DESIRED CONDITIONS FOR USE IN FOREST PLAN REVISION IN THE SOUTHWESTERN REGION

Development and Science Basis

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PURPOSE

This document provides background, context, and linkages among forest plans, desired ecosystem conditions (i.e., desired conditions), and restoration objectives. It describes concepts upon which desired conditions are based, summarizes the history and process that prompted the development of desired conditions to guide forest plan revisions, and supplies language specific to Southwestern forest types that is suitable for describing desired conditions during subsequent forest plan revisions.

INTRODUCTION

In an age of accelerating threats to the health and productivity of ecosystems, restoration and maintenance of ecosystem function and resilience should be an integral part of forest management plans. Desired conditions describe attributes and characteristics that comprise structure, function, and composition of resilient systems while providing services that benefit both man and nature. Desired conditions must be developed based on a synthesis of scientific knowledge of the ecology and habitats of component species to an ecosystem: dominant and co-dominant over- and understory plants as well as native and desired non-native wildlife and plant species in a forest type.

Forest Service policy directs that resource management programs address ecological restoration and that restoration be integrated into forest plans. Ecological restoration is a process that assists recovery of resilience and adaptive capacity of ecosystems that have been degraded, damaged, or destroyed. [1] The objective of ecological restoration is to reestablish and retain biodiversity, health and productivity, ecological function, and resilience of National Forest System lands.

Given the importance of restoration in Forest Service policy and that declines in biodiversity resulted largely from human-induced changes to ecosystems during the past century, defining desired conditions that include historical plant and animal habitats arrayed into dynamic landscapes is an ecologically sound approach. Desired conditions should be based on an ecosystem's historical ecology, composition, structure, and landscape pattern, which can be inferred based on historic ranges of variability. It is also necessary to reflect social and economic desires in terms of the services humans expect from ecosystems (Choi et al. 2008). Achieving desired conditions that emphasize ecosystem composition, productivity, structure and function, as well as desired services, will: a) add value to plant and wildlife habitats b) improve hydrologic function and visual quality c) increase availability of wood products and forage d) reduce fire hazards (Fulé et al. 2001), and e) increase resilience to insects, disease, and other stressors such as climate change.

[1] Forest Service Manual 2000 –National Forest Management, Chapter 2020 – Ecological Restoration and Resilience.

In 2008 a multidisciplinary team was established to develop regionally consistent guidance for forest plan revision. The team sought to develop mechanisms to incorporate existing plan management direction for the Mexican spotted owl (MSO), northern goshawk (NOGO), and old-growth forests into the plan revision process. They concluded that the best way to achieve that goal was to develop desired conditions for the relevant set of forest and woodland ecosystems. Ultimately, the desired conditions went further: they established a vision for restoration of species composition, forest structure, and ecological function to address long-term sustainability of forested ecosystems, including habitats for native and desired species. The desired conditions were based on existing science in wildlife ecology, forest ecology, and restoration principles. The intent was for the National Forests in the Southwestern Region to use desired conditions as a basis for collaborating with interested stakeholders while revising forest plans. Local adaptation of desired conditions by individual National Forests was and is encouraged, provided that revisions are based on best available science.

A second multidisciplinary group was convened in 2014 to revisit and update guidance related to desired conditions in light of advances in best available scientific information. Specifically, Reynolds et al. (2013) supplied improved direction relating to historic disturbance regimes, structure, and function in ponderosa pine and dry mixed-conifer forests of the Southwest. The current desired conditions document was also expanded to address a wider array of forest and woodland ecosystems (e.g., pinyon juniper and Madrean woodlands).

FOREST PLAN DESIRED CONDITIONS

Desired conditions are the foundation of forest plan development. They describe the goals and outcomes of forest management and the ecological, social, and economic attributes that a forest can achieve over time. Desired conditions guide the development of future projects and activities and establish a means for determining the consistency of projects with forest plans. Management actions must support the attainment of desired conditions in the forest plan. Desired conditions, together with the other plan components, constitute a framework for sustainability and should clearly articulate management intent over the life of the plan.

Ecosystem-based forest management requires long planning horizons and must therefore incorporate forest dynamics – spatial and temporal changes resulting from vegetation growth and succession and the periodic influence of these by natural and human-caused disturbances such as fire, wind, insects, and tree harvests. Desired conditions include enough detail to determine if, when, and where there is sufficient departure from desired condition to warrant intervention. Ecologically speaking, they describe a desired species composition, structure, landscape pattern and processes in a forest or woodland type. This includes over- and under-story composition and age class distributions, tree densities, size and density of snags and woody debris. Desired conditions also incorporate natural processes such as nutrient cycling, trophic interactions[2], fire, insects, and disease dynamics.

Ecosystem-based desired conditions vary across spatial and temporal scales. Spatially, three scales are defined and applied in this document: landscape, mid-scale, and fine-scale. The temporal scale (e.g., centuries) recognizes the dynamic aspects of vegetation resulting from growth, senescence, succession, and the natural

[2] Trophic interactions are those related to an organism's place in the food web of an ecosystem.

and anthropogenic disturbances that periodically influence these processes. Given these dynamics, desired conditions describe how landscape mosaics of vegetation shift over time.

Forest Service emphasis on desired conditions has increased since the first forest plans were published in the 1980s. The first plans emphasized specific activities and restrictions rather than identifying desired ecological, social, and economic conditions. Current revisions of forest plans emphasize ecological, social, and economic conditions and provide clearer vision of what is to be achieved on the landscape over time.

ECOLOGICAL RESTORATION and THE LINK TO DESIRED CONDITIONS

Ecological restoration is an outcome of managing for desired conditions. Restoration is an intentional activity that initiates or accelerates ecosystem recovery with respect to its health (functional processes, productivity), integrity (species composition, community structure), and sustainability (resistance and resilience to disturbance). The objective of ecological restoration is to reestablish and retain ecological resilience of National Forest System lands. Restoration focuses on reestablishing the composition, structure, pattern, and ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient, and productive under current and future conditions. Restoration may not necessarily return an ecosystem to its former state, because contemporary constraints and conditions can cause it to develop along an altered trajectory (Clewell et al. 2005, US Forest Service GTR 173 2006).

Reference conditions, often characterized by historic range of variability (HRV), provide a scientific basis for understanding forests, and a framework for understanding forest conditions and ecological processes prior to extensive human influence. Reference conditions provide a best estimate of a functional and sustainable system, and are a useful basis for developing desired conditions while accounting for uncertainties (e.g., climate change). That is, restoration looks to ecological history as a means of identifying appropriate desired conditions. Desired conditions use historical ecology within the context of HRV in each vegetation type, in addition to social and economic considerations, as a template for management action. Action is focused on bringing the ecosystem to the desired condition by restoring composition, structure, and function on the same or similar trajectory. The range of natural variability differs across sites, both within and among vegetation types, because landscapes vary widely in soils, elevation, aspect, species composition, structure, and pattern. Historical evidence (old trees, large snags and logs, old stumps) on sites are used to develop desired conditions and guide prescriptions at the site level (Moore et al. 1999, Friederici 2003, Reynolds et al. 2006).

Forest Service policy requires the Regional Forester to establish policy consistent with national policy for ecological restoration, and to provide direction ensuring that ecological restoration is integrated into regional programs and forest plans. The policy must include goals and objectives in strategic plans to maintain the adaptive capacity of ecosystems to achieve desired conditions for National Forest System lands. Southwestern Regional restoration policy[3] includes a strategic action plan for restoring the functionality of ecosystems that directly addresses uncertainty related to climate change and other stressors.

[3] See Forest Service Southwestern Region Strategic Action Plan for Landscape Restoration and Conservation.

RECENT FOREST MANAGEMENT PLANNING DIRECTION SUMMARY

The original 1980s Southwestern forest plans featured management strategies focused on even-aged forest vegetation management. These plans did not include a description of desired forest conditions, but instead contained goals characterized as outputs, such as specifications of how much timber could be removed on a sustained basis given a land unit's capability and allocation emphasis, and standards and guidelines that prescribed how various activities could be conducted to ensure resource protection. The focus of these plans was on the removal of products from the land and, more importantly, the restrictions (standards and guidelines) to be followed while extracting these products.

Upon completion of original forest plans, concerns related to the population persistence of the Mexican spotted owl (MSO) and northern goshawk (NOGO) precipitated interim direction for management and protection of these species. In 1989, the Southwestern Region developed the first of a series of interim management direction for MSO. Interim directives constrained management activities and identified protective measures for these species; directives did not include desired conditions upon which to focus management. In 1993, the MSO was listed as threatened under the Endangered Species Act by the U.S. Fish and Wildlife Service (FWS) because forest plan management direction prescribed tree cutting practices that led to even-aged forests resulting in a loss of habitat and insufficient protection (FR Vol. 58, No. 49, Tuesday, March 16, 1993:14248). In 1995 the FWS issued the MSO Recovery Plan (amended 2012). The Recovery Plan provided guidance and constraints on forest management activities thought necessary to protect MSO. The plan was based on a "reserve" approach and described protected activity centers (PACs) for conservation of the species. The 1995 Recovery Plan did not account for forest dynamics (change resulting from vegetation establishment and growth, senescence, succession, and natural disturbances), nor habitat sustainability, health, or productivity. The 2012 amended recovery plan better recognizes forest vegetation dynamics, and the threats to MSO habitat posed by uncharacteristically severe fire, but the plan still constrains implementation of full forest restoration strategies in some habitats.

In 1991, the Regional Forester, in an effort to avoid having the NOGO listed under the ESA, commissioned a scientific committee to develop science-based forest management recommendations for protecting NOGO populations. In 1992, the NOGO was added to the Regional Forester's sensitive species list and the scientific committee published Management Recommendations for the NOGO in the Southwestern United States (hereafter "NOGO recommendations", Reynolds et al. 1992). NOGO recommendations were designed to conserve this top predator by accounting for factors limiting their populations: vegetation structures, prey availability, predators, and competitors. The recommendations combined coarse and fine filter[4] approaches to develop desired predator and prey habitats in managed landscapes based on ecologies of the dominant understory and overstory vegetation in three main southwest forest ecosystems: ponderosa pine, mixed-conifer, and spruce-fir. This approach to developing desired conditions was founded on the assumption that a conservation strategy that addresses (1) all stages of a species' life history, (2) physical and biological factors

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[4] A coarse filter approach is a means to ensure adequate distribution and abundance of an array of habitats across a broad landscape, considering historical range of variability and natural disturbance processes in ecosystem. A fine filter approach is a means to evaluate if there is sufficient amount and distribution of habitat for a particular species under the coarse filter approach.

limiting its populations, (3) habitats of other members of its ecological community (especially plants and animals in its food web), and (4) spatial and temporal dynamics of forests it occupies, should be robust to failure[5] (Reynolds et al. 2006). In sum, management recommendations described sets of desired forest conditions based on desired forest species composition, structure, and ecological conditions needed to sustain habitats of NOGO and plants and animals in its food web. As such, the NOGO recommendations represent the first ecosystem-based approach to developing desired conditions in the Southwestern Region.

The NOGO recommendations (Reynolds et al. 1992) received extensive peer review prior to publication from 18 wildlife biologists, forest ecologists, silviculturists, and biometricians (see Reynolds et al. 1992). Following publication, the recommendations received critical review by a panel of animal and forest ecologists assembled by The Wildlife Society and the American Ornithologist's Union (Braun et al. 1996). In June of 1996, all forest plans in the Southwestern Region were amended to add management direction for MSO, NOGO, and old growth using the protective constraints from the MSO Recovery Plan and the desired conditions in the NOGO recommendations. These amendments to the original forest plans established new forest vegetation management direction that is still in effect for all 1980s-era forest plans, (amended in 1996). Amended plans shifted vegetation management direction from even-aged to uneven-aged forest management strategies in dominant Southwestern forest types (e.g., ponderosa pine and much of the mixed conifer[6]). Uneven-aged management develops and maintains forests characterized by variable-aged trees (young to old) arranged in small groups within a matrix of open grass/forb/shrub plant communities that mimic historic conditions. The 1996 forest plan amendments were documented in an Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act.

Shortly after the Southwestern Region adopted the management recommendations in 1996, Long and Smith (2000) reviewed the recommendations in their article, "Restructuring the forest: goshawks and the restoration of Southwestern ponderosa pine." They concluded that "The underlying management strategy, while superficially another example of a narrow, single-species focus, is in fact a coarse filter approach that includes a mosaic of age and structural classes intended to provide habitats and food chains for a broad array of wildlife species, including goshawk prey species. This landscape mosaic will be created and maintained under an uneven-aged silvicultural system intended to approximate the composition, structure and landscape patterns existing in southwestern ponderosa pine forests before fundamental changes in natural disturbance regimes. The recommendations are based on a conceptual framework and a desired future condition with multiple scales."

Following the issuance of the 1996 forest plan amendments, several wildlife conservation groups expressed different interpretations about the habitat preferences of the NOGO. Some claimed that NOGO preferred large landscapes of dense-canopied old forests. On the basis of this belief, The Center for Biological Diversity

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[5] In a statistical sense, robust to failure means the result of an analysis is not sensitive to violations of assumptions; in this case, the analysis is not likely to fail if one or a few of elements in the goshawk/prey/vegetation syntheses are incorrect.

[6] The current MSO Recovery Plan (USDI, 2012): Designates "Protected habitat" -existing nest roost/roost habitat (Protected Activity Centers-PACs) and requires these areas to be managed for mature forest structure; Designates all ponderosa pine-oak and mixed conifer forests as "Recovery habitat," and requires that 10% of ponderosa pine-oak and 25% of mixed conifer forests (per acre basis) be managed for replacement nest/roost habitat (high-density, mature, even-aged structure); For the remainder of the MSO recovery habitat areas (pine-oak and mixed conifer), the recovery plan recommends that forests be managed to promote uneven-aged forest structure.

petitioned the US Fish and Wildlife Service (FWS) several times to list the NOGO under the Endangered Species Act. The FWS, after reviewing the available information, concluded in its June 1998 12-month petition finding that "listing this population as endangered or threatened is not warranted" (FR Vol. 63, No. 124, Monday, June 29, 1998:35183). The Service found that "while goshawks frequently use stands of old growth and mature forest for nesting, overall the species appears to be a forest habitat generalist in terms of the variety and age-classes of forest types it uses to meet its life history requirements."

In 2000, the Center for Biological Diversity filed suit charging that the 1996 Plan Amendment Final EIS (FEIS) did not adequately address opposing viewpoints. Specifically, they claimed that the FEIS failed to discuss or analyze specific scientific studies describing NOGO habitat and foraging needs. The District Court granted summary judgment in favor of the Forest Service in May of 2002 (Center for Biological Diversity and Sierra Club v. Dombeck and Towns CV-00-1711-PHX-RCB, D. AZ). However, the Ninth Circuit Court ruled in 2003 that documentation of the agency's evaluation of opposing scientific viewpoints, which was included in the administrative record, must be contained within the main body of the NEPA document. (Center for Biological Diversity and Sierra Club v. U.S. Forest Service, No.02-16481, 9th Circuit Court opinion No. CV-00-01711-RCB issued 18 November 2003)

In response to the Ninth Circuit Court ruling, the Forest Service in 2006 issued a Final Supplement to the Final EIS for the Amendment of forest plans in Arizona and New Mexico, evaluating and disclosing alternative points of view and scientific perspectives in the NEPA document. This Supplement contained a review of pertinent information concerning habitat management for the NOGO, including 35 scientific papers published prior to and after the 1996 amendment. In the Record of Decision dated June 2006 for this Supplement, the Forest Service reaffirmed the vegetation management direction contained in the 1996 amendment of forest plans, completing another NEPA process.

In 2003, the recommendations received further review by a USDA Forest Service panel in response to a petition submitted under the Federal Data Quality Act (DQA) (Public Law 106-554 § 515) requesting the withdrawal of information disseminated in the NOGO recommendations. The panel upheld the science quality of recommendations (letter, USDA Forest Service 2004) to which the petitioners filed for "reconsideration." The petitioner's reconsideration request was reviewed by a US Department of Agriculture panel, which also affirmed the Forest Service's original panel response and rejected the request for reconsideration (letter, Forest Service 2004). Coincident with the DQA reconsideration petition, the Rocky Mountain Research Station (RMRS) contracted with the Ecological Society of America for three independent reviews of the original point-by-point responses to the original DQA petition. The three reviewers each agreed that the authors' responses were well-founded and factually correct (letter, ESA 2003).

In 2005 the Coronado National Forest and Cibola National Grasslands initiated revision of their land and resource management plans in accordance with National Forest Management Act requirements for periodic plan revision. [7] . In 2006, five additional Arizona National Forests, (Apache-Sitgreaves, Coconino, Kaibab, Prescott and Tonto), also initiated forest plan revision. In 2008, a team was chartered by the Regional Forester to develop regional guidance necessary to achieve consistency in revising forest plans with respect to habitats

[7] The National Forest Management Act (NFMA) calls for plans to be revised from time to time, to incorporate new information, to account for changed national policy and direction, and to address new issues and opportunities. NFMA requires that plan be revised at least every 15years.

of MSO and NOGO, and to old-growth forests. The team concluded that the best way to achieve consistent direction for forest plan revision with respect to these two species, old growth, and new national agency direction to focus on forest restoration, was to develop desired conditions for the relevant set of forest vegetation types. The concept of desired conditions is consistent with the recently revised MSO recovery plan.

SUMMARY OF DESIRED CONDITION DEVELOPMENT AND ANALYSIS

In 2005, the Southwestern Region embarked on forest plan revision on all National Forests and Grasslands. Regional leadership wanted revision of management direction in the 1996 Amendment and the Supplement related to MSO, northern goshawk, and old growth to be addressed in a consistent manner by all National Forests in the region. Regional leadership chartered a team, the MSO/ Goshawk/ Old Growth Working Group[8], to develop consistent regional guidance while retaining flexibility for unit-specific situations. The team included specialists from vegetation, fire/fuels, wildlife/ESA, planning, appeals, silviculture, and research. The charter directed the team to base its guidance on the 1996 Regional Amendment, the MSO/Goshawk Implementation Guide, the Mexican spotted owl Recovery Plan, best available science on forest and wildlife ecology, and recent MSO/goshawk/old growth project-specific plan amendments.

The team met eight times in person beginning in July, 2008, and also held numerous conference calls, in addition to spending significant time in the field. Several meetings included discussions with forest staff regarding challenges in interpreting and implementing plan direction related to these areas. The team also spent time with Dr. William Block, Rocky Mountain Research Station and Leader of the MSO Recovery Team, academics from Northern Arizona University (NAU), and members of the Ecological Restoration Institute, also of NAU. The team decided the best way to address the need for a consistent approach to plan revision in these areas was to develop desired conditions for forested vegetation types, customizable by individual forests to meet their specific circumstances.

The Regional Leadership approved the team's approach for developing desired conditions in November of 2008. Sample draft products were provided for review at the meeting. Draft products for each vegetation type were sent out to the forests for review and comment on several occasions between October 2008 and April 2009. The team reviewed and discussed each comment with the participation of the National Forests and appropriate changes were made. Additional products were developed based on special requests from National Forests to meet unique situations that existed in more than one place across the region. Other comments were solicited from Regional Office specialists in vegetation ecology.

In 2014 the second iteration of the Desired Conditions Working Group held a series of multidisciplinary meetings and completed several rounds of revisions focused on updating and expanding desired conditions guidance in light of advances in best available scientific information.

The desired conditions developed for the forested vegetation types were based on a broad range of scientific publications covering topics including wildlife and forest ecology, restoration principles, economics, and ecosystem services (See References). The team abstracted the desired conditions from both the NOGO management recommendations (Reynolds et al. 1992) and the large body of scientific literature on forest ecology, silvics, succession, restoration and historic range of variability, economics, and ecosystem services;

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[8] See the Workgroup Charter for an outline of the team's direction and purpose as well as team membership.

tempered by social considerations and professional experience of managers. These desired conditions are well-supported by broad-based peer-reviewed science; they are similar to Reference Conditions and fall within the Historic Range of Variability of pre-European settlement southwestern forests prior to the interruption of natural disturbance regimes, tree harvests, and livestock grazing. The desired conditions are designed to: a) promote native plants and animals, forage production, wood products, visual quality, trophic interactions, and ecosystem functionality b) restore or maintain old-growth and hydrological functionc) reduce fire hazards and improve flexibility for appropriate fire management response d) increase resilience to insects, diseases, and climate change, and e) to facilitate ecological adaptation of ecosystems to future threats to biodiversity.

Desired conditions reflect the characteristics necessary to restore and sustain ecosystems including structure, composition, landscape patterns, and processes, and to provide for the habitats of the MSO, NOGO, and other native species. They also provide for abundant and well-distributed old growth as a sustainable forest component and many of the above values.

Desired conditions were developed for the following forest/woodland types:

- Ponderosa Pine Forest (including bunchgrass and Gambel oak subtypes)
- Ponderosa Pine Evergreen Oak (perennial grasses and evergreen shrub subtypes)
- Dry (frequent fire) Mixed Conifer
- Wet (infrequent fire) Mixed Conifer
- Spruce-fir Forest (including lower and upper elevation types)
- Pinyon juniper
    - Pinyon Juniper Grass and Juniper Grass
    - Pinyon Juniper Sagebrush
    - Pinyon Juniper Evergreen Shrub
    - Pinyon Juniper Woodlands (persistent)
- Madrean Woodlands
    - Madrean Pinyon-Oak
    - Madrean Encinal Woodland

An introduction provides the context, including concepts and definitions of terms, in which desired conditions should be construed. This context is provided in the next section titled ‘Desired Condition Concepts’. The glossary of terms is attached at the end of this paper.

The building blocks upon which the desired conditions were based have been through extensive NEPA analysis, in addition to being supported by science. The Region completed an EIS for the NOGO recommendations to be included in the forest plans in 1996. Ten years later, the Region completed an EIS Supplement that considered alternative viewpoints, once again following the NEPA process. (See Historical Summary)

These desired conditions describe how the forested vegetative communities should look and function when restored. They were developed as a starting place to continue the dialogue about desired conditions with the public in the forest plan revision process. The working group understood that local ecological conditions vary across the region and there may be a need to make adjustments to account for unique situations. The desired conditions could not account for all of the social and economic factors that might be unique to different National Forests; such factors should be considered at the Forest level to produce a complete set of desired forest conditions for the revised plan. These desired conditions are intended to be adjusted by the adaptive management process to assure consistency with current science and managerial experiences.

Each National Forest has the flexibility to customize the desired conditions and add to them to meet Forest specific situations as long as the intent of the overall direction is maintained. This is being done through a collaborative public process by each forest during plan revision. Adjustments are being reviewed by team members as appropriate to ensure that incorporated changes are within the bounds of best science.

Finally, seral stage proportions were identified for desired conditions used in planning and are posted on the Southwestern Region's Plan Revision Desired Conditions web site (http://fsweb.r3.fs.fed.us/eap/nfma/working-group/products/desired-conditions). These tables provide quantitative information that reflects the planning desired condition narratives for each forest and woodland type. Seral stage percentages represent the approximate mid-point of the conditions expressed in the narratives, and are used primarily to compute overall ecosystem departure (see *R3 Seral State Proportions Supplement* for further guidance).

SUMMARY OF THE SCIENCE: FOREST ECOLOGY

Note: This paper emphasizes the scientific information available on forest ecology. There is a significant body of literature and scientific knowledge on the ponderosa pine and dry mixed conifer forest types; there is much less information available, on other forest and woodland types. The differences in available information are clear in this paper. In addition, most forest vegetation management activities in the Southwestern Region are conducted in ponderosa pine and dry mixed conifer types as opposed to wet mixed conifer and spruce fir types. The latter two types occur primarily on steeper slopes, which limits management to a significant degree. Wet mixed conifer on steeper slopes is often managed for MSO replacement nest/roost habitat, which further limits management options. Hence the emphasis on ponderosa pine and dry mixed conifer forest types in this section.

ERUs: Ecological Classification

The forested vegetation types for which desired conditions were developed were based on Ecological Response Units (ERUs). ERUs represent an ecosystem stratification based on vegetation characteristics that would occur when natural disturbance regimes and biological processes prevail (TNC 2006), and combine potential vegetation and historic fire regimes to form ecosystem classes useful for landscape assessment. Technical ERU descriptions were developed to assist in the analysis of ecological sustainability for plan revision (Wahlberg et al. 2014). The vegetation types used in describing desired conditions were based on these technical ERU descriptions, but were written in more general terms for ease of understanding.

Mixed Conifer Forest Classification

Historical mixed conifer forests were typically uneven-aged, and tree spatial patterns varied from open and clumped to moderately-sized homogeneous patches. Density ranged from open to moderately dense. The warmer/drier mixed conifer forest types experienced more frequent fire intervals and were typically uneven-aged, growing in a patchy structure, containing fewer trees per acre than existing stands, and experienced relatively frequent low- to moderate-severity fire, similar to ponderosa pine forests. The cooler/wetter mixed conifer forest types historically experienced less frequent, mixed-severity fire, resulting in larger patches of homogeneous tree ages, and higher patch density overall (Smith 2006, Romme 2009, Fule and Laughlin 2007, Reynolds et al. 2013). Due to the frequent disturbance regime, historical species composition in the warmer/dryer mixed conifer forests was dominated by fire resistant, shade-intolerant conifer species such as ponderosa pine, southwestern white pine and Douglas-fir. Shade tolerant species were historically absent or present as a minor stand component on the drier sites such as ridge tops and southwest-facing slopes, with more abundant but still subdominant representation on cooler, wetter, north-facing slopes (Reynolds et al. 2013, also see Table 1 and Figure 3).

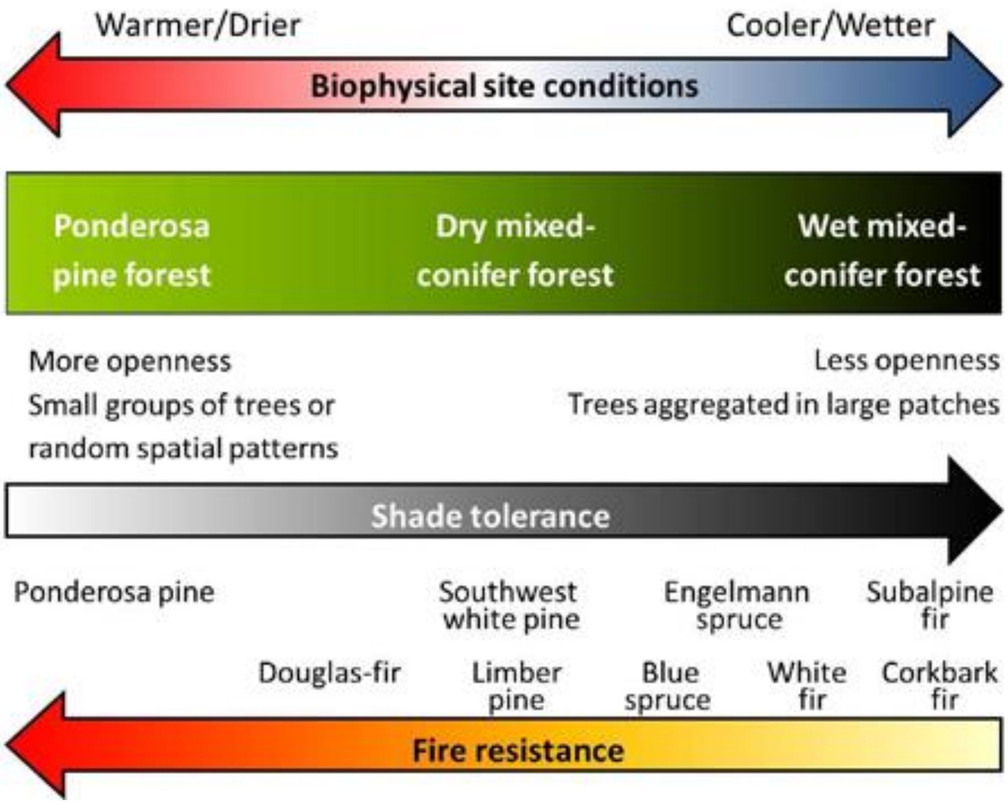


Figure 3. *Dry mixed-conifer forests occupy the ecological gradient from warm/dry to cool/wet biophysical site conditions. Dry mixed-conifer is not a homogenous type, intergrading with ponderosa pine forest on warm/dry sites and wet mixed conifer forests on cool/wet sites. Its structure and composition become more similar as it intergrades with adjacent forest. Common tree species in ponderosa pine and mixed-conifer forests also vary in their relative shade and fire tolerance.*

Historic Range of Variability

In every biophysical environment, natural disturbances such as fire, insects, disease, wind, etc. have measurable patterns related to the type, frequency, intensity, and spatial scale of each disturbance. The characteristic pattern of variability in the effects of disturbance on vegetation over time constitutes the historical range of variability (HRV). The temporal and spatial variability in disturbance regimes define the range of forest species composition, structure, and landscape patterns. The ability of an ecosystem to absorb and recover from disturbances without drastic alteration of its inherent function is central to the concept of HRV. In the southwestern US, fire is a primary disturbance agent and fire regimes are central to understanding HRV as it relates composition, structure, and pattern in various forest types (Fulé et al. 2003). A general description of fire regimes and ecological characteristics by forest type is displayed in Table 1. A more current synthesis of the science relative to the historic range of variability for ponderosa pine and dry mixed conifer forests is summarized by Reynolds et al. (2013).

Table 1. Historic Disturbance Regimes of Southwestern Forests and Woodlands

Forest Type	**Fire Regime [1, 2, 3, 4]**	**Fire Type [5]**	**Forest Structure**	**Seral Species**	**Climax Species**
Ponderosa PineForest (and sub-types)	frequent/ low severity 2-24 years (regime I)	surface (common) mixed (rare)	uneven-aged, grouped, open	ponderosa pine	ponderosa pine
Dry Mixed Conifer/Frequent Fire (warmer/drier)	frequent/ low severity 2-24 years (regime I) Fire Regime III 35-200 years moderate severity	surface (common) mixed (infrequent)	uneven-aged, grouped, open occasional even-aged patches	dominant - ponderosa pine subdominant - aspen and/or oak (sub-stand scale patches)	fire dis-climax historic condition-shade intolerant species: dominant – ponderosa pine; subdominant - Douglas-fir, Southwestern white pine or limber pine
Wet Mixed Conifer/ Infrequent Fire (cooler/wetter)	relatively infrequent/ mod-high severity variable, 22-150 yrs. (regime III, IV)	mixed (common) stand-replacing (rare)	even-aged, patched, closed even-aged, closed	dominant – aspen or Douglas-fir, depending upon plant association habitat type	shade tolerant species, depending upon plant association habitat type: white fir, blue spruce
Spruce-Fir Forest (mixed, lower sub-alpine)	infrequent/ mod-high severity 150-400 yrs. (regime III, IV)	mixed/stand-replacing	even-aged, closed	dominant – aspen or Douglas-fir, depending upon plant association habitat type	shade tolerant species, depending upon plant association habitat type: Engelmann spruce, white fir
Spruce-Fir Forest (upper sub-alpine)	infrequent/ high severity 150-400 yrs. (regime IV, V)	stand-replacing	even-aged, closed	dominant – aspen, Douglas-fir or Engelmann spruce, depending upon plant association habitat type	shade tolerant species: Engelmann spruce and corkbark or sub-alpine fir co-dominate

Forest Type	Fire Regime [1, 2, 3, 4]	Fire Type [5]	Forest Structure	Seral Species	Climax Species
Madrean Woodlands (Madrean Pinyon-Oak, Madrean Encinal Woodland)	Fire Regime I 0-35 years low severity Fire Regime III 35-200 years moderate severity	surface (common) mixed (infrequent)	uneven-aged, grouped, open occasional even-aged patches	dominant – evergreen oak trees, pinyons and Chihuahua pine (in Madrean Pinyon-Oak), alligator juniper, oneseed juniper	shade intolerant species: evergreen oak trees, border pinyon, twoneedle pinyon
Pinyon-Juniper Grass and Juniper Grass	Fire Regime I 0-35 years low severity	surface (common)	uneven-aged, grouped, open	dominant – juniper and pinyons	shade intolerant species, juniper and pinyons
Pinyon-Juniper Sagebrush	Fire Regime III 35-200 years moderate severity Fire Regime V 200+ years high severity	mixed (infrequent) stand-replacing	even-aged, moderately open	dominant – juniper and pinyons	shade intolerant species, juniper and pinyons
Pinyon-Juniper Evergreen Shrub	Fire Regime III 35-200 years moderate severity Fire Regime IV 35-200+ years high severity	mixed (infrequent) stand-replacing	even-aged, moderately open	dominant – juniper and pinyons	shade intolerant species, juniper, pinyons, evergreen oaks
Pinyon-Juniper Woodland	Fire Regime III 35-200 years moderate severity Fire Regime V 200+ years high severity	mixed (infrequent) stand-replacing	even-aged, closed	dominant – juniper and pinyons	shade intolerant species, juniper and pinyons

[1]Brown and Wu 2005 ; [2]Kaufman et al. 1998; [3]Schussman et al. 2006; [4]Swetnam and Baisan 1996.
[5]Historical Range of Variation and State and Transition Modeling of Historic and Current Landscape Conditions for Ecological Response Units of the Southwest (Wahlberg et al. 2014). The Nature Conservancy: Southwest Forest Assessment Project. 2006.

Ponderosa Pine Forest and Dry Mixed Conifer HRV

An integration of information on the ecology of forest vegetation is essential for developing and sustaining desired forest conditions. There is a wealth of information on ecosystem characteristics available for guiding the development of desired conditions. This information includes descriptions of forest conditions by early explorers (Beale 1858, Wheeler 1875, Dutton 1882, Leopold 1924), early scientists (Lieberg et al. 1904, Plummer 1904, Woolsey 1911, Pearson 1950), vegetation classifications (e.g., USDA 1997a), forest vegetation simulations (e.g., Youtz and Vandendriesche, 2012), natural area and old growth studies (e.g., White 1985, Pearson 1950, reviewed in Reynolds et al. 2013), fire histories (reviewed in Reynolds and et al. 2013), and wildland fuel management strategies (e.g., Haig et al. 1941, Pearson 1950, Daubenmire and Daubenmire 1968, Fulé et al. 1997, Reinhardt and Crookston 2003, Graham et al. 2004). This information provides reality checks that increase the likelihood that the desired conditions can be attained and sustained. Sustaining the desired landscape mix of plant and animal habitats over space and time requires the incorporation of the spatial and temporal dynamics of vegetation. Vegetation dynamics, including the establishment, development, senescence, and its composition, structure, and pattern, can be estimated and modeled (see Oliver and Larson 1990, Reynolds et al. 1992, Franklin et al. 2002, Reinhardt and Crookston 2003). An example of the incorporation of dynamics in sustaining the maximum amount of mature and old trees in Southwestern forests can be achieved with about 20% of a landscape in grasses, forbs, seedlings, and saplings, 20% in young forest, 20% in mid-aged forest, 20% in mature forest, and 20% in old forest (Reynolds et al. 1992). These proportions reflect forest development from cohort establishment through canopy closure to old forests. Figure 2 shows the different age classes of a developing group or patch of trees.

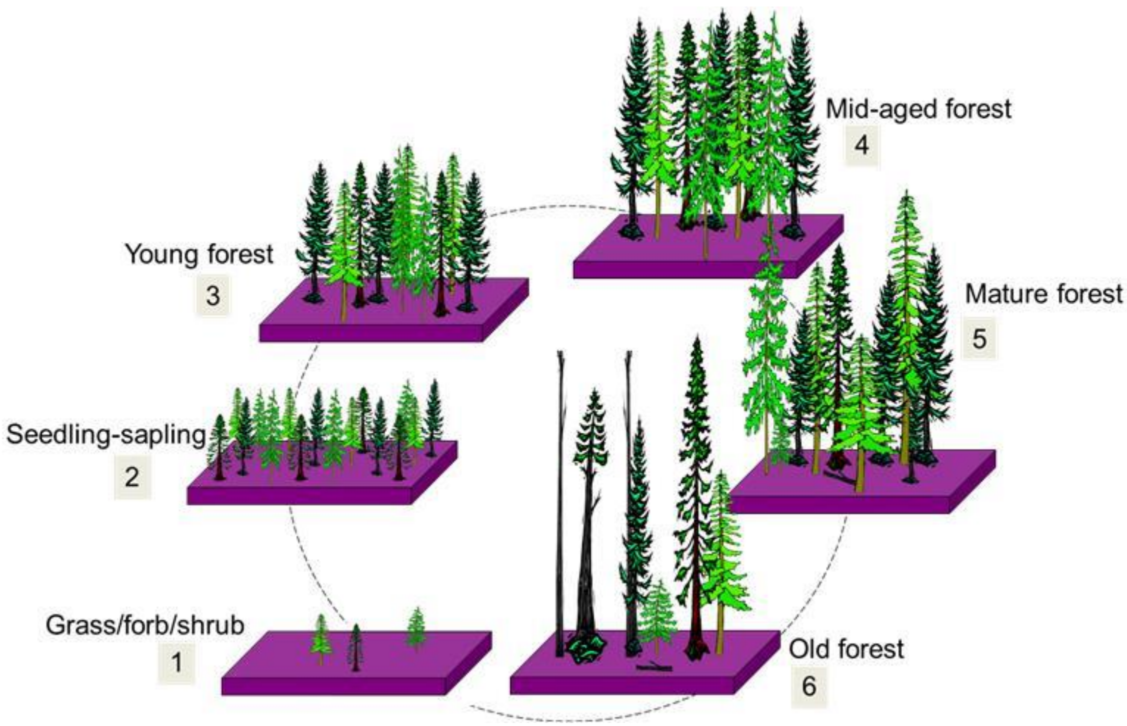


Figure 2: Vegetation Structural Stages - Growth of Trees

Extensive research has demonstrated that current ponderosa pine forests of the Southwest are greatly altered in terms of forest structure, density and ecological function. Most pine forests are at much higher risk of high intensity and severity fire than they were prior to Euro-American settlement (Covington 1993, Moore et al. 1999). A century ago the pine forests had widely-spaced large trees, often occurring in small groups, with a more open, herbaceous forest floor (Cooper 1960, Pearson 1950, White 1985, Reynolds et al. 2013). These conditions were maintained by fairly frequent low-intensity surface fires that did not kill the large trees (Dieterich 1980, Weaver 1951, Fiedler et al. 1996). These fires occurred every 2 to 24 years and maintained an open canopy structure (Moir et al. 1997, Reynolds et al. 2013). The herbaceous understory and fine fuels (needles, limbs) falling from older trees fueled frequent fires started by lightning, and thinned and/or eliminated thickets of small trees keeping the forest open and park-like (Cooper 1960, Allen et al. 2002, Reynolds et al. 2013). In his 1911 report, Woolsey (USFS Assistant District Forester, District [Region] 3) reported on the general character of ponderosa pine forests, Woolsey noted;

> *"The typical western yellow (ponderosa) pine forest of the Southwest is a pure park-like stand made up of scattered groups of from 2 to 20 trees, usually connected by scattering individuals.*

Openings are frequent and vary in size. Because of the open character of the stand and the fire-resisting bark, often 3 inches thick, the actual loss in yellow (ponderosa) pine by fire is less than with other more gregarious species. A crown fire in mature timber is almost unheard of, and in a ground fire in the virgin forest young saplings often escape complete destruction, though with a fair wind and on a steep slope destruction of seedlings and saplings is often complete…In June 1910, a fire occurred on the Gila, Datil and Apache National Forests which burned over about 60 square miles. The area burned was steep and rocky, with an unusual quantity of dry forage. An investigation showed that injury to the yellow (ponderosa) pine was confined very largely to the reproduction. On the area as a whole, from 40 to 50 percent of the seedlings were killed (Woolsey 1911)."

A local reference condition was estimated as 23-56 trees per acre on the Fort Valley Experimental Forest, near Flagstaff, Arizona (Covington 1993). One recent study reported that on permanent plots located throughout southwestern ponderosa pine forests, re-measurements conducted during 1997-1999 show that average trees per acre have increased by up to 33-fold since the plots were established in 1909-1913 (Moore et al. 2004). On the Long Valley Experimental Forest (sedimentary soils on the Mogollon Rim, central Arizona), the sampled trees per acre (1938) ranged up to 99 trees per acre, with an estimated 75 trees per acre being present prior to the cessation of frequent fire (circa 1880-1900, USDA Forest Service, unpublished data from Long Valley Experimental Forest). Table 2 displays a summary of ranges of historic conditions based on many studies from localities throughout the greater southwestern U.S.

Table 2. Range of reference conditions for ponderosa pine and dry mixed-conifer forests in the Southwestern United States (adapted from Reynolds et al. 2013).

	Reference conditions by forest type	
Forest attribute	Ponderosa pine	Dry mixed-conifer[b]
Trees / acre	11.7-124	20.9-99.4
Basal area (ft^2 / acre)	22.1-89.3	39.6-124
Openness (%)[a]	52-90	78.5-87.1
Openness on sites with strong tree aggregation (%)[a]	70-90	79-87
Spatial patterns	grouped or random	grouped or random
Number of trees / group	2-72	insufficient data
Size of groups (acres)	0.003-0.72	insufficient data
Number of groups / acre	6-7	insufficient data
Snags / acre	1-10	≥ ponderosa pine forests
Logs / acre	2-20	≥ ponderosa pine forests

[a]Openness is the proportion of area not covered by tree crowns, estimated as the inverse of canopy cover.
[b]Limited number of studies available. Ranges may expand based on additional studies.

Southwestern Old Growth Defined

Old-growth forests provide many ecosystem services-- plant and animal habitat, high-quality wood products, carbon sequestration, hydrologic function, esthetics, and spiritual values. There are many definitions and synonyms for old growth, but all commonly refer to tree age (mature, old), tree size (large), tree decadence (some), and structural features. Common synonyms for old growth are relic, climax, late-successional, ancient, legacy, primary, primeval, pristine, and virgin. Some define old growth as the climax or late-successional stage of forest development (Helms 2004). These definitions, however, ignore the old stages in early successional forests such as in quaking aspen stands that are successional to climax spruce-fir forests. An ecological understanding of old growth requires a perspective that includes multiple spatial and temporal scales, ranging from individual trees, to stands, to regions, and across forest types. While the structural and ecological definitions of old growth were first developed in the coastal Pacific Northwest (Franklin et al. 1981, Er and Innes 2003), those particular definitions do not work for most forests in other ecological settings. This is because there are substantial differences in the species compositions, tree longevities, sizes, densities, and variations in the types, intensities, and frequencies of natural disturbances across forest types (Harmon et al. 1986). These biological and ecological factors result in different tree structures, densities, distributions, and landscape patterns when a forest type is in its old stage. Because of the complex and dynamic nature of forests, efforts to conserve biodiversity by providing old growth in landscapes must take into account all developmental stages, not just old growth (Spies 2004).

A controversy regarding the definition of old growth concerns whether it must be undisturbed by humans or whether there can be some level of human modification. To some, old growth is a forest that simply has not been disturbed by logging. To others it can be a forest containing old trees and otherwise *resembles* the composition and structure of a particular forest type before interruption of its associated natural disturbances and other human induced changes. Nonetheless, from an ecosystem function viewpoint there may be little difference between a completely undisturbed old-growth forest (rare indeed in the 21st century) and a previously disturbed but fully restored old-growth forest. The point here is that even though social values are at the heart of many old growth controversies, ecological perspectives must be taken into account if new policies are to lead to successful management for creating and sustaining old growth (Spies 2004). After all, at its most fundamental level, old growth is the product of structures and processes associated with the maturation and senescence of a population of trees (Spies 2004). While past strategies for protecting old growth created reserves of existing old trees, many of these reserves in the Southwest are degraded. Degradation of old growth reserves is an outcome of the persistent interruption of frequent low severity fires that historically typified Southwestern forests. To reverse this degradation, long-term management strategies are needed to develop dynamic landscape populations of old growth that are able to withstand wildfire, parasites, diseases, human disturbances, and climate change. Desired forest conditions that include all tree age classes and are based on forest restoration principles and objectives are such a strategy.

Definitive characteristics of old growth in the Southwest vary by forest type. This is because the tree species composition, their longevities, sizes, and densities combined with the types, intensities, and frequencies of natural disturbances vary by forest type (Harmon et al. 1986). In general, the defining old-growth characteristics in the Southwest (Table 3) can be partitioned into forest conditions resulting from three different types of fire severity and frequency: (1) forests distinguished by frequent, low severity fires that result in fine-scale groups of trees interspersed within a grass/forb/shrub matrix--ponderosa pine and dry mixed conifer are frequent fire forests, and (2) forests distinguished by an infrequent mixed-severity fire regime, and (3) forests distinguished by a very infrequent high severity fire regime. A mixed-severity regime is characterized by infrequent high severity, stand replacing fires mixed with more frequent smaller scale surface fires. Mixed-severity fire regimes typically have moderate-to-large and sometimes distinctive patches of forests reflecting patches burned infrequently at different times and more frequent smaller scale surface fires within the larger patches (Grissimo-Mayer et al. 1995, Fulé et al. 2003)--wet mixed conifer and spruce-fir (lower sub-alpine) forests, and pinyon-juniper woodlands are mixed-severity fire forests. The upper sub-alpine spruce-fir forests are characterized by a very infrequent high-severity fire regime.

Table 3. Essential structural features of old growth in fire-adapted forests.
Whether or not a feature is essential may depend on scale (clump/gap, stand, or landscape). For example, age variability is likely at a landscape scale, and snags and large dead and downed fuels may not exist in some patches (adapted from Kaufmann et al. 2007).

Structural feature	**Essential Structural Feature?**	**Comment**
Large trees	No	Tree size depends on species and site characteristics (moisture, soils, and competition). Young trees may be large, and old trees may be small.
Old trees	Yes	Trees develop unique structural characteristics when old (e.g., dead tops, flattened crowns, branching characteristics, bark color and texture.
Age variability	No	An important feature in some old-growth forest types. Some forests regenerate episodically (even-aged) with most trees establishing in a few years to a decade, probably in conjunction with wet years and large seed crops, and in concurrence with relatively long intervals between fires. Others may regenerate over decades (uneven-aged).
Snags and large dead and downed fuels	Yes	Snags and large logs are essential for old growth, but forests with more frequent fires may have fewer logs. Densities and sizes of snags and logs vary depending on forest type, precipitation, and other factors. Snags, logs, and woody debris typically distributed unevenly in landscapes.
Structural variability	Yes	Both vertical and horizontal variability are critical features of old growth. At broader scales, structure can also be characterized by variability within and among patches. Proportions of patches in different developmental stages of forest succession are also important.

Frequent-fire forests are less dense and have fewer logs and woody debris under the canopy than infrequent-fire forests. For example, a hectare (ha) (1 hectare = 2.47 acres) of old-growth forest might have 15 patches of trees, with each patch covering about 0.05 ha (0.12 ac). Tree canopies cover about 30-70% (depending on forest type and site quality) of an area with grass/forb/shrub interspaces comprising the remainder. Old growth in frequent-fire ponderosa pine forests are typically uneven-aged at the fine-scale (Meyer 1934, Weaver 1951); they are composed of small (0.1-0.5 ac) old tree groups interspaced with similar sized groups of younger trees, seedlings to mid-aged (Cooper 1961, Morgan et al. 2002, Harrod et al. 1999). Some early reports on ponderosa pine age structure demonstrated an approximate balance of age classes at the mid-scale (Woolsey 1911, Pearson 1950, Figure 38); such age-balanced old-growth stands were therefore likely self-sustaining at the fine to mid-scales. Old-growth dry mixed-conifer forests resemble the grouped nature of trees in ponderosa pine old growth, but tree groups in the dry mixed conifer are typically composed of multiple tree species (ponderosa pine, white fir, Douglas-fir, aspen, spruce) and tend to have trees of many ages (Kaufmann et al. 2007).

In contrast, mixed and high severity infrequent fire forests, which, because of longer periods between disturbances, are largely driven by plant succession and large-scale disturbances, have overstories in some forest patches dominated by large, old trees with multiple canopy layers formed by younger, smaller trees beneath the upper canopy. Because these forests rarely become very dry and fire is unlikely for greater than 30 years, and up to three or more centuries, large amounts of decaying wood accumulate. Moderate- to high-severity fire over large landscapes tends to structure these forests as even-aged patches with similar characteristics across landscapes, at least in the early post-fire successional stages. Such patches may include fairly similar tree ages and sizes or combinations of ages and sizes, limited amounts of dead and downed material, and dead trees and spike tops, but they can commonly be distinguished from adjacent patches having different characteristics (Brown et al. 2001; Brown and Wu 2005; Fulé et al. 2003, 2009; Grissino-Mayer et al. 1995, 2004; Heinlein et al. 2005).

DEVELOPMENT OF DESIRED CONDITION CONCEPTS

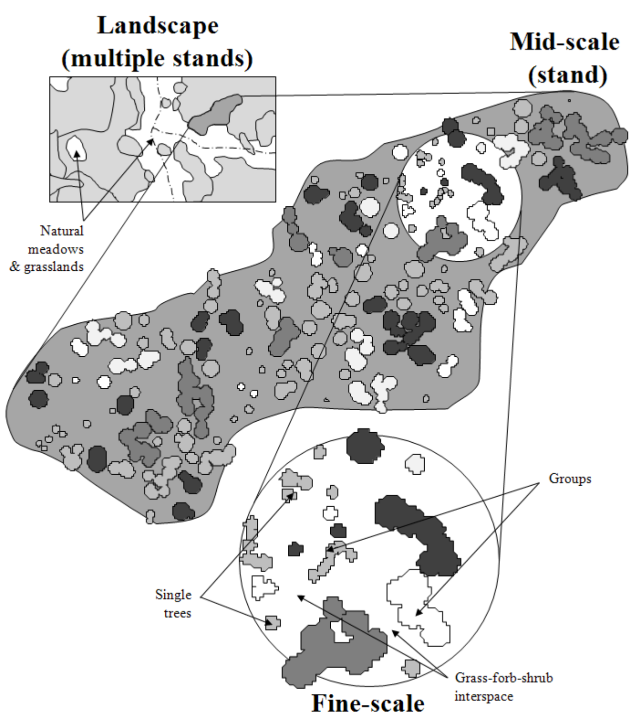
Various concepts and processes were used to develop and describe sets of desired conditions for the forests and woodlands in the Southwest. The interdisciplinary team used best available science to determine historic conditions as a basis for discussions and development of these desired conditions for management planning and projects. Forest ecology, including historical (reference) conditions and the natural range of variability are frequently used to define restoration goals, to estimate the restoration potential of sites, and to evaluate the success of restoration efforts. Natural range of variability is useful for understanding the natural variability in composition, structure, processes, and functions among sites and for understanding the dynamic nature of ecosystems. It is also a useful reference for establishing limits of acceptable change for ecosystem components and processes (Morgan et al. 1994). For ponderosa pine and dry mixed conifer forest ecosystems, much of the cited historic reference conditions and other forest ecology science is found in Reynolds et al. (2013). This science was used to inform discussions; however, the professional judgment of the interdisciplinary team and local Forest unit reviewers was also used to incorporate social, economic, and managerial feasibility considerations into the development of these desired conditions. Therefore, these desired conditions are not intended to re-create specific reference conditions, but rather to guide management goals and objectives towards the development and maintenance of ecologically resilient forest and woodland ecosystems that provide for social objectives in a sustainable manner.

The iterative processes of science review, use and modeling of local resource data (Forest Inventory Analysis and other sources), social considerations and objectives, and managerial perspectives, have resulted in development of these desired conditions. In some instances, the historic range of variability was fully consistent with other management objectives, while in other cases, the full range of historic variability was deemed to be inconsistent with other management objectives. In many cases, the desired conditions described do not represent the full range of historic conditions, but do fall within the historic ranges. In some instances, the lowest-densities of the historic ranges are not desired for local management goals and objectives. For example, very open forest conditions (trees per acre and proportion of area not covered by tree crowns [i.e., openness]) may not meet social (public perceptions, recreation and other desires) and/or economic objectives (timber long-term sustained yield). Also, maintenance of very open, low-density conditions with very frequent fire may not be operationally feasible due to budgetary and workforce constraints, and limited public tolerance for burning and smoke. Specific legal and policy requirements for managing the habitats of threatened, endangered, rare or sensitive species may not be consistent with managing for historic conditions on small local scales. In some instances, the desired conditions describe the lower end of historic ranges for natural fuels such as coarse woody debris, to reduce wildfire hazards to public safety and natural resources loss over a longer timeframe, while compensating for limitations on very frequent burning.

Scale

Desired conditions for each vegetation type are presented at three spatial scales: the landscape scale (1,000-10,000 acres+), mid-scale (10 to 1,000 acres), and fine-scale (<10 acres) (Figure 1). Vegetation descriptions at these scales provide adequate detail and guidance for the design of projects and activities that will help achieve the desired conditions over time. In some cases (i.e., pinyon-juniper vegetation types), not enough science is available to provide descriptions at multiple scales. Descriptions begin with the landscape scale to provide a "big picture" of the desired conditions across the larger land area. Descriptions at the mid- and fine-scales provide additional detail necessary for guiding future projects and activities. The landscape scale is typically composed of variable elevations, slopes, aspects, soils, plant associations, and disturbance processes. A landscape area is comprised of ten or more mid-scale units. The mid-scale is composed of assemblages of fine-scale units which have similar biophysical conditions. The fine-scale is an area in which the species composition, age, structure, and distribution of plants (single, grouped, or aggregates of groups) is described.

Figure 3. Desired conditions at three spatial scales. The landscape scale illustrates multiple stands and natural meadows and grasslands. The mid- and fine-scales illustrate open grass-forb-shrub interspaces and uneven-aged stand conditions consisting of single and grouped trees of different vegetation structural stages, young to old, represented by different shades and sizes (Reynolds et al. 2013).



Ranges

Ranges (minimum, maximum) of values presented in desired conditions were informed by current science for natural variation in the composition and structure within a vegetation type, and tempered by social/economic desires and management experience. Desired conditions vary within a vegetation type due to spatial variability in soils, elevation, or aspect, and to provide managerial flexibility to meet local project objectives. The ranges presented here often represent the upper and lower extremes for a given variable (e.g., the lowest and highest tree densities in a vegetation type). It is important to recognize that the goal is generally to manage toward average desired conditions for a given variable. However, it may be appropriate to have different desired conditions within a vegetation type, such as a lower density of vegetation in the wildland urban interface (WUI) than outside of the WUI to achieve the desired fire behavior in proximity to property and human occupancy.

Forest Structure, Interspaces, and Openness

Forest structure includes both the vertical and horizontal dimensions of a forest. Horizontal structure refers to patterns of trees or groups of trees and interspaces, as well as tree sizes and species composition. Interspaces are areas identified at the fine-scale; they are not currently under tree canopies. They serve to define groups of trees, and to reduce competition between trees. They are generally composed of grass-forb-shrub communities, but could also be areas with scattered rock or exposed mineral soil. Interspaces do not include meadows, grasslands, rock outcroppings, and wetlands (i.e., exclusions adjacent to and sometimes within forested landscapes), which are classified instead as openings. Openings are generally defined at the fine-scale. some openings may be long-term; others will will be regenerated by tree seedlings.

The vertical component refers to layers of vegetation between the forest floor and the top of the canopy. There may be only one layer, or several. Several descriptive terms related to forest structure are used in desired condition statements and are defined in the glossary. Other terms may be defined in more detail in the forest plan.

Resilience

For the purposes of these desired conditions, resilience is used to infer the capacity of a system to rebound from disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks (Walker et al. 2004). Forest types are subject to different disturbance regimes that vary in severity, extent, and frequency; therefore, the capacity for resilience is displayed through responses consistent with that disturbance regime.

DESIRED CONDITIONS BY ERU

While it is not considered necessary, or even desirable in some cases, to mimic historic conditions throughout southwestern forests and woodlands today, the historic range of variability does represent conditions that are more synchronous with the natural disturbance regimes to which ecosystems are adapted. Social, political and economic factors are much different today than a century ago, and there are valid considerations for leaving areas of higher tree density to meet management objectives. But restoration of some portion of the landscape to conditions reminiscent of pre-European settlement times would most likely provide for greater biodiversity, and greater ecosystem productivity, stability and sustainability. Ranges (minimum, maximum) of values presented in desired conditions were informed by current science for natural variation in the composition and structure within a vegetation type, and tempered by social/economic desires and management experience. Desired conditions vary within a vegetation type due to spatial variability in soils, elevation, or aspect, and to provide managerial flexibility to meet local project objectives.

Note: there is a significant body of literature and scientific knowledge on the historic conditions of ponderosa pine and dry mixed conifer forest types, much more so than on other forest and woodland types. For the wet mixed conifer and spruce-fir forests (infrequent fire forest types) the interdisciplinary team assumed that the characteristic fire regime and forest structure has not been highly altered relative to historic conditions; therefore a composite summary of existing conditions derived from southwest-wide FIA plot data was used to classify desired forest characteristics by successional states (USDA Forest Service Southwestern Region, unpublished planning record data). Desired conditions will be updated as more information becomes available.

SPRUCE-FIR FOREST DESIRED CONDITIONS

General Description

The spruce-fir forest vegetation community generally occurs at elevations ranging from approximately 9,500 to 11,500 feet. It is often dominated by Engelmann spruce, but contains other species depending on elevation. The understory commonly includes currants, maples, honeysuckle, common juniper, huckleberry, alpine clover, and sedges. Spruce-fir forests occur on the coldest and highest elevation sites in the Region, with the most precipitation. This forest vegetation community can be subdivided into lower elevation (spruce fir mix) and upper elevation (subalpine spruce-fir) spruce-fir types, with differing fire regimes and subdominant species composition. The lower spruce-fir type typically occurs between 9,500 and 10,500 feet in elevation, while the upper spruce-fir type typically occurs between 10,500 and about 11,500 feet in elevation and is bounded, where present, by the alpine tundra vegetation above 11,500 feet.

Lower elevation spruce-fir resembles wet mixed conifer with a different composition of tree species, due to relatively warmer, drier conditions, and is a transition zone between wet mixed conifer and the upper elevation spruce-fir forest type. In the lower type, common seral tree species are aspen, Douglas-fir, white fir, and Southwestern white/limber pine. Climax forest is dominated by Engelmann spruce, white fir and occasionally blue spruce. Subdominant species may include corkbark/subalpine fir, white fir, and bristlecone pine. In the upper type, dominant tree species are Engelmann spruce and corkbark fir (subalpine fir). Patches of aspen are occasionally present, but aspen is typically incidental or co-dominant. Disturbances in these types typically occur at two temporal and spatial scales: large-scale infrequent disturbances (mostly fire,) and small-scale frequent disturbances (fire, insect, disease, wind).

Landscape Scale Desired Conditions (1,000-10,000 + acres)

The spruce-fir vegetation community is a mosaic of structural and seral stages ranging from young trees through old, and is composed of multiple species. Seral state proportions (per the R3 Seral State Proportions Supplement) are applied at the landscape scale, where contributions from all seral stages and low overall departure from reference proportions are positive indicators of ecosystem condition. Patch sizes vary but are mostly in the hundreds of acres (Margolis 2007), with rare disturbances in the thousands of acres. Tree canopies are generally more closed than in mixed conifer. An understory consisting of native grass, forbs, and/or shrubs is present.

Old growth generally occurs over large areas as stands or forests. Old growth includes old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The spruce-fir vegetation community is composed predominantly of vigorous trees, but older declining trees are a component and provide snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris, all well-distributed throughout the landscape. The number of snags and amount of downed logs (>12 inch diameter at mid-point, >8 feet long) and coarse woody debris (>3 inch diameter) vary by seral stage.

Vegetative conditions (composition, structure, and function) are broadly resilient to disturbances of varying frequency, extent, and severity. The forest landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from endemic levels of disturbances (e.g. insects, diseases, fire, and wind), including old trees, downed logs, and snags. Organic ground cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. In the lower spruce-fir type, mixed-severity fires (Fire Regime III) infrequently occur. Shrub cover is variable and depends on the TEUI unit (USDA Forest Service 1986). At the scale of the Plan unit, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at the mid- and fine- scales owing to a diversity of seral conditions. In the upper spruce-fir type, high severity fires (Fire Regime IV and V) occur very infrequently. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, age, spatial structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (10 -1,000 acres)

The size and number of tree groups and patches vary depending on disturbance, elevation, soil type, aspect, and site productivity. There may also be small disturbances resulting in groups and patches of tens of acres or less. Grass, forb, shrub interspaces created by disturbance may involve single trees or comprise up to 100 percent of the mid-scale area following major disturbances. Aspen is occasionally present in large patches.

Density ranges from 20 to 250 or greater square foot basal area per acre based upon age and site productivity, and depending upon disturbance and seral stages of the groups and patches. Snags, 18 inches or greater at DBH, range from 5 to greater than 30 snags per acre, with lower range of snags associated with early seral stages and the upper range associated with late seral stages. Snag density in general (> 8" DBH) averages 20 per acre with a range of 13 to 30. Coarse woody debris, including downed logs, averages vary by seral stage, ranging from 5 to 30 tons per acre for early-seral stages; 30 to 40 tons per acre for mid-seral stages; and 40 tons per acre or greater for late-seral stages.

Mixed (Fire Regime III) and high (Fire Regime IV and V) severity fires and other disturbances maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling. Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 20% depending on the TEUI unit (USDA Forest Service 1986).

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests typically contain 10 percent or greater tree density (basal area) than goshawk foraging areas and the general forest. Nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the spruce-fir type.

Fine-Scale Desired Conditions (< 10acres)

Mid- to old-age trees grow tightly together with interlocking crowns. Trees are generally of the same height and age in early group\patch development but may be multilayered in late development. Gaps are present as a result of disturbances.

WET (INFREQUENT) MIXED CONIFER FOREST DESIRED CONDITIONS

General Description

The wet mixed conifer forest vegetation community generally occurs at elevations ranging from approximately 6,500 to 10,000 feet. Tree species composition varies depending on seral stage, elevation, and moisture availability. It can be composed of early and mid-seral species such as aspen, Douglas fir, New Mexico locust, southwestern white pine and limber pine, and late seral species such as maple, white fir and blue spruce. Ponderosa pine may be present in minor proportions. The absence of Engelmann spruce and/or corkbark fir plant associations (USDA 1997a) distinguishes wet mixed conifer from the spruce-fir forest. Disturbances typically occur at two temporal and spatial scales: large-scale infrequent disturbances (mostly fire), and small scale frequent disturbances (fire, insect, disease, wind). This forest has an understory of a wide variety of shrubs, grasses, and forbs depending on soil type, aspect, elevation, disturbance, and other factors.

Landscape Scale Desired Conditions (1,000-10,000 + acres)

The wet mixed conifer forest vegetation community is a mosaic of structural and seral stages ranging from young trees through old. The landscape arrangement is an assemblage of variably sized and aged patches of trees and other vegetation associations similar to historic patterns. Tree patches are comprised of variable species composition depending on forest seral stages. Patch sizes vary but are frequently in the hundreds of acres, with rare disturbances in the thousands of acres. Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition. Canopies are generally more closed than in dry mixed conifer. An understory consisting of native grass, forbs, and/or shrubs is present. The amount of shrub cover depends on the TEUI unit (USDA Forest Service 1986). At the Plan unit scale, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions.

Old growth generally occurs over large areas as stands. Old growth includes old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The wet mixed conifer forest vegetation community is composed predominantly of vigorous trees, but older declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris, all well-distributed throughout the landscape. Number of snags and the amount of downed logs (>12 inch diameter at mid-point, >8 feet long) and coarse woody debris (>3 inch diameter) vary by seral stage.

Vegetative conditions (composition, structure, and function) are broadly resilient to disturbances of varying frequency, extent, and severity. The forest landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from endemic levels of disturbances (e.g. insects, diseases, wind, and fire), including snags, downed logs, and old trees. Organic ground cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and ecosystem function. Mixed-severity fire (Fire Regime III) is characteristic, especially at lower elevations of this type. High severity fires (Fire Regime IV & V) rarely occur and are typically at higher elevations of this type. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (10 -1,000 acres)

The size and number of groups and patches vary depending on disturbance, elevation, soil type, aspect, and site productivity. Groups and patches of tens of acres or less are relatively common. A mosaic of groups and patches of trees, primarily even-aged, and variable in size, species composition, and age is present. Openness and prevalence of some species (e.g. aspen) is dependent on seral stages. Grass, forb, shrub openings created by disturbance, may comprise 10 to 100 percent of the mid-scale area depending on the disturbances and on time since disturbance. Aspen is occasionally present in large patches. Density ranges from 20 to 180 or greater square foot basal area per acre based upon age and site productivity, and depending upon time since disturbance and seral stages of groups and patches. Snags 18 inches or greater at DBH range from 1 to 5 snags per acre, with the lower range of snags of this size associated with early seral stages and the upper range associated with late seral stages. Snag density in general (>8 inches DBH) averages 20 per acre. Coarse woody debris, including downed logs, vary by seral stage, with averages ranging from 5 to 20 tons per acre for early-seral stages; 20 to 40 tons per acre for mid-seral stages; and 35 tons per acre or greater for late-seral stages.

Fire severity is mixed or high, with a fire return interval of 35 to 200 or more years (Fire Regimes III, IV, and V). Fires and other disturbances maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling. During moister conditions, fires exhibit smoldering low-intensity surface behavior with single tree and isolated group torching. Under drier conditions, fires exhibit passive to active crown fire behavior with conifer tree mortality up to 100 percent across mid-scale patches. High severity fires generally do not exceed 1,000 acre patches of mortality. Other smaller disturbances occur more frequently. Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 20% depending on the TEUI unit (USDA Forest Service 1986, 2006).

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests typically contain 10 percent or greater tree density (basal area) relative to PFAs than goshawk foraging areas and the general forest. Nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the wet mixed conifer type.

Fine-Scale Desired Conditions (< 10acres)

In mid-aged and older forests, trees are typically variably-spaced with crowns interlocking (grouped and clumped trees) or nearly interlocking. Trees within groups can be of similar or variable species and ages. Small openings are present as a result of disturbances.

Organic ground cover and herbaceous vegetation provide protection for soil and moisture infiltration, and contribute to plant diversity and ecosystem function. Due to presence of ladder fuels, fires usually burn either with low intensity, smoldering combustion, or transition rapidly in the canopy as passive or active crown fire.

DRY (FREQUENT FIRE) MIXED CONIFER FOREST DESIRED CONDITIONS

General Description

The dry mixed conifer forest vegetation community is transitional with increasing elevation between ponderosa pine and wet mixed-conifer forests and generally occurs at elevations ranging from approximately 6,000 to 9,500 feet. Dry mixed-conifer forests are dominated by mainly shade intolerant trees such as ponderosa pine, southwestern white pine, limber pine, quaking aspen, and Gambel oak, with a lesser presence of shade tolerant species such as white fir and blue spruce. Mid-tolerant species such as Douglas-fir are common. Aspen may occur as individual trees or small groups. This forest vegetation community typically occurs with an understory of grasses, forbs, and shrubs.

Landscape Scale Desired Conditions (1,000-10,000 + acres)

The dry mixed conifer vegetation community is a mosaic of forest conditions composed of structural stages ranging from young to old trees. Forest appearance is variable but generally uneven-aged and open; occasional patches of even-aged structure are present. The forest arrangement is in small clumps and groups of trees interspersed within variably-sized openings of grass/forb/shrub vegetation associations similar to historic patterns. Openness typically ranges from 10 percent in more productive sites to 50 percent in the less productive sites. Size, shape, number of trees per group, and number of groups per area are variable across the landscape. Where they naturally occur, groups of aspen and all structural stages of oak are present. Denser tree conditions exist in some locations such as north facing slopes and canyon bottoms. Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The dry mixed conifer forest vegetation community is composed predominantly of vigorous trees, but declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (>3 inch diameter), all well-distributed throughout the landscape. Snags are typically 18 inches or greater at DBH and average 3 per acre. Smaller snags, 8 inches and above at DBH, average 8 snags per acre.

Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 per acre within forested areas. Coarse woody debris, including downed logs, ranges from 5 to 15 tons per acre.

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent, severity of disturbances, and to climate variability. The landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from endemic levels of disturbances (e.g. insects, diseases, fire, and wind), including snags, downed logs, and old trees. Grasses, forbs, shrubs, needle cast (fine fuels), and small trees maintain the natural fire regime. Organic ground cover (leaf litter/needle cast, etc.) and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. The amount of shrub cover depends on the TEUI unit (USDA Forest Service 1986, 2006). At the Plan unit scale, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions. Frequent, low severity fires (Fire Regime I) are characteristic, including throughout goshawk home ranges. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (10 -1,000 acres)

The dry mixed conifer forest vegetation community is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The more biologically productive sites contain more trees per group and more groups per area. Openness typically ranges from 10 percent in more productive sites to 50 percent in the less productive sites. Tree density within forested areas generally ranges from 30 to 100 square foot basal area per acre.

The mosaic of tree groups generally comprises an uneven-aged forest with all age classes and structural stages. Occasionally small patches (generally less than 50 acres) of even-aged forest structure are present. Disturbances sustain the overall age and structural distribution.

Ground cover consists primarily of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values ranging between about 5 and 20% depending on the TEUI unit (USDA Forest Service 1986, 2006). Fires burn primarily on the forest floor and do not spread between tree groups as crown fire.

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests contain 10 to 20 percent higher basal area in mid- to old-age tree groups than in goshawk foraging areas and in the general forest. Goshawk nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the dry mixed conifer type.

Fine-Scale Desired Conditions (< 10acres)

Trees typically occur in irregularly shaped groups and are variably-spaced with some tight clumps. Crowns of trees within the mid- to old-age groups are interlocking or nearly interlocking. Interspaces surrounding tree groups are variably-shaped and comprised of a grass/forb/shrub mix. Some natural openings contain individual trees or snags. Trees within groups are of similar or variable ages and one or more species. Size of tree groups typically is less than 1 acre. Groups at the mid- to old-age stages consist of 2 to approximately 50 trees per group.

PONDEROSA PINE FOREST DESIRED CONDITIONS

General Description

The ponderosa pine forest vegetation community includes two sub-types: Ponderosa pine bunchgrass and ponderosa pine Gambel oak. The ponderosa pine forest vegetation community generally occurs at elevations ranging from approximately 5,000 to 9,000 feet. It is dominated by ponderosa pine and commonly includes other species such as oak, juniper, and pinyon. More infrequently species such as aspen, Douglas-fir, white fir, and blue spruce may also be present, and may occur as individual trees. This forest vegetation community typically occurs with an understory of grasses and forbs although it sometimes includes shrubs.

Landscape Scale Desired Conditions (1,000-10,000 + acres)

The ponderosa pine forest vegetation community is composed of trees from structural stages ranging from young to old. Forest appearance is variable but generally uneven-aged and open; occasional areas of even-aged structure are present. The forest arrangement is in individual trees, small clumps, and groups of trees interspersed within variably-sized openings of grass/forbs/shrubs vegetation associations similar to historic patterns. Openness typically ranges from 10 percent in more productive sites to 70 percent in the less productive sites. Size, shape, number of trees per group, and number of groups per area are variable across the landscape. Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition. In the Gambel oak sub-type, all sizes and ages of oak trees are present. Denser tree conditions exist in some locations such as north facing slopes and canyon bottoms.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The ponderosa pine forest vegetation community is composed predominantly of vigorous trees, but declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (>3 inch diameter), all well-distributed throughout the landscape. Ponderosa pine snags are typically 18 inches or greater at DBH and average 1 to 2 snags per acre. In the Gambel oak subtype, large oak snags (>10 inches) are a well-distributed component. Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre.

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances and climate variability. The landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from endemic levels of disturbances (e.g. insects, diseases, fire, and wind), including snags, downed logs, and old trees. Grasses, forbs, shrubs, and needle cast (fine fuels), and small trees maintain the natural fire regime. Organic ground cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. The amount of shrub cover depends on the TEUI unit (USDA Forest Service 1986, 2006). At the Plan unit scale, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions. Frequent, low severity fires (Fire Regime I) are characteristic in this type, including throughout goshawk home ranges. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (100 -1,000 acres)

The ponderosa pine forest vegetation community is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The more biologically productive sites contain more trees per group and more groups per area, resulting in less space between groups. Openness typically ranges from 52 percent in more productive sites to 90 percent in less productive sites. In areas with high fine-scale aggregation of trees into groups, mid-scale openness ranges between 78-90%. Tree density within forested areas generally ranges from 22 to 89 square foot basal area per acre (Reynolds et al. 2013). Ground cover consists primarily of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values ranging between about 5 and 20% depending on the TEUI unit (USDA Forest Service 1986, 2006).

The mosaic of tree groups generally comprises an uneven-aged forest with all age classes present. Infrequently, patches of even-aged forest structure are present. Disturbances sustain the overall age and structural distribution.

Fires burn primarily on the forest floor and do not spread between tree groups as crown fire.

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests contain 10 to 20 percent higher basal area in mid- to old-age tree groups than in goshawk foraging areas and the general forest. Goshawk nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the ponderosa pine type.

Fine-Scale Desired Conditions (< 10acres)

Trees typically occur in irregularly shaped groups and are variably-spaced with some tight clumps. Crowns of trees within the mid- to old-age groups are interlocking or nearly interlocking. Interspaces surrounding tree groups are variably-shaped and comprised of a grass/forb/shrub mix. Some natural openings contain individual trees. Trees within groups are of similar or variable ages and may contain species other than ponderosa pine. Size of tree groups typically is less than 1 acre, but averages 0.5 acres. Groups at the mid- to old-age stages consist of 2 to approximately 40 trees per group.

PONDEROSA PINE – EVERGREEN OAK FOREST DESIRED CONDITIONS

General Description

Ponderosa Pine - Evergreen Oak generally occurs at elevations ranging from approximately 5,000 to 6,500 feet. It is dominated by ponderosa pine and can be distinguished from ponderosa pine forest by somewhat more even-aged dynamics, and by one or more well-represented evergreen oak species (e.g., Emory oak, Arizona white oak, silverleaf oak, grey oak). Other species include juniper species, pinyon pine species, and Arizona cypress in some locations. Ponderosa Pine - Evergreen Oak has two subclasses: one with a more continuous layer of perennial grasses and few shrubs, and one with an understory of primarily evergreen shrubs including manzanita, turbinella oak, sumac species, and mountain mahogany species. Stand dynamics are essentially uneven-aged, though the area represented by cohorts varies from individual trees and small groups at the warm-dry end of the perennial grass subclass, to larger groups and patches at the cool-mesic end of the evergreen shrub subclass.

PONDEROSA PINE – EVERGREEN OAK (PERENNIAL GRASS) FOREST DESIRED CONDITION

Landscape Scale Desired Conditions (1,000-10,000+ acres)

The ponderosa pine-evergreen oak perennial grasses sub-type is composed of trees from structural stages ranging from young to old. Forest appearance is variable but generally uneven-aged and open at landscape scales (though can appear even-aged within tree groups); occasional larger areas of even-aged structure are present. The forest arrangement is in individual trees, small clumps and groups of trees interspersed within variably-sized openings of grass/forbs/shrub vegetation associations similar to historic patterns. Openness typically ranges from 10 percent in more productive sites to 70 percent in the less productive sites. Shrubs occur in low densities which do not inhibit ponderosa pine regeneration. Size, shape, number of trees per group, and number of groups per area are variable across the landscape. All structural stages of oak are present, with old trees occurring as dominant individuals, and small groups occurring typically within openings. Denser overall tree conditions exist in some locations such as north facing slopes and canyon bottoms. Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The ponderosa pine –evergreen oak perennial grasses sub-type is composed predominantly of vigorous trees, but declining trees are a component and provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (>3 inch diameter), all well-distributed throughout the landscape. Ponderosa pine snags are typically 18 inches or greater at DBH and average 1 to 2 snags per acre, while snags greater than 8 inches average 5 snags per acre (Weisz et al. 2011). Large oak snags (>10 inches) are a well-distributed component. Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre.

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances, and climate variability. The landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from natural disturbances (e.g. insects, diseases, fire, and wind), including old growth. Grasses, forbs, shrubs, and needle cast (fine fuels), and small trees maintain the natural fire regime. Organic ground cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. Shrubs average less than 30% cover. At the Plan unit scale, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions. Frequent, primarily low severity fires (Fire Regime I) are characteristic including throughout goshawk home ranges. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (100 - 1000 acres)

The ponderosa pine-evergreen oak perennial grasses sub-type is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The more biologically productive sites contain more trees per group and more groups per area. Openness typically ranges from 10 percent in more productive sites to 70 percent in the less productive sites. Tree density within forested areas generally ranges from 20 to 80 square foot basal area per acre.

The mosaic of tree groups generally comprises an uneven-aged forest with all age classes and structural stages present, though tree groups and patches may be relatively even-aged. Small areas of even-aged forest structure are present. The mix of natural disturbances sustains the overall age and structural distribution. Patch sizes range from less than 1 acre to 10s of acres.

Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 15% depending on the TEUI unit (USDA Forest Service 1986). Fires burn primarily on the forest floor and do not typically spread between tree groups as crown fire. Mixed-severity fires occur at less frequency and over smaller spatial extents than low severity fires occur.

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests contain 10 to 20 percent higher basal area in the mid- to old-age tree groups than goshawk foraging areas and the general forest. Goshawk nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the ponderosa pine-evergreen oak type.

Fine-Scale Desired Conditions (<10 acres)

At the fine-scale, trees typically occur in small groups in which they are variably-spaced with some tight clumps. Crowns of trees within the mid- to old-age groups are interlocking or nearly interlocking. Interspaces between tree groups are variably-shaped and comprised of a grass/forb/shrub mix. Some natural openings contain individual trees, including large open-grown oaks. Trees within groups are of similar or variable ages and may contain species other than ponderosa pine. Size of tree groups typically is less than 1 acre. Groups at the mid-to old-age stages consist of 2 to approximately 40 trees.

PONDEROSA PINE – EVERGREEN OAK (SHRUB) FOREST DESIRED CONDITIONS

Landscape Scale Desired Conditions (1,000-10,000+ acres)

The ponderosa pine-evergreen shrub sub-type is composed of trees from structural stages ranging from young to old. Forest appearance is variable but generally uneven-aged and open; areas of even-aged structure are present. The forest arrangement is in small clumps and groups of trees interspersed within variably-sized openings of moderate to high density shrubs and limited grass cover. Openness typically ranges from 10 percent in more productive sites to 70 percent in the less productive sites. Size, shape, number of trees per group, and number of groups per acre are variable across the landscape. All structural stages of oak are present, with old trees occurring as dominant individuals or in small groups. Denser tree conditions exist in some locations such as north facing slopes and canyon bottoms. Seral state proportions, per the R3 Seral State

Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality).

The ponderosa pine –evergreen shrub sub-type is composed predominantly of vigorous trees and shrubs, but declining trees and shrubs are a component. Declining trees provide for snags, top-killed, lightning- and fire-scarred trees, and coarse woody debris (>3 inch diameter), all well-distributed throughout the landscape. Ponderosa pine snags are typically 18 inches or greater at DBH and average 1 to 2 snags per acre, while snags greater than 8 inches average 5 snags per acre (Weisz et al. 2011); large oak snags (>10 inches) are a well-distributed component. Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 logs per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 3 to 10 tons per acre.

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances and climate variability. The landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from natural disturbances (e.g. insects, diseases, fire, and wind), including old growth. Dwarf-mistletoe occurs in less than 15 percent of host trees in uneven-aged forest structures and less than 25 percent in even-aged forest structures. Limited grasses, forbs, and a moderate density of shrubs, needle cast, and small trees maintain the natural fire regime. Organic ground cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. Shrubs average greater than 30% canopy cover. At the Plan unit scale, overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions. Low to mixed-severity fires (Fire Regimes I and III) are characteristic in this type, including throughout goshawk home ranges. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Mid-Scale Desired Conditions (100-1,000 acres)

The ponderosa pine-evergreen shrub sub-type is characterized by variation in the size and number of tree groups depending on elevation, soil type, aspect, and site productivity. The more biologically productive sites contain more trees per group and more groups per area. Openness typically ranges from 10 percent in more productive sites to 70 percent in the less productive sites. Tree density within forested areas generally ranges from 20 to 80 square foot basal area per acre.

The mosaic of tree groups comprises a mix of even-aged and uneven-aged patches with all age classes and structural stages present. The mix of natural disturbances sustains the overall age and structural distribution. Patch sizes range from less than 1 acre to 10s of acres.

Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 15% depending on the TEUI unit (USDA Forest Service 1986). Fires are of low to mixed-severity burning on the forest floor as well as in the overstory. Crown fires occur in small patches.

Forest conditions in goshawk post-fledging family areas (PFAs) are similar to general forest conditions except these forests contain 10 to 20 percent higher basal area in the mid- to old-age tree groups than goshawk foraging areas and the general forest. Goshawk nest areas have forest conditions that are multi-aged but are dominated by large trees with relatively denser canopies than other areas in the ponderosa pine-evergreen shrub type.

Fine-Scale Desired Conditions (< 10 acres)

Trees typically occur individually or in small groups in which they are variably-spaced with some tight clumps. Crowns of trees within mid- to old-age groups are interlocking or nearly interlocking. Interspaces between tree groups are variably-shaped and comprised of shrubs and limited grass cover. Some natural openings may contain a high density of shrubs and/or individual trees, including large oaks. Trees within groups are of similar or variable ages and may contain species other than ponderosa pine. Size of tree groups typically is less than 0.5 acre.

PINYON-JUNIPER DESIRED CONDITIONS

General Description

The pinyon-juniper (PJ) vegetation community is collectively composed of the Juniper Grass, PJ Grass, PJ Sagebrush, PJ Evergreen Shrub, and PJ Woodland (persistent) Ecological Response Units (ERUs). These generally occur at elevations between approximately 4500 and 7500 feet. They are dominated by one or more species of pinyon pine and/or juniper and can occur with a grass/forb dominated understory (PJ grassland), a shrub dominated understory (PJ Sagebrush/Evergreen Shrub), or a discontinuous understory of some grasses and/or shrubs (PJ Woodland). Two-needle, single-leaf, Mexican, and border pinyon pine are common.Oone-seed, Utah, redberry, Rocky Mountain, and alligator junipers are common, with a lesser abundance of oaks. Species composition and stand structure vary by location primarily due to precipitation, elevation, temperature, and soil type.

PINYON-JUNIPER GRASS and JUNIPER GRASS DESIRED CONDITIONS

Landscape Scale Desired Conditions (1,000–10,000+ acres)

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances (e.g. insects, diseases, and fire) and climate variability. Fires are typically frequent and low-severity (Fire Regime I). Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Snags are scattered across the landscape, with snags 8 inches and above at DRC averaging 5 snags per acre, while snags 18 inches and above average 1 snag per acre (Weisz et al. 2011). Coarse woody debris increases with succession and averages 1-3 tons per acre. Overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at the fine- and mid- scales owing to a diversity of seral conditions.

Mid-Scale Desired Conditions (100-1,000 acres)

Scattered shrubs and a dense herbaceous understory including native grasses, forbs and annuals are present to support frequent surface fires. Ground cover consists primarily of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values averaging between about 10 and 30% depending on the TEUI unit (USDA Forest Service 1986, 2006). Shrubs average less than 30% canopy cover.

Fine-Scale Desired Conditions (< 10 acres)

Pinyon-juniper grass and juniper grass are generally uneven aged and open in appearance. Trees occur as individuals, but occasionally in smaller groups, and range from young to old. Patch sizes of woodlands range from individual trees and clumps that are less than one-tenth acre, to tree groups of approximately an acre (Muldavin et al. 2003).

PINYON-JUNIPER SAGEBRUSH DESIRED CONDITIONS

Landscape Scale Desired Conditions (1,000-10,000+ acres)

Pinyon-juniper sagebrush is a mix of trees and shrubs that occurs as a series of vegetation states that move from herbaceous-dominated to shrub-dominated to tree-dominated over time. Pinyon trees are occasionally absent but one or more juniper species is always present. The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances (e.g. insects, diseases, and fire) and climate variability. Fires are typically infrequent mixed-severity, with rare stand replacement fires (Fire Regime III(V)). Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Snags and old trees with dead limbs/tops are scattered across the landscape, with snags 8 inches and above at DRC averaging 6 snags per acre, while snags 18 inches and above average 1 snag per acre (Weisz et al. 2011). Coarse woody debris averages about 4 tons per acre (Ernest et al. 1993). Overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at the fine- and mid- scales owing to a diversity of seral conditions.

Mid-Scale Desired Conditions (100-1,000 acres)

The understory is dominated by moderate to high density shrubs depending on successional stage. The shrub component consists of one or a mix of sagebrush, evergreen shrub, oak, and other shrub species, which are well-distributed. Shrubs typically are in a closed canopy state during later successional stages. Native perennial grasses and annual and perennial forbs are present as understory components. Ground cover consists primarily of shrubs, perennial grasses, and forbs capable of carrying surface fire only infrequently, with basal vegetation values averaging between about 10 and 35% depending on the TEUI unit (USDA Forest Service 1986, 1993). Shrubs average greater than 30% canopy cover.

Fine-Scale Desired Conditions (< 10 acres)

Trees occur as individuals or in smaller groups ranging from young to old. Typically groups are even-aged in structure. The patch size of woodlands ranges from 1 to 10s of acres.

PINYON-JUNIPER EVERGREEN SHRUB DESIRED CONDITIONS

Landscape Scale Desired Conditions (1,000-10,000+ acres)

Pinyon-juniper evergreen shrub is a mix of trees and shrubs that occurs as a series of vegetation states that move from herbaceous-dominated to shrub-dominated to tree-dominated over time. Pinyon trees are occasionally absent but one or more juniper species is always present. The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances (e.g. insects, diseases, and fire), and climate variability. Fires are typically mixed-severity with a moderate frequency (Fire Regime III). Some evergreen shrub types exhibit occasional high severity fires (Fire Regime IV). Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth occurs throughout the landscape, generally in small areas as individual old growth components, or as clumps of old growth. Old growth components include old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Snags and old trees with dead limbs/tops are scattered across the landscape, with snags 8 inches and above at DRC averaging 3 snags per acre, while snags 18 inches and above average 1 snag per acre (Weisz et al. 2011). Large dead wood is present, and coarse woody debris averages 2-4 tons per acre. Overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions.

Mid-Scale Desired Conditions (100-1,000 acres)

The understory is dominated by low to moderate density shrubs depending on successional stage, overall averaging greater than 30% canopy cover. The shrub component consists of one or a mix of evergreen oak, manzanita, mountain mahogany, sumac and other shrub species, which are well-distributed. Native perennial grasses and annual and perennial forbs are present in the interspaces. Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 15% depending on the TEUI unit (USDA Forest Service 1986, 2000a).

Fine-Scale Desired Conditions (< 10 acres)

Trees occur as individuals or in smaller groups ranging from young to old. Typically groups are even-aged in structure with all ages represented across the landscape for an overall uneven-aged grouped appearance. The patch size of woodlands ranges from 1 to 10s of acres.

PINYON-JUNIPER WOODLAND (PERSISTENT) DESIRED CONDITIONS

Landscape Scale Desired Conditions (1,000-10,000+ acres)

Pinyon-juniper woodland (persistent) is characterized by even-aged patches of pinyons and junipers that at the landscape level form multi-aged woodlands. The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances (e.g. insects, diseases, and fire), and climate variability. Insects and disease occur at endemic levels. Fire as a disturbance is less frequent and variable due to differences in ground cover, though some sites are capable of carrying surface fire. The fires that do occur are mixed to high severity (Fire Regime III, IV, & V). Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition.

Old growth includes old trees, dead trees (snags), downed wood (coarse woody debris) and structural diversity, and is often concentrated in mid- and fine-scale units as patches of old growth. The location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Very old trees (>300 years old) are present, while snags and older trees with dead limbs and/or tops are scattered across the landscape. Snags 8 inches and above at DRC average 5 snags per acre, while snags 18 inches and above average 1 snag per acre (Weisz et al. 2011). Coarse woody debris increases with succession and averages 2-5 tons per acre. Overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions.

Mid-Scale Desired Conditions (100-1,000 acres)

Tree density and canopy cover are high, shrubs are sparse to moderate, and herbaceous cover is low and discontinuous. The amount of shrub cover depends on the TEUI unit (USDA Forest Service 1986, 1993, 2000b, 2006). Ground cover consists of shrubs, perennial grasses, and forbs with basal vegetation values ranging between about 5 and 15% depending on the TEUI unit (USDA Forest Service 1986). Trees occur in even-aged patches ranging from young to old, where patch size of these woodlands ranges from 10s to 100s of acres (Muldavin et al. 2003).

MADREAN WOODLAND DESIRED CONDITIONS

General Description

The Madrean woodland vegetation community is collectively composed of the Madrean pinyon-oak and Madrean Encinal Woodland. While the Madrean woodlands are concentrated in the Madrean region of northern Mexico and southeastern Arizona, these types extend into other ecoregions of Arizona and New Mexico. Communities similar to the Madrean pinyon-oak, in physiognomy, dynamics, and dominance by evergreen oaks and pinyon, extend as far north as central Arizona and central New Mexico. Madrean pinyon-oak is a subcategory of the Madrean *pine*-oak (LANDFIRE 2010, TNC 2006) that represents only the woodland life zone, separate from its montane counterpart – ponderosa pine-evergreen oak. Madrean Encinal Woodland often occurs below Madrean pinyon-oak, at the interface with semi-desert grassland.

The Madrean woodlands generally occur at elevations between 4,900 and 7,500 feet (1500-2300m)(LANDFIRE 2010)(Wahlberg et al. 2014) and can occur with a grass/forb-dominated understory or a shrub-dominated understory. Madrean Encinal Woodland is characterized by the dominance of oak trees, while Madrean pinyon-oak is dominated by both oaks and pinyon. Juniper can be co-dominant in either type. The two Madrean types can intergrade with one another and with pinyon-juniper woodlands. Common tree species include Arizona white oak, Emory oak, gray oak, and Mexican blue oak, with lesser amounts of silverleaf oak, and Toumey oak depending on the location. In central and southeastern New Mexico, oaks include gray oak and occasionally Chinkapin oak. Juniper species include alligator juniper, one-seed juniper, and redberry juniper. Arizona cypress is co-dominant on some sites. In the Madrean pinyon-oak, common pines include Mexican pinyon, Chihuahua pine, border pinyon, and Apache pine, with twoneedle pinyon as the surrogate pine in central and southeastern New Mexico. Interior chaparral species may be present in some locations but do not co-dominate. A shrub layer is present and often contains species such as beargrass, littleleaf and evergreen sumac, silktassel, birchleaf buckthorn, and ceanothus species. The herb layer is dominated by warm-season grasses such as threeawns, blue grama, sideoats grama, Rothrock grama, Arizona cottontop, curly-mesquite, green sprangletop, muhly grasses, or Texas bluestem.

The composition, structure, and function of vegetative conditions are resilient to the frequency, extent and severity of disturbances and climate variability. The landscape is a functioning ecosystem that contains all its components, processes, and conditions that result from natural disturbances (e.g. insects, diseases, fire, and wind), including old growth. Grasses, forbs, shrubs, and needle cast (fine fuels), and small trees help to maintain the natural fire regime. Litter cover and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. Frequent, primarily low severity fires (Fire Regime I/III) burn on the forest floor and do not typically spread between trees as crown fire. Mixed-severity fires occur less frequently and over smaller spatial extents than low severity fires. Natural and anthropogenic disturbances are sufficient to maintain desired overall tree density, structure, species composition, coarse woody debris, and nutrient cycling.

Landscape Scale Desired Conditions (10,000+ acres)

Seral state proportions, per the R3 Seral State Proportions Supplement, are applied at the landscape scale, where low overall departure from reference proportions is a positive indicator of ecosystem condition. The Madrean types are relatively homogenous in structure, generally uneven-aged and open, with occasional patches of even-aged structure. Declining trees are a component and provide for snags, top-killed, lightning-and fire-scarred trees, and coarse woody debris, all well-distributed throughout the landscape. Snags 8 inches or greater at DBH average 4 snags per acre, while snags 18 inches or greater average 1 snag per acre (Weisz et al. 2011). Large oak snags (>10 inches) are a well-distributed component. Coarse woody debris increases with forest succession and averages 2-3 tons per acre. The amount of shrub cover depends on the TEUI unit (USDA Forest Service 1986). Overall plant composition similarity to site potential (FSH 2090.11) averages greater than 66%, but can vary considerably at fine- and mid- scales owing to a diversity of seral conditions.

Mid-Scale Desired Conditions (100-1,000 acres)

The majority of woodland is in open condition with tree cover averaging between 10 and 40% depending on site productivity and past disturbance, with tree cover in canyons and drainage bottoms nearer the upper end of this range. A lesser amount is in closed canopy condition characteristic of the reference condition. Patch sizes range from less than 1 acre to 10s of acres. Tree groups vary in size and number depending on climate, soil type, and past disturbance. The more biologically productive sites contain more trees per group and more groups peracre. Shrubs occur in low to moderate densities which does not inhibit tree regeneration. The size, shape, and number of trees per group, and number of groups per mid-scale unit are variable. All structural stages of oak are present with old trees occurring as dominant individuals, and small groups occurring typically within openings. Denser overall tree conditions exist in some locations such as north facing slopes and canyon bottoms. Ground cover consists of perennial grasses and forbs capable of carrying surface fire, with basal vegetation values between about 2 and 20% depending on the TEUI unit (USDA Forest Service 1986).

Fine-Scale Desired Conditions (< 10 acres)

At the fine-scale, forest arrangement is in individual trees, small clumps, and groups of trees interspersed within variably-sized openings of grass/forbs/shrub vegetation associations similar to historic patterns. Trees typically occur in small groups in which they are variably-spaced with some tight clumps. Crowns of trees within the mid- to old-age groups are interlocking or nearly interlocking. Interspaces between tree groups are variably-shaped and comprised of a grass/forb/shrub mix. Some natural openings contain individual trees, including large open-grown oaks. Trees within groups are of similar or variable ages and may contain species other than oak, juniper, and pinyon pine. The size of tree groups is typically 1 acre or less. Groups at the mid- to old-age stages consist of 2 to approximately 40 trees.

COMMON TO ALL ECOLOGICAL RESPONSE UNITS

Wildland Urban Interface (WUI) Desired Conditions

Wildland fires in the WUI result in the minimal loss of life, property, or characteristic ecosystem function. Wildland fires in the WUI are low intensity surface fires as ladder fuels are nearly absent. Firefighters are able to safely and efficiently suppress wildfires in the WUI.

In forested vegetation communities, the area occupied by interspace with grass/forb/shrub vegetation is on the upper end of, or above, the range given in the vegetation community desired conditions. Trees within groups may be more widely spaced with less interlocking of the crowns than desirable in adjacent forest lands. Interspaces between tree groups are of sufficient size to discourage isolated group torching from spreading as a crown fire to other groups. The tree basal area in the WUI is on the lower end of the range given in the vegetation community desired conditions. When WUI intersects vegetation types with a mixed or high-severity fire regime, such as spruce-fir, characteristic ecosystem function is modified to promote low intensity surface fires.

In shrubland/chaparral vegetation communities, the live and dead fuel loading in the WUI is on the lower end of the range given for the vegetation community desired conditions. Enough cover exists to meet the needs of a variety of wildlife species.

Logs and snags, which often pose fire control problems, are present in the WUI, but at the lower end of the range given in the appropriate vegetation community desired conditions. Dead and down fuel load is between 1 and 10 tons per acre, depending on ERU, with lower amounts in fire-adapted ERUs, and higher amounts in infrequent fire types. This light fuel load applies even in vegetation types with higher reference fuel loads, such as mesic mixed conifer or spruce-fir, to provide improved fire protection to human developments deemed to have special significance. Higher fuel loading or tree densities may occur in areas where it provides for important fine-scale habitat structure, as long as it meets the overall intent of protecting WUI values at risk.

Adjusting Desired Conditions to Account for Vulnerability to Climate Change

In areas of high vulnerability to climate change, based on 100-year climate projections (Triepke et al. 2014), tree basal area is restored or maintained at the low end of the desired range to mitigate water stress. In these areas, early-mid seral species dominate over late-seral species, given the adaptations of many early-mid species for warmer and drier conditions. Encroaching species characteristic of lower life zones are maintained.

GLOSSARY

Age class is defined as trees that originated within a relatively distinct range of years. Typically the range of years is considered to fall within 20 percent of the average natural maturity (e.g. if 100 years is required to reach maturity, then there would be five 20-year age classes, Helms 1998).

Basal area is the cross-sectional area at breast height (4.5 ft. above the ground) of trees measured in square feet. Basal area is a way to measure how much of a site is occupied by trees. The cross-sectional area is determined by calculating the tree's radius from its diameter (diameter/2 = radius) and using the formula for the area of a circle (π x radius^2 = cross-sectional area). Basal area per acre is the summation of the cross-sectional area of all trees in an acre or in a smaller plot used to estimate basal area per acre. Diameter at root collar (defined below) is used to calculate the cross-sectional area of multi-stemmed trees such as juniper and oak.

Clump refers to (1) the aggregate of stems issuing from the same root, rhizome system, or stool; or (2) an isolated generally dense group of trees (Helms 1998). A clump is relatively isolated from other clumps or trees within a group of trees, but a stand-alone clump of trees can function as a tree group or a single structure.

Coarse woody debris is dead woody material on the ground greater than three inches in diameter, including logs.

Declining refers to the senescent (aging) period in the lifespan of plants that includes the presence of dead and/or dying limbs, snag-tops, and other characteristics that indicate the later life-stages of vegetation.

Diameter at breast height (DBH) is the diameter of a tree typically measured at 4.5 feet above ground level.

Diameter at root collar (DRC) is the diameter typically measured at the root collar or at the natural ground line, whichever is higher, outside the bark. For a multi-stemmed tree, DRC is calculated from the diameter measurements of all qualifying stems (≥ 1.5" diameter and at least one foot in length).

Gap refers to the space occurring in a forested area as a result of individual or group tree mortality from small disturbance events or from local site factors such as soil properties that influence vegetation growth patterns.

Ecological Response Units (ERUs) – A system of ecosystem types, "ecological response units" (ERUs), used to facilitate landscape analysis and strategic planning. The ERU framework (formerly "PNVT") represents all major ecosystem types of the region and is a coarse set of biophysical themes that, in concept and resolution, are most useful to management. ERUs are map unit constructs, technical groupings of finer vegetation classes with similar site potential (Daubenmire 1968) and historic disturbance regime, similar to LANDFIRE Biophysical Settings (Barrett et al. 2010). Each ERU reflects plant communities of similar natural disturbance regime, biological processes, successional pattern, physiognomy, and community dominants (TNC 2006). Physical characteristics include similar climate, geology, geomorphology, and soils.

Even-aged forests are forests that are comprised of one or two distinct age classes of trees.

Fire regime refers to the patterns of fire that occur over a long period of time across an appropriately scaled area (outlined in Table 1 below) and its immediate effects on the ecosystem in which it occurs. There are five fire regimes which are classified based on frequency (average number of years between fires) and severity (amount of replacement on the dominant overstory vegetation) of the fire. These five regimes are:

> *Fire regime I* – 0 to 35 year frequency and low severity (surface fires most common, isolated torching can occur) to mixed-severity (< 75% of dominant overstory vegetation replaced);
>
> *Fire regime II* – 0 to 35 year frequency and high severity (> 75% of dominant overstory vegetation replaced);
>
> *Fire regime III* – 35 to 100+ year frequency and mixed-severity;
>
> *Fire regime IV* – 35 to 100+ year frequency and high severity;
>
> *Fire regime V* – 200+ year frequency and high severity

Foraging areas surround Post Fledgling Family Areas (PFAs) and are used by goshawks to hunt for prey. They are approximately 5,400 acres in size.

Group refers to a cluster of two or more trees with interlocking or nearly interlocking crowns at maturity surrounded by grass-forb-shrub interspaces. Size of tree groups is typically variable depending on forest type and site conditions and can range from fractions of an acre in ponderosa pine or dry mixed conifer forest (i.e. a two-tree group), to many acres, as is common in Wet Mixed-Conifer and Spruce Fir Forests. Trees within groups are typically non-uniformly spaced, and some may be tightly clumped.

Interspaces are areas not currently under the vertical projection of the outermost perimeter of tree canopies. They are the spaces between groups of trees (or say, they define tree groups)They are generally composed of grass-forb-shrub communities but could also be areas with scattered rock or exposed mineral soil. Interspaces do not include meadows, grasslands, rock outcroppings, and wetlands (i.e., exclusions adjacent to and sometimes within forested landscapes).

Invasive species are species that are not native to the ecosystem being described. For all ecosystems, the desired condition is that invasive species are rarely present, or are present at levels that do not negatively influence ecosystem function.

Nest areas are the areas immediately around a nest that are used by northern goshawks in relation to courtship and breeding activities. They are approximately 30 acres in size and contain multiple groups of large, old trees with interlocking crowns.

Old growth in Southwestern forested ecosystems is defined differently than the traditional definition based on Northwestern infrequent-fire forests. Due to large differences among Southwest forest types and their characteristic disturbances, old growth forests vary extensively in tree size, age classes, presence and abundance of structural elements, stability, and presence of understory (Helms 1998). Old growth refers to specific habitat components that occur in forests and woodlands – old trees, dead trees (snags), downed wood (coarse woody debris), and structure diversity (Franklin and Spies 1989, Helms 1998, Kaufmann et al. 2007). These important habitat features may occur in small areas, with only a few components, or over larger areas as stands or forests where old growth is concentrated (Kaufmann et al. 2007). In the Southwest, old growth is considered "transitional" (Oliver and Larson 1996), given that that the location of old growth shifts on the landscape over time as a result of succession and disturbance (tree growth and mortality). Some species, notably certain plants, require "old forest" communities that may or may not have old growth components but have escaped significant disturbance for lengths of time necessary to provide the suitable stability and environment.

In frequent fire, all-aged systems (e.g., ponderosa pine, dry mixed conifer, some pinyon-juniper types), old growth components occur individually or in small areas from 0.1 to 1-plus acres (Cooper 1961, White 1985). In infrequent fire systems (e.g., wet mixed conifer, spruce-fir, and some pinyon-juniper types), old growth components are often concentrated in larger areas, forming stands or "old growth forest" from 10s to 100s of acres. Old growth is not equated to any particular successional stage, though late seral states are more likely to contain old growth features. "Old growth trees" are old and sometimes large (Kaufmann et al. 2007). It is the decadence (dead tops, dead wood) or structure diversity (flattened crowns, branch characteristics), associated with old age that provide essential habitat. By managing for desired conditions, as described for each forest and woodland type, old growth is being continually developed as a byproduct of the management.

Openings are areas greater than 1/10 acre devoid of trees because they either; 1) preclude tree growth (e.g., rock outcroppings, wetlands [*natural openings*]); 2) were the site of a stand-clearing disturbance event (also *natural openings*); or 3) were cleared of trees to promote regeneration (*regeneration openings*). Openings are generally larger than interspaces and should not be confused with interspaces, which are areas between and among trees that are capable of supporting tree growth but, at a given point in time, are absent of tree canopy (typically created and maintained by lower intensity disturbances [e.g., frequent fire]).

Openness is estimated as the inverse of forest canopy cover for a given area. For example, a forest with 70 percent canopy cover would have openness of 30 percent.

Patches are areas larger than tree groups in which the vegetation composition and structure are relatively homogeneous. Patches can be composed of randomly arranged trees or multiple tree groups, and they can be even-aged or uneven-aged. Patches comprise the mid-scale, typically ranging in size from 10 to 1,000 acres. Patches and stands are roughly synonymous.

Post-fledging Family Areas (PFAs) are the areas that surround nest areas. They represent an area of concentrated use by the goshawk family until the time the young are no longer dependent on adults for food. PFAs are approximately 420 acres in size.

Reference Conditions are environmental conditions that infer ecological sustainability. When available, reference conditions are represented by the characteristic range of variation (not the total range of variation), prior to European settlement and under the current climatic period. For many ecosystems, the range of variation also reflects human-caused disturbance and effects prior to settlement. It may also be necessary to refine reference conditions according to contemporary factors (e.g., invasive species) or projected conditions (e.g., climate change). Reference conditions are most useful as an inference of sustainability when they have been quantified by amount, condition, spatial distribution, and temporal variation.

Site potential, for a given potential vegetation type, represents the successional condition with the greatest representation of late-seral vegetation that is typical under characteristic, pre-settlement levels of fire and herbivory. The existing vegetation of such a plant community would have 100% similarity to site potential when computing ecological status (FSH 2090.11), and would be at *reference condition*. Site potential is relative to the potential vegetation type.

Snags are standing dead or partially dead trees (snag-topped), often missing many or all limbs. They provide essential wildlife habitat for many species and are important for forest ecosystem function.

Stands are areas in which the biophysical site conditions, and the vegetation composition and structure are relatively homogeneous. Stands comprise the mid-scale, thus ranging in size from 10 to 1,000 acres. Stands and patches are roughly synonymous.

Uneven-aged forests are forests that are comprised of three or more distinct age classes of trees, either intimately mixed or in small groups (Helms 1998).

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