mountain Alumroot • Zuni Fleabane*
Aquatic Features (Riparian areas, springs, permanent water)	• Groundwater depletion and streamflow diversion, roads, trails, facilities, nonnative plant species and upland species encroachment, uncharacteristic fire in riparian and adjacent areas, mining, or unmanaged herbivory, leads to loss or damage of riparian characteristics. • Disturbance to soil in these areas due to unmanaged herbivory, dispersed camping, or construction activities can decrease plant numbers. • Spring development for livestock or wildlife use decreases water available for local ecosystems and trampling further degrades these areas. • In some places, invasive species can outcompete native species found only in aquatic features.	• Arizona Myotis • Dumont's Fairy Shrimp • Red-faced Warbler • Lewis's Woodpecker • Mexican Spotted Owl* • Southwestern Willow Flycatcher* • Western Yellow-Billed Cuckoo* • Alamosa Springsnail* • Chiricahua Leopard Frog* • Northern Leopard Frog • Zuni Bluehead Sucker*
Meadows, Small Openings, other Grassland Features	• Unmanaged herbivory can change local conditions and invertebrate communities. • Encroachment by woody vegetation eliminates grasses and forbs and decreases the size of these features.	• Loggerhead Shrike • Northern Aplomado Falcon*
Soil Features	• In some places, invasive species can outcompete native species found only in special soil types. • Disturbance to soils from dispersed camping, off-highway vehicle use, unmanaged herbivory, or mining can negatively impact species.	• Red-faced Warbler • Sandia Mountain Alumroot • Zuni Fleabane*

The final product of the Risk Assessment Database are species ratings tables that give a numerical overall risk value to each species for each ERU in each ranger district. These have been averaged to provide a single overall risk value and qualitative ranking for each species and federally recognized species are presented in Table 54 while potential SCC are presented in Table 55. These potential SCC have been found by external entities including the U.S. Fish and Wildlife Service, Region 3 of the U.S. Forest Service, the New Mexico Department of Game and Fish, the New Mexico Department of Forestry, the Navajo Nation, Natural Heritage New Mexico, and others to already be at-risk for extinction. It was further determined that management actions implemented by the Cibola National Forest further threatened these species' persistence on the Cibola. These species, in addition with federally listed species relevant to the plan area (Table 44) will be considered as the Cibola evaluates needs for change to the current Land and Resource Management Plan.

Table 54. Federally recognized species relevant to the Cibola National Forest. The Risk Assessment Database calculates a risk value between 1 and 3. Risk values <1.50 are high, 1.51-2.50 are moderate, and >2.51 are low.

Scientific Name	Common Name	Risk Assessment Value	Overall Risk
Mammals			
Canis lupus baileyi	Mexican Wolf	2.13	Moderate
Birds			
Coccyzus americanus occidentalis	Western Yellow-Billed Cuckoo	2.03	Moderate
Empidonax traillii extimus	Southwestern Willow Flycatcher	2.10	Moderate
Falco femoralis septentrionalis	Northern Aplomado Falcon	2.23	Moderate
Strix occidentalis lucida	Mexican Spotted Owl	2.18	Moderate
Fish			
Catostomus discobolus yarrow	Zuni Bluehead Sucker	1.91	Moderate
Amphibian			
Rana chiricahuensis	Chiricahua Leopard Frog	1.79	Moderate
Invertebrate			
Pseudotryonia alamosae	Alamosa Springsnail	2.11	Moderate
Plant			
Erigeron rhizomatus	Zuni Fleabane	2.40	Moderate

Table 55. Potential list of species of conservation concern for the Cibola National Forest. The Risk Assessment Database calculates a risk value between 1 and 3. Risk values <1.50 are high, 1.51-2.50 are moderate, and >2.51 are low.

Scientific Name	Common Name	Risk Assessment Value	Overall Risk
Mammals			
Corynorhinus townsendii pallescens	Pale Townsend’s Big-Eared Bat	2.09	Moderate
Cynomys gunnisoni	Gunnison’s Prairie Dog	1.96	Moderate
Myotis occultus	Arizona Myotis	2.02	Moderate
Ovis canadensis canadensis	Rocky Mountain Bighorn Sheep	2.07	Moderate
Birds			
Accipiter gentilis	Northern Goshawk	2.11	Moderate
Athene cunicularia hypugaea	Burrowing Owl	2.17	Moderate
Baeolophus ridgwayi	Juniper Titmouse	2.71	Low
Cardellina rubrifrons	Red-faced Warbler	2.20	Moderate
Dendroica graciae	Grace's Warbler	2.52	Low
Falco peregrinus anatum	American Peregrine Falcon	2.10	Moderate
Lanius ludovicianus	Loggerhead Shrike	2.27	Moderate
Melanerpes lewis	Lewis’s Woodpecker	2.24	Moderate
Toxostoma bendirei	Bendire’s Thrasher	2.41	Moderate
Vireo vicinior	Gray Vireo	2.47	Moderate
Amphibian			
Rana pipiens	Northern Leopard Frog	1.78	Moderate
Invertebrate			
Streptocephalus henridumontis	Dumont’s Fairy Shrimp	2.21	Moderate
Plant			
Heuchera pulchella	Sandia Mountain Alumroot	2.30	Moderate

These 17 potential SCC meet the requirements set forth in the proposed directives, FSH 1909.12 and have been linked to current Forest Plan management direction that may be negatively affecting either habitat or populations on the Cibola. Many of these species are also affected by activities outside of the plan area or beyond Forest Service control; it is important to recognize the limits to agency authority and the inherent capability of the plan area. These SCC species, along with the 9 federally recognized species will be considered as the plan revision process moves forward and considers needs for change to the existing Forest Plan. The coarse-filter/fine-filter approach used to assess species will also be carried forward through the next steps. Plan components will be developed to maintain or restore ecological conditions for ecosystem integrity and ecosystem diversity in the plan area. By working toward the goals of ecosystem integrity and ecosystem diversity with connected habitats that can absorb disturbance, it is expected that over time, management would maintain and restore ecological conditions which provide for diversity of plant and animal communities and support the abundance, distribution, and long-term persistence of native species, both those considered common and secure as well as those considered imperiled or vulnerable. In addition, species-specific plan components, the fine-filter approach, will provide for additional specific habitat needs or other ecological conditions for those species that are not met through the coarse-filter approach. The species for which the 2012 planning rule requires fine-filter plan components, when necessary, are federally listed threatened and endangered species, proposed and candidate species, and SCC.

Summary of Conditions, Trends, and Risks

The Cibola is home to hundreds of animal and plant species, some of which are found only on the Cibola, and others for which changing land-use patterns have increased their reliance on Cibola-managed lands. These species provide many ecosystem services: (1) *supporting* services such as nutrient cycling, soil formation and manipulation, primary production, and seed dispersal; (2) r*egulating* services including carbon sequestration, pollination, and erosion control; (3) *provisioning* services such as food, fiber, medicine, and forest products; and (4) *cultural* services including recreation, opportunities for scientific discovery and education, and cultural, intellectual, or spiritual inspiration. The most important drivers of change in ecosystem services are habitat change, climate change, invasive species, overexploitation, and pollution. This chapter focused on at-risk species that occur in the plan area—the ecosystem services provided by these species are decreasing and at risk.

Federally recognized and species of conservation concern were identified and evaluated for the Cibola. A total of 9 federally recognized species (4 endangered) were determined to be relevant to the plan area: 1 mammal, 4 birds, 1 fish, 1 amphibian, 1 invertebrate, and 1 plant. Species of conservation concern were determined following guidance in the proposed directives issued for the 2012 Planning Rule. Wildlife and plant species identified as at-risk by a number of different entities were considered. The species which were ultimately considered to be at risk (1) met the initial requirements, (2) had been documented on the Cibola since 1998, and (3) had the potential to be affected by Forest Service management activities. Historic and current status and future trend for each species population and associated habitat type, as well as any other specific threats either directly to the species or to special habitat features not captured in the habitat analysis, were used to calculate an overall risk assessment for each species. A total of 17 species of conservation concern were determined to be at risk by current Forest Service management activities: 4 mammals, 10 birds, 1 amphibian, 1 invertebrate, and 1 plant.

Key Message

By working toward the goals of ecosystem integrity and ecosystem diversity with connected habitats that can absorb disturbance, it is expected that over time, management would maintain and restore ecological conditions which provide for diversity of plant and animal communities and support the abundance, distribution, and long-term persistence of native species, both those considered common and secure as well as those considered imperiled or vulnerable. In addition, species-specific plan components will provide for additional specific habitat needs or other ecological conditions for those species that are not otherwise met.

Chapter 8. Summary of Primary Ecological Findings: Risks to Ecological Integrity

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

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

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

Vegetation and Related Resources

Vegetation of all ERUs on the Cibola is at risk in all Geographic Areas (Table 56). While the soil resources of most Geographic Areas (GAs) are also at risk (Table 56), these risks primarily reflect factors that directly or indirectly influence, or are influenced by, vegetation or the lack thereof (timber harvest, grazing, fire suppression, uncharacteristic wildfire, erosion). Risks to carbon stocks are also intimately associated with vegetation, although carbon-related measures are largely stable, as are most measures of air quality.

Air is largely influenced by context- or higher-level factors and is minimally influenced by Cibola management activities. Vegetation, soil, and carbon stocks, however, are largely under agency authority and control and influenced at the plan- and local levels. Future consideration should emphasize ecosystem restoration activities that seek to emulate historic plant community structure and fire regimes, and in turn, mitigate the effects of insects and disease and improve soil condition.

Water Resources

Perennial Streams. No perennial streams occur in the Datil Mtns, Magdalena Mtns, and Gallinas Mtns GAs. The risk to perennial streams is high in the Manzano Mtns GA due to the presence of a single perennial stream in that GA. There is a moderate risk for the ecological integrity of perennial streams in the remaining GAs (Table 56). While the perennial streams are rare, they are to some degree distributed across the landscape on these mountain units. In addition, there are perennial streams outside of the plan area which reduces the risk to moderate.

Table 56. Summary of risk by ecological resource and Geographic Area.

LEGEND	Low risk	Moderate risk	High risk	Not Applicable

Ecological Resource	Cibola % of Context	Geographic Area* Mt	Zu	Br	Dt	Mg	Sm	Ga	Mz	Sd
Vegetation	10.0	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk	High risk
Soils	10.0	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	High risk	Moderate risk	Moderate risk	Low risk
Air	2.1	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Carbon	10.0	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Perennial Streams	29.4	Moderate risk	Moderate risk	Moderate risk	Not Applicable	Not Applicable	Moderate risk	Not Applicable	High risk	Moderate risk
Springs	29.4	High risk	High risk	High risk	Moderate risk	Moderate risk	Moderate risk	High risk	High risk	Moderate risk
Groundwater	29.4	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	Low risk	Moderate risk	Moderate risk	High risk
Riparian Areas	29.4	Moderate risk	Moderate risk	High risk	Moderate risk	High risk	Low risk	Not Applicable	High risk	Moderate risk
Watershed	29.4	Moderate risk	Moderate risk	Moderate risk	Low risk	Low risk	Low risk	Moderate risk	Moderate risk	High risk
At-Risk Species	Not Applicable	10	17	7	5	14	16	4	10	14

*Geographic Area abbreviations: Mt (Mt Taylor), Zu (Zuni Mtns), Br (Bear Mtns), Dt (Datil Mtns), Mg (Magdalena Mtns), Sm (San Mateo Mtns), Ga (Gallinas Mtns), Mz (Manzano Mtns), Sd (Sandia Mtns).

Springs. Five mountain units have a high risk to the ecological integrity of springs and four mountain units have a moderate rating (Table 56). Springs are uncommon—they tend to cluster in areas where hydrogeologic conditions are favorable, leading to an uneven distribution across many areas. High risk ratings are largely due to low redundancy combined with non-representative distributions. A more even distribution of springs inside and outside of the plan area leads to a moderate rating.

Riparian Areas. Riparian areas in the Manzano Mtns, Magdalena Mtns, and Bear Mtns GAs have a high risk due to low acres and distribution largely located within the plan area (Table 56). The Sandia Mtns, Mt Taylor, Zuni Mtns, and Datil Mtns GAs have moderate risk ratings due to distributions outside as well as within the plan area. The San Mateo Mtns GA has a good diversity of riparian area located outside and inside the plan area, resulting in a low rating.

Groundwater. The Sandia Mtns GA is at high risk due to the large number of groundwater wells in the plan area and adjacent area (context scale). The Mount Taylor, Zuni Mtns, Datil Mtns, Gallinas Mtns, and Manzano Mtns GAs are at moderate risk because while they have fewer wells in the plan area, they have numerous wells in the adjacent area. The lower numbers of wells in both the plan area and adjacent area result in a low risk in the Bear Mtns, Magdalena Mtns, and San Mateo Mtns GAs (Table 56).

Watersheds. While the risk to the ecological integrity of watersheds in the Datil Mtns, Magdalena Mtns, and San Mateo Mtns GAs is low, the rest of the GAs are at moderate or high risk (Table 56).

Species

Risks to species are largely influenced by vegetation condition (habitat) and trend. There are 17 potential SCC on the Cibola: 4 mammals, 10 birds, 1 amphibian, 1 invertebrate, and 1 plant. This is in addition to 9 federally listed species relevant to the Cibola: 1 mammal, 4 birds, 1 fish, 1amphibian, 1 invertebrate, and 1 plant (Table 1).

Summary of Risks to Ecological Integrity

Patterns of risk. There is no apparent spatial pattern to ecological risk on the Cibola for vegetation, soils, and water resources:

- Vegetation is at high risk in all Geographic Areas (GAs)
- Soils of most GAs are at least moderately at risk
- All GAs are at moderate or high risk for at least two water resources.

Three of the five water resources are at low risk in the San Mateo Mtns GA; however, it is the only GA with an overall high risk for its soil resource—a condition that is vulnerable to negative hydrogeologic impacts like flooding, surface erosion, gullying, and reduced infiltration, percolation, and retention of precipitation water.

A positive correlation exists between the number of at-risk species in a GA and the number of riparian ERUs in a GA.[42] Riparian areas collectively occupy less than one-half of one percent of the Cibola, and this correlation highlights the importance of these rare riparian areas to at-risk species.

Interactions of risk. A negative ecological synergy exists among the current vegetation structure, fire regime, and patch size. Large patches of overstocked stands are extremely vulnerable to insect and disease outbreaks and uncharacteristic stand-replacing wildfire. In the Southwest, wildfire is most common in the dry spring–early summer, followed by heavy monsoon rains in mid- to late summer. Erosion, gullying, and floods occur when these rains fall on large expanses of charred, bare, hydrophobic soil left by wildfire. Moreover, climate change can potentially compound all risks by reducing ecosystem health and the ability to withstand stresses like invasive species, insects, and disease—and in a warmer, drier climate—wildfires may become more frequent and severe, increasing soil erosion and hydrologic degradation and further reducing ecosystem health and increasing risk.

[42] The correlation between at-risk species per GA and the number of riparian ERUs per GA (R^2=0.57) is stronger than the correlation between at-risk species per GA and number of ERUs per GA (R^2=0.45), total acres per GA (R^2=0.37), and total riparian acreage per GA (R^2=0.21).