DESIRED CONDITION WORKSHOP AGENDA
May 9 and 10, 2012

Day 1: May 9 — **Future Foundations Building**
551 Washington Ave./ Grants, NM 87020

8:00 Welcome and Introductions — ERI

8:30 Regional Forester Perspective on Desired Condition (DC), Landscape Scale Restoration — Corbin

- Why Desired Conditions dialogue? Why now?
- Expectations for the workshop
- R3 Desired Conditions: why and how we are using them?
- Adaptive nature of Desired Conditions
- Today's focus: the scientific basis for the ecological DCs consideration of the socio-economic values that influence them

9:00 Setting the Stage for Desired Condition Dialogue — Dave

- Current conditions: how did we get here, where are we headed?
- Ecological restoration: what is restoration and the science that supports it?
- Sustainability: key elements of self-regulating landscapes
- Benefits of restoration
- Resilience to climate variability, change, and other stressors

9:45 Break

10:00 Desired Condition Description — DC Team
What are Desired Conditions, how they were developed, why we need desired conditions

- Common vision
- Restoration target
- Measure success
- Wildlife Discussion as it relates to Desired Conditions — Richard

11:00 Desired Condition Panel — Corbin, Dave, Richard, Jim, Andrew, Pat

12:00 Description of the field visits (map) — ERI

12:15 Load into vans to travel to Blue Water Site (eat lunch along the way)

1:15 Review Blue Water Site — All

3:30 Return to Grants

4:00 Drive to Albuquerque on your own

(Holiday Inn Express Hotel & Suites Albuquerque, N. Balloon Fiesta Park 5401 Alameda Blvd NE Albuquerque, NM 87113)

Day 2: May 10

Start at the Holiday Inn Express parking lot (5401 Alameda Blvd NE Albuquerque, NM 87113)

8:00 Load into vans and travel to Santa Fe National Forest to review various sites that facilitate DC discussion. All travel to 3-5 different stops to look at dry-mixed conifer DC discussion points.

10:00 Stop 1 – East Fork Picnic Ground - three discussion points

- Goshawk management thin and evidence-based thin on The Nature Conservancy Collaborative Forest Restoration Project
- Dwarf mistletoe
- How this stand as-is fits into a DC landscape
- How advanced regeneration like this fits in the DC trajectory

12:00 Break for lunch. **Please bring your own, lunch is not provided.**

1:00 Stop 2 – Dry Mixed Conifer

- Untreated area; define dry mixed conifer
- Discussion of basic dry mixed conifer ecology
- Look at sample mark

3:00 Close Out – What have we learned? ERI – All

3:30 – 5:30 Travel home and arrive back at Holiday Inn

NORTHERN ARIZONA UNIVERSITY
ECOLOGICAL RESTORATION INSTITUTE
Box 15017 • Flagstaff AZ 86011 • 928.523.7182 • www.eri.nau.edu

DISK CONTENTS

ERI—Issues in Forest Restoration

Smoke from Prescribed Burning: Issues on public forest lands of the western United States

Forest Lands Health and Carbon Sequestration: Strengthening the case for Western forest restoration

Integrating Ecological Restoration and Conservation Biology: A case study from southwestern ponderosa pine forests

Public Perceptions of Forest Restoration in the Southwest: A synthesis of selected literature and surveys

Communications between Forest Managers and Property Owners in Pine Flats, Arizona: A case study of community interactions in a high fire hazard area

Wilderness Management and the Restoration of Fire: An analysis of laws and regulations in northern Arizona

Forest Service Contracting: A basic guide for restoration practitioners

Navigating the Motives and Mandates of Multiparty Monitoring

Case Study of a Community Stewardship Success: The White Mountain Stewardship Contract

What to Expect from Collaboration in Natural Resource Management: A synthesis for practitioners

Southwest Ecological Restoration Institutes (SWERI) Biophysical Monitoring Workshop Report

Designing a Framework for Evaluating the Impacts and Outcomes of Forest Service Appeals

Carbon Credits for Restored Western Dry Forests?

Exploring the Potential of Obtaining Carbon Credits for Restoration Activities on Navajo Tribal Forest Lands

Ecological Restoration as Economic Stimulus: A Regional Analysis

Integrating Domestic and Wild Ungulate Grazing into Forest Restoration Plans at the Landscape Level

Working Papers in Forest Restoration

Restoring the Uinkaret Mountains: Operational lessons and adaptive management practices

Understory Plant Community Restoration in the Uinkaret Mountains, Arizona

Protecting Old Trees from Prescribed Fire

Fuel Treatments and Forest Restoration: An analysis of benefits

Limiting Damage to Forest Soils during Restoration

Butterflies as Indicators of Restoration Success

Establishing Reference Conditions for Southwestern Ponderosa Pine Forests

Controlling Invasive Species as Part of Restoration Treatments

Restoration of Ponderosa Pine Forests to Presettlement Conditions

The Stand Treatment Impacts on Forest Health (STIFH) Model

Collaboration as a Tool in Forest Restoration

Restoring Forest Roads

Treating Slash After Restoration Thinning

Effects of Forest Thinning Treatments on Fire Behavior

Snags and Forest Restoration

Bat Habitat and Forest Restoration Treatments

Prescribed and Wildland Fire Use Fires in the Southwest: Do Frequency and Timing Matter?

Understory Seeding in Southwestern Forests Following Wildfire and Ecological Restoration Treatments

Controlling Cheatgrass in Ponderosa Pine and Pinyon-Juniper Areas

Managing Coarse Woody Debris in Fire-adapted Southwestern Forests

Restoring Spatial Pattern to Southwestern Ponderosa Pine Forests

Guidelines for Managing Small Mammals in Restored Ponderosa Pine Forests of Northern Arizona

Protecting Old Trees from Prescribed Burning

Fact Sheets

Accounting for Watershed and Other Resource Values: Consideration in the NEPA process

Canopy Cover and Canopy Closure

Carbon Costs of Mitigating High-severity Wildfires

Challenges and Opportunities in Forest Restoration Outreach: The Example of Southwestern Ponderosa Pine Forests

Collaborative Forest Restoration Program Monitoring Curriculum: Background and Activities for Ecological Monitoring

Compilation of Historical Forest Structural Characteristics across the Southern Colorado Plateau

Conserving and Restoring Old Growth in Frequent-fire Forests: Cycles of Disruption and Recovery

Dead Wood Plays Important Roles in Pinyon-Juniper Woodland Recovery after Wildfire

Defining Old Growth for Fire-adapted Forests of the Western United States

Ecological Restoration as Economic Stimulus II

Effectiveness of Post-wildfire Seeding in Western U.S. Forests

Effects of Restoration on Wildlife Density and Populations

Forest Restoration and Carbon Sequestration

Humans, Fires, and Forests: Social Science Applied to Fire Management (Workshop Summary)

Living among Frequent-fire Forests: Human History and Cultural Perspectives

Managing for Old Growth in Frequent-fire Landscapes

Methods for Estimating Surface Live Fuel Loading

Monitoring Old Growth in Frequent-fire Landscapes

Past, Present, and Future Old Growth in Frequent-fire Conifer Forests of the Western United States

Old-growth Policy

Post-Wildfire Fuels and Regeneration Dynamics

Restoration at the Landscape Scale: Western Mogollon Plateau Adaptive Landscape Assessment

Social Science to Improve Fuels Management: A Synthesis of Research on Collaboration

Socio-economic Barriers to Landscape-scale Restoration

Spatial Pattern Terms Comparison

Systematic Reviews and the Quality of Evidence

The Economic Value of Selling Carbon Credits by Restoring the Navajo Nation's Tribal Forests

The Role of Old-growth Forests in Frequent-fire Landscapes

The Tribal Perspective of Old Growth in Frequent-fire Forests—Its History

Using a Terrestrial Ecosystem Survey to Estimate the Historical Density of Ponderosa Pine Trees in Northern Arizona

Evidence-based Systematic Reviews

Does Seeding After Severe Forest Fires in Western USA Mitigate Negative Impacts on Soils and Plant Communities?

How do Thinning and Burning Treatments in Southwestern Conifer Forests in the United States affect Wildlife Density and Population Performance?

Other ERI Publications

Exploring Barriers to Collaborative Forestry

Multiparty Monitoring Handbook 1: What is Multiparty Monitoring?

Multiparty Monitoring Handbook 2: Developing a Multiparty Monitoring Plan

Multiparty Monitoring Handbook 3: Budgeting for Monitoring

Multiparty Monitoring Handbook 4: Monitoring Ecological Effects

Multiparty Monitoring Handbook 5: Monitoring Economic and Social Effects of Forest Restoration

Multiparty Monitoring Handbook 6: Analyzing and Interpreting Monitoring Data

Photographic Guide to Pinyon and Juniper Maturity Classes

Stewardship Contract for Landscape-scale Projects

ERI Authored Articles and Reports in Federal and Non-profit Publications

A Demonstration Project to Test Ecological Restoration of a Pinyon-Juniper Ecosystem

Changes in Gambel Oak in Southwestern Ponderosa Pine Forests since Euro-American Settlement

Changes in Ponderosa Pine Forests of the Mt. Trumbull Wilderness

Characteristics of Buckbrush Shrubs Exposed to Herbivores after Seven Years of Protection

Dynamics of Buckbrush Populations under Simulated Forest Restoration Alternatives

Estimating Soil Seed Bank Characteristics in Ponderosa Pine Forests Using Vegetation and Forest-floor Data

Historical and Modern Disturbance Regimes of Pinyon-Juniper in the Western U.S.

Pinyon-Juniper Fire Regime: Natural Range of Variability

Quantifying Forest Reference Conditions for Ecological Restoration: The Woolsey Plots

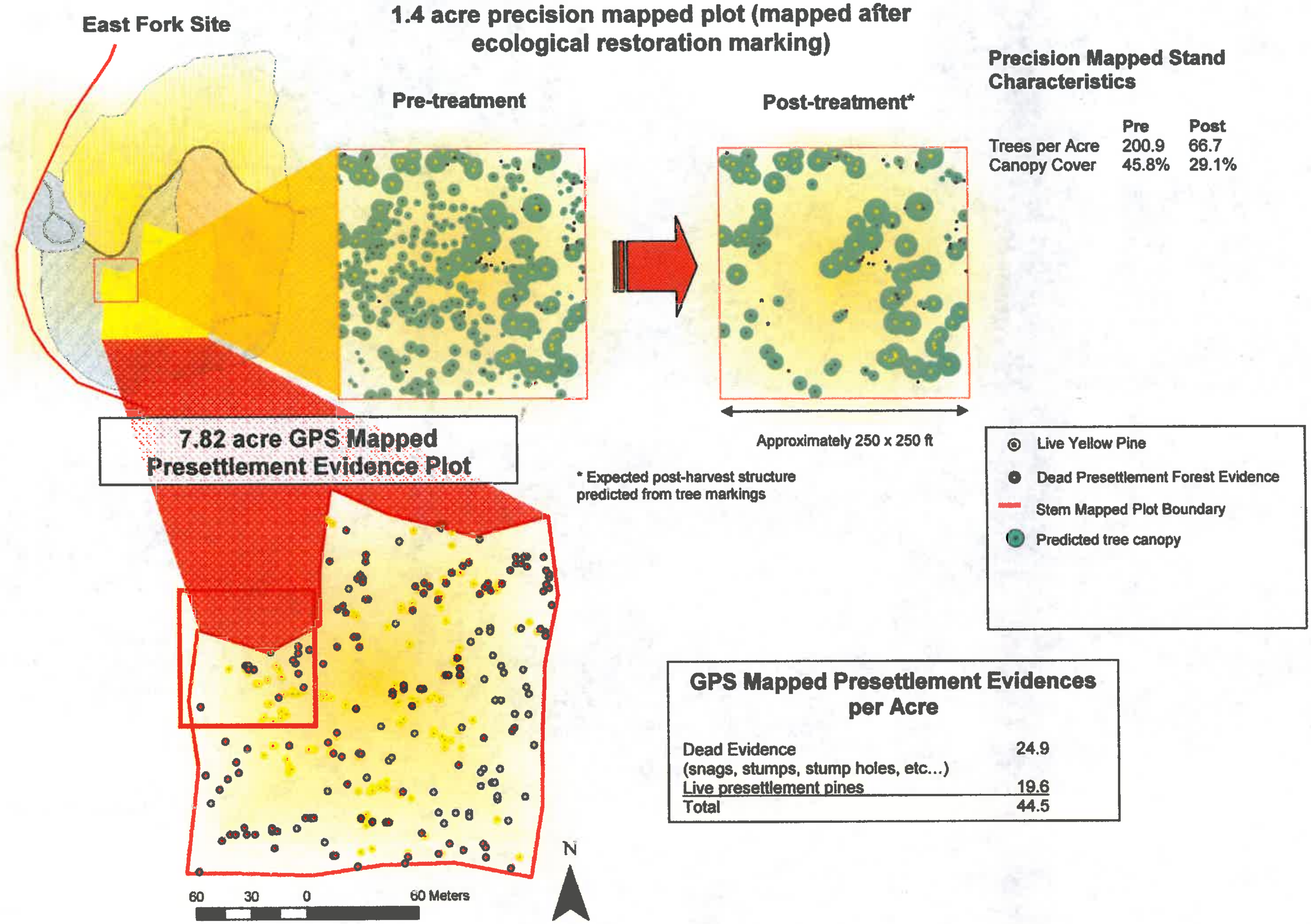
Restoration of Forest Ecosystem Western Long-needled Pines

Other Publications with ERI Involvement

Analysis of the Small-diameter Wood Supply in Northern Arizona

Statewide Strategy for Restoring Arizona's Forests

East Fork Stem Mapped Macroplots



Precision Mapped Stand Characteristics

	Pre	Post
Trees per Acre	200.9	66.7
Canopy Cover	45.8%	29.1%

GPS Mapped Presettlement Evidences per Acre

Dead Evidence (snags, stumps, stump holes, etc...)	24.9
Live presettlement pines	19.6
Total	44.5

Restoration of Western Frequent Fire Forests: An Evolutionary Perspective of Desired Conditions

Wally Covington
School of Forestry
and
The Ecological Restoration Institute
Northern Arizona University

Overview

- Where are we?
- Where have we been
- How did we get here?
- Where are we going?
- What should we do?

The greater ecosystem of the West are in widespread decline

- Greater ecosystems are regional complexes of ecosystems
- Generally 1-10 million acres in size
- Have common landscape-level characteristics
- Linked by: 1) wide ranging wildlife, 2) landscape scale disturbance regimes, and 3) human social and political systems.

What is ecological restoration?

- Based on evolutionary biology and ecosystem ecology
- Reference conditions are fundamental—natural patterns and processes are the starting poing
- Departures from reference conditions should be based on best available science
- Maintenance of restored landscapes involves a broad set of options from allowing for self-regulation to active management

Where are we?
The greater ecosystems of the West are exhibiting alarming disease symptoms

- Population irruptions and population crashes
- Spread of invasive exotic plants
- Decreasing diversity, increasing homogeneity at all levels of the ecosystem
- Unnatural disturbance regimes: fire, insects
- Trajectory of spiraling decline of ecological and social system health
- Declines are greatest in frequent fire forests

Evolutionary ecology of frequent fire forests

- Ponderosa pine, the archetypal frequent fire tree, exhibits morphological and physiological adaptations to frequent surface fire
- Shows up in fossil record 70 million ybp
- At 25 million ybp evidence from SW Colorado
- Communities of organisms have tracked favorable climatic regimes up and down in elevation and latitude over time
- Self-regulating processes have assured persistence in the face of climate change

"Our view of the past is compromised by our failure to recognize the uncharacteristic nature of the present."

Evolutionary biologist Stephen Jay Gould, 1991

Climate and CO_2 fluctuations have been common throughout evolutionary time

- Frequent fire forest have been resilient to wide swings in temperature and CO_2
- CO_2 during the early Eocene (58-48 M ybp) was over 1100 ppm, compared to today's concentration of 387 ppm up by 80 ppm since 1940
- Sudden (within 100 yr) 4-6 degree C changes in temperature are common throughout the fossil record
- Frequent fire forests have been resilient to these changes under natural densities and self-regulatory mechanisms such functional redundancy and frequent fire.

What is coming at us?

"... we anticipate an acceleration of historical changes in the Inland West including increased fuel accumulations, lengthened fire seasons and intensified burning conditions, all contributing to larger and more catastrophic fires."

From "Historical and Anticipated Changes in Forest Ecosystems of the Inland West of the United States." Covington, Everett, Steele, et al. 1994

How did we get here?

Overgrazing
Predator "control"
Fire exclusion
Overcutting of old-growth trees
Failure to control density of young trees
Introduction of invasive exotic species
Unplanned, poorly engineered road systems
Inadequate social system futuring/adaptation

Crownfires are the latest in a long series of symptoms of declining ecosystem health

- Loss of herbaceous cover
- Increased erosion
- Tree population explosions
- Watershed degradation
- Loss of plant and animal diversity
- Loss of esthetic values
- Unnatural insect and disease epidemics
- Shift to catastrophic crownfires
- Destruction of human and wildlife habitats

The catastrophic fire seasons of 2000, 2002 and 2011 were predicted; the trend will continue

Environmental Impacts

- Costs of fire suppression
- Homes and infrastructure
- Wildlife and human habitats
- Air quality and carbon dioxide balance
- Watersheds and water quality and supply
- Recreation facilities
- Evacuation costs
- Tourism
- Timber
- Cultural and archaeological sites
- Rehabilitation and restoration costs
- Public health

Large landscape scale beetle and defoliator epidemics are here and becoming common.

"If we are serious about practicing land health then, we have to know what we the land was like to begin with."

Aldo Leopold 1947.

Reference conditions vary with soil type, elevation, and climatic regime

Broad similarities exist, but variations in pattern and processes do occur

- Fort Valley Experimental Forest AZ
- Pringle Falls Experimental Forest OR
- Black Hills National Forest SD

Reference Restoration Thinning Treatment

- Retain trees which predate settlement
- Retain postsettlement trees needed to re-establish presettlement structure
- Thin and remove excess trees
- Rake heavy fuels from base of trees
- Burn to emulate natural disturbance regime
- Seed with natives/control exotics

Change Basic Prescription for Specific Resource Objectives

- Might leave more trees to accommodate specific resource management objectives, e.g., screening cover for human or wildlife habitat goals, future wood harvesting, favoring specific uses
- Might leave fewer trees to accommodate other objectives, e.g., to favor viewsheds, wildlife goals, grazing, water balance

Alternative Restoration Thinning Prescriptions Produce Very Different Outcomes for Fire Behavior and Resource Responses: There Appear to be Thresholds

Burn Only

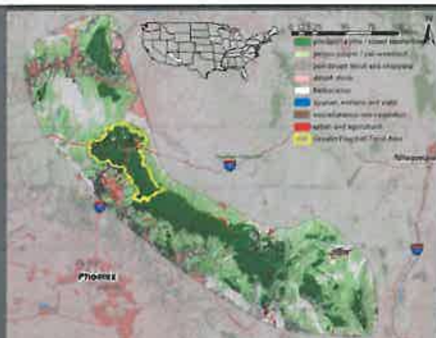
Minimal Thinning

Full Restoration

Predicted Fire Characteristics
June 97th-percentile weather, 30 mph

	1876	1997	1.5:1	3:1
Tree/ac	47	383	70	141
Fire type	**surface**	**active**	**surface**	**passive**
% crown	0	100	20	69
btu/ft^2	491	2331	673	1790
herbage	856	112	571	134

Comprehensive ecosystem restoration approaches not only reduce crownfire threat, but also improve forest health and resource use opportunities for present and future generations.



We must think and act at a scale and pace appropriate to the forest health crisis.

What is the role of SWERI?

- Evidence-based decisions are fundamental
- Knowledge synthesis
- Knowledge discovery
- Knowledge translation
- Knowledge transfer
- Cooperative knowledge application
- Central is pursuit of relevant knowledge in direct support of ongoing implementation
- Neutral unbiased convener for collaboration

This is a big problem--but we can solve it

- Restoration based approaches are proven at a small scale (1000+ ac)
- They must be tested and refined as we apply them at large scales (1,000,000+ ac) in an adaptive management approach
- Multi-scaled collaborative adaptive approaches must be based on solid science
- Communities and local gov'ts. have major leadership roles to play in this effort

"Between the two extremes of blindly following nature on the one hand and open revolt against her on the other, lies a broad area for working in harmony with natural tendencies."

Forest ecologist Henry J. Lutz 1969.

SETTING THE STAGE FOR DESIRED CONDITION DIALOGUE

DESIRED CONDITION WORK SHOP

PURPOSE OF WORKSHOP

Initiate a Desired Condition dialogue related to ponderosa pine and dry mixed conifer forest types to guide landscape-scale restoration and inform Forest Plan revision in Region 3.

OBJECTIVES OF WORKSHOP

1. Begin a dialogue about desired conditions for Forest vegetation types
2. Share the Forest Service's Desired Condition perspective
   a. Share the current Desired Conditions for ponderosa pine and dry mixed conifer.
   b. Explain why they are important to our landscape scale restoration efforts.
3. Present a clear picture of Desired Conditions and gain a common understanding through field visits that illustrate Desired Conditions, function, and processes.
4. Hear social and scientific perspectives about desired conditions from others interested parties.
5. Explain how the Desired Conditions will be used in Forest Plan revision, and landscape and small scale project development.
6. Explain how the Desired Conditions can be used as a measure of success.

OVERVIEW OF DESIRED CONDITION

The desired conditions describe tree species compositions, densities, structural and age-class distributions, as well as spatial distribution of trees. Specific to some of the forest types (ponderosa pine and dry mixed conifer), the composition, location, and amount of grass/forb/shrub openings (the degree of openness) is described , as are the dimensions, spatial distributions, amounts and densities of snags, down logs, woody debris, and various natural processes such as nutrient cycling, trophic interactions, fire, insect, and diseases. Because the desired conditions incorporated forest dynamics – the spatial and temporal changes resulting from vegetation growth and succession and periodic resetting of these by natural and human-caused disturbances such as fire, wind, insects, diseases, and tree harvests – they describe forest and woodlands as shifting mosaics of different vegetation structural (age) classes and/or successional stages. This dynamic is described at three spatial scales (fine scale, mid-scale and landscape scale) and incorporate six forest ages classes (seedling, saplings, young, mid-aged, mature, and old forest). Refer to Tables 1 and 2 for comparisons of current and desired forest conditions for ponderosa pine and dry mixed conifer by characteristic and function.

SCIENTIFIC BASIS OF DESIRED CONDITION

The process used to develop the desired conditions involved syntheses of scientific information on habitats of native plants and animals, their food webs, the ecologies of the dominant over story and understory vegetation and the types, frequencies, and intensities of natural and anthropogenic disturbances typical of the forest types. As a result of (1) the synthetic process used to develop the desired conditions, (2) the breadth of ecological knowledge on the composition, structure, and ecological function included in the syntheses, and (3) the incorporation of natural disturbances that shaped the historic conditions within ecosystems, the desired conditions fall within the range of natural conditions of each forest type. This suggests that the desired conditions are both attainable and sustainable. Natural conditions provide a good estimate of a functioning and sustainable system and are a powerful basis for evaluating desired condition. The scientific literature supporting the key characteristics and functions of these desired conditions are included in the summary of supporting science document attachment B.

BENEFITS OF DESIRED CONDITION

Desired conditions describe the characteristics necessary to restore and sustain ecosystems including structure, composition, landscape patterns, and processes and provide for habitats of native wildlife species including the Mexican spotted owl and the northern goshawk. They promote ecosystem functionality, hydrological function, reduce fire hazard, and provide for abundant and well-distributed old growth as a sustainable forest component.

RELATIONSHIP BETWEEN FOREST PLANS AND DESIRED CONDITION

Desired conditions are the foundation of current Forest Plan development. They describe the goals and outcomes of forest management and 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. 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.

ADAPTIVE NATURE OF DESIRED CONDITION

Desired conditions are a work in progress and will change over time as new scientific information is developed and as we adapt them to new monitoring information from ongoing efforts such as the Four Forest Restoration Initiative.

DESIRED CONDITION EXPRESSED AS A RANGE ACROSS THE REGION

Desired condition characteristics are expressed in ranges, as opposed to traditional target metrics, to account for natural variation in composition and structure that occurs within a vegetation type as well as for social and economic considerations. Desired conditions will vary somewhat within a vegetation type due to spatial variability in soils, elevation, or aspect.

Table 1: Comparison of Current and Desired Condition by Forest Characteristic (Ponderosa Pine and Dry Mixed Confer Forest Types)

Characteristic	Current condition	Desired condition
Species composition	PP type: ponderosa pine and other minor species, little if any oak and other shade intolerant species Dry MC type: species composition shifting towards shade-tolerant species (white-fir, blue spruce). Shade intolerant species becoming sub-dominant.	PP type: ponderosa pine is dominant, but other shade intolerant species are present depending on appropriate local site conditions (ie: juniper species, oak and other hardwood species) Dry MC type: dominated by shade intolerants species (ponderosa pine, Douglas-fir, white pine, aspen), other species present but are sub-dominant
Forest tree density	Most sites > 80 sq ft of ba/acre	PP type: 20-80 sq ft of ba/acre Dry MC type: 30-100 sq ft of ba/acre
Spatial distribution	Typically even to random spacing, little in the way of tree groups	Groups of trees separated by forest openings
Forest openings occupied by grass/forb/shrub vegetation	Typically few openings with limited grass/forb/shrub vegetation	Openings are generally from 30% to 60% of the area occupied by grass/forb/shrub veg: 10% and 70% representing the extremes
Tree ages	Typically single- and two- aged forests = even-aged	All ages present, young, mid and old = uneven-aged
Habitats, biodiversity and food webs	Typically little biodiversity, primarily conifer tree cover, limited understory herbaceous/shrub composition due to closed canopy	Much greater biodiversity, multiple tree species; oak, aspen, and other hardwoods and broad number of herbaceous grass/forb/shrub species due to openings
Snags/acre, down woody material	Typically < 2/acre, generally greater than 7 tons per acre	1-2 Snags/Acre 18 inches DBH PP type: 3-7 tons per acre Dry MC type: 5-15 tons per acre

Note we are not likely to achieve desired condition in one treatment. It may take many years or even decades depending on how departed current condition is from desired.

Table 2: Comparison of Current and Desired Condition by Forest Function (Ponderosa Pine)		
Characteristic	**Current Condition**	**Desired Condition**
Fire Behavior/frequency and effects Surface fire, Crown fire potential passive and active	Fires infrequent become uncharacteristic resulting in active crown fire on a large scale (high mortality): limited nutrient cycling	Fires frequent, primarily surface fire, do not spread between tree groups as crown fire (low mortality): promotes nutrient cycling
Hydrologic function	Typically little precipitation penetration of closed canopy, most lost to evaporation and transpiration	Precipitation reaching the forest floor, improved infiltration, surface flow, soil moisture, herbaceous cover.
Visual attributes	Limited visual diversity due to dense even-aged continuous tree stands, limited viewing opportunities.	Improved visual diversity due to openness between the groups of trees. Greater variety due to tree age diversity and density variation
Sustainability and resilience	Limited resilience to insects, diseases, uncharacteristic fire, climate variability, change, and other stressors. Not sustainable over time	Increased resilience to insects, diseases, uncharacteristic fire, and climate variability, change and other stressors. Sustainable over time.

Desired Conditions Descriptions by Forest Types

PONDEROSA PINE (bunchgrass and Gambel oak subtypes)

The ponderosa pine forest vegetation community includes two subtypes: 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 conditions (10,000 + acres)

At the landscape scale, 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 open grass-forb-shrub interspaces, an association similar to historic patterns. Openings typically range from 10 percent in more productive sites to 70 percent in the less productive sites, based upon the make-up and aggregation of mid-scale units. Size, shape, number of trees per group, and number of groups per area are variable across the landscape. 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 5 to 14 tons per acre with areas of Ponderosa Pine Gambel oak in the lower range and ponderosa pine bunchgrass in the higher range.

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. 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 conditions (100 -1,000 acres)

At the mid-scale 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. Openings typically range 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 90 square foot basal area per acre.

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.

Fine-scale conditions (<10 acres)

Trees typically occur in irregularly shaped groups and are variably-spaced with some tight clumps. Crowns of trees within the mid-aged to old groups are interlocking or nearly interlocking. Openings surrounding tree groups are variably-shaped and comprised of open grass-forb-shrub interspaces. Some 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, and may range from a few trees to 0.75 acres, but occasionally 1+ acres in size (Table 4). Groups at the mid-aged to old stages consist of 2 to 70+ trees per group. A spectrum of group sizes is desired.

***Ponderosa Pine* - Evergreen Oak**

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 the 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 a relatively minor shrub component; and one with an understory of primarily evergreen shrubs including manzanita, turbinella oak, sumac species, and mountain mahogany species.

***Ponderosa Pine* - Evergreen Oak (perennial grasses subtype)**

Landscape-scale conditions (10,000+ acres)

At the landscape scale, 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; 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 open grass-forbs-shrub interspaces similar to historic patterns. Openings typically range from 10 percent in more productive sites to 70 percent in the less productive sites. Shrubs occur in low to moderate densities so as 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.

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. 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. 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 conditions (100 - 1000 acres)

At the mid-scale 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. Openings typically range 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 90 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. Small areas of even-aged forest structure are present. The mix of natural disturbances sustains the overall age and structural distribution.

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.

Fine-scale 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. Openings in between tree groups are variably-shaped and comprised of open grass-forb-shrub interspaces. Some 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 may range from a few trees to 0.75 acres, but are occasionally 1+ acres in size. Groups at the mid-age to old stages typical range from 2 to 70+ trees. A spectrum of group sizes is desired.

Ponderosa Pine* - *Evergreen Oak (evergreen shrub subtype)

Landscape-scale conditions (10,000+ acres)

At the landscape scale, 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. Openings typically range 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. 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.

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 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; 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. 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 conditions (100-1000 acres)

At the mid-scale 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. Openings typically range 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 90 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.

Fires are of low- to mixed-severity burning on the forest floor as well as in the overstory. Crown fires occur in small patches.

Fine-scale 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. Openings in between tree groups are variably-shaped and comprised of shrubs and limited grass cover. Some 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 are greater than 0. 5 acre, and may be 1+ acres. A spectrum of group sizes is desired.

Dry Mixed-Conifer

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 5,500 to 9,500 feet, depending upon aspect. It is very common for dry mixed-conifer forest types to occupy the north-facing slopes, and ponderosa pine forests the south-facing slopes at the lower elevations of the range. At the upper elevations of the range, this is often reversed, with dry mixed-conifer forests occupying south slopes, while wetter mixed conifer types are found on the north-facing slopes. 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, but typically does not form a seral forest cover type. This forest vegetation community typically occurs with open grass-forb-shrub interspaces.

Landscape-scale conditions (10,000 + acres)

At the landscape scale, 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 open grass-forb-shrub interspaces similar to historic patterns. Openings typically range 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.

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. Downed logs (>12 inch diameter at mid-point, >8 feet long) average 3 per acre within the forested area of the landscape. Coarse woody debris, including downed logs, ranges from 8 to 16 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 and herbaceous vegetation provide protection of soil, moisture infiltration, and contribute to plant and animal diversity and to ecosystem function. 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 conditions (100 -1,000 acres)

At the mid-scale 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. Openings typically range from 10 percent in more productive sites to 50 percent in the less productive sites. Tree density within forested areas generally ranges from 40 to 125 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.

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

Fine-scale conditions (< 10acres)

Trees typically occur in irregularly shaped groups and are variably-spaced with some tight clumps. Crowns of trees within the mid-aged to old groups are interlocking or nearly interlocking. Openings surrounding tree groups are variably-shaped and comprised of open grass-forb-shrub interspaces. Some 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 0.25 acre, but occasional patches may be 1 acre or greater). Groups at the mid-age to old stages consist of 2 to 70+ trees per group. A spectrum of group sizes is desired. Where the understory plant composition is dominated by grasses and forbs, fire severity is lesser and tree groups are smaller in size. Where the understory plant composition is dominated by shrubs, fire severity is greater and tree groups are larger in size.

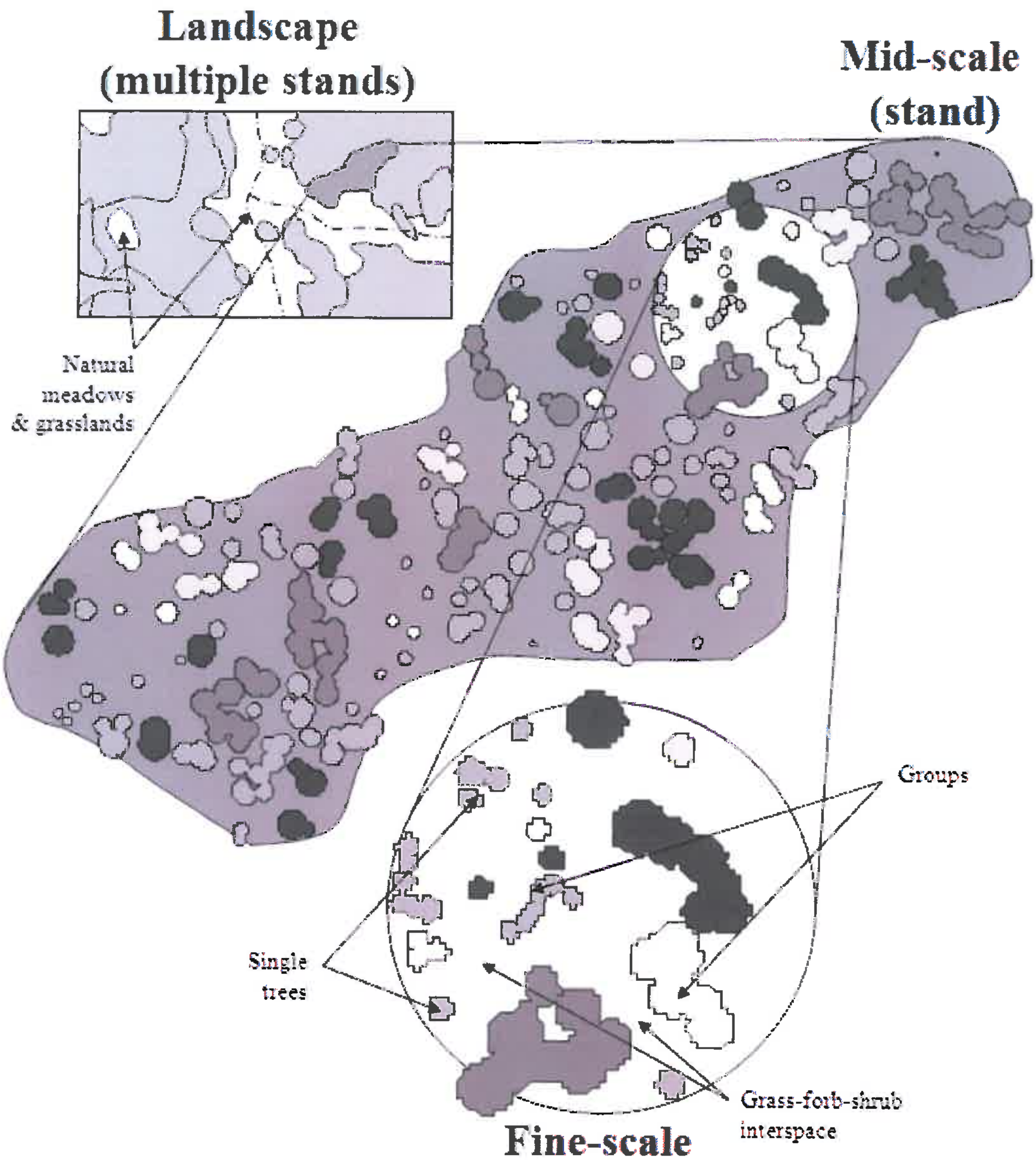


Figure 1. Conceptualized forest reference conditions at three spatial scales. The landscape-scale illustrates multiple stands and natural meadows and grasslands. The mid- and fine-scales illustrate open grass-forb-shrub interspaces and uneven-aged stand conditions consisting of single and grouped trees of different vegetation structural stages, young to old, represented by different shades and sizes.

DESIRED CONDITIONS DIALOGUE WORKSHOP

May 9-10, 2012

OBJECTIVES

- Begin a dialogue on desired forest conditions to develop a common understanding and a framework for shared learning
- Describe desired conditions for ponderosa pine and dry mixed conifer forests
- Describe links between desired conditions and ecological restoration
- Discuss use of desired conditions as a target and measure of success

Development of R3 Desired Conditions

- DC team commissioned in 2008
- History of development
  - DC developed for Forest Plan Revision
  - Iterative and adaptive process
- DCs used in project level development
- Based on best available science for forest ecology, wildlife ecology, natural range of variability, etc.

Desired Condition Team

Christine Dawe
Roy Hall
Bruce Higgins
Emily Irwin
Pat Jackson
Ronnie Maes
Mike Manthei
Tessa Nicolet
Richard Reynolds
Joe Stringer
Linda Wadleigh
Jim Youtz

Desired Conditions: key elements

- Tree species and age composition
  - Sustaining a balance of tree ages
- Spatial characteristics of forests
  - Tree groups: size, density, arrangement
  - Openings: composition, size, arrangement
- Processes and Functions
  - Biological diversity, foodwebs, hydrologic processes, nutrient recycling, etc.
  - Disturbances (fire, insects, disease, windthrow) at natural frequencies and levels

P Pine vs Dry Mixed conifer

Similar structure and function

P pine

- Ponderosa pine dominated
- Dryer and warmer
- Less productive

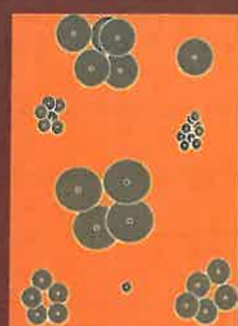
Dry MC

- Mix of conifers w/ ponderosa pine
- Cooler and wetter
- More productive
  - larger, denser groups
  - smaller openings

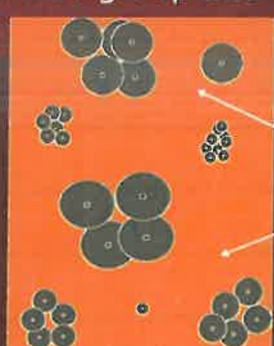
Desired Forest Conditions

Spatial and Age Characteristics

- Trees grouped with interlocking crowns
- Openings between tree groups
- All age classes and as much old forest as is ecologically sustainable
- High interspersion of age classes



Tree group size and variability



Group size ranges from a few trees to as many as 70 trees up to ¾ acre in size

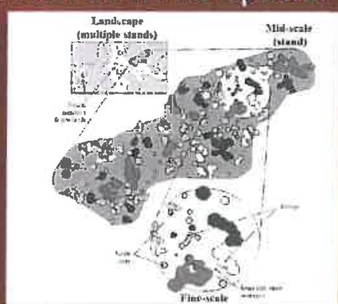
Openness Variability

72% of area is open grass/forb/shrub

28% is under mid-old tree cover

Open area, grass/forb/ shrub

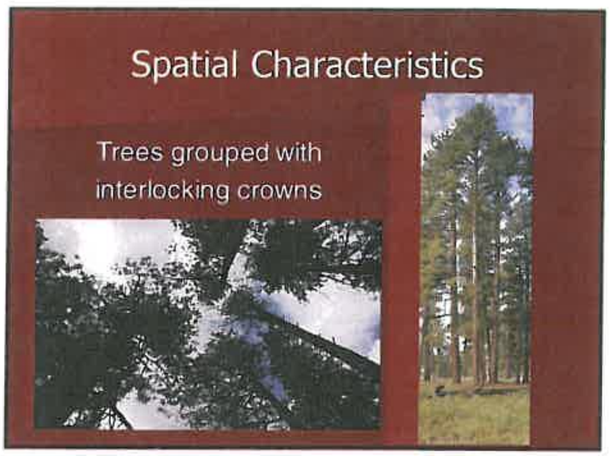
Conceptualized forest reference condition at three spatial scales

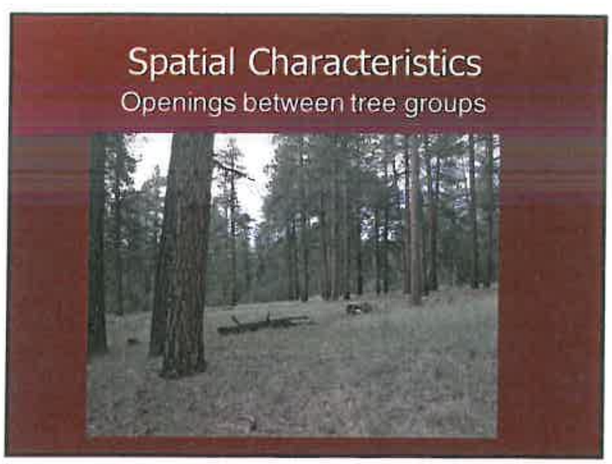


Spatial and Age Characteristics

"Historical" Condition Fort Valley Experimental Forest (1940)

Grass/ seedlings
Poles
Blackjack
Yellow pine


Spatial Characteristics
Trees grouped with interlocking crowns


Spatial Characteristics
Openings between tree groups

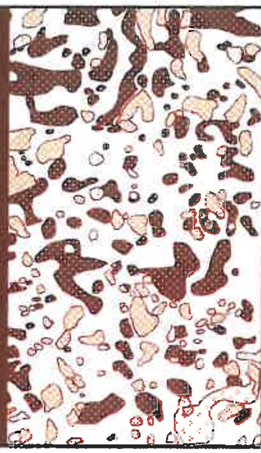
Tree Age

All age classes and as much old forest as is ecologically sustainable

Spatial and Age Characteristics

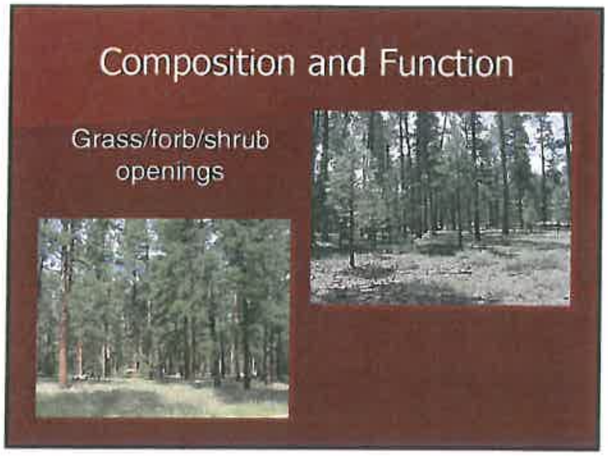
"Historical" Condition
Fort Valley Experimental Forest (1940)

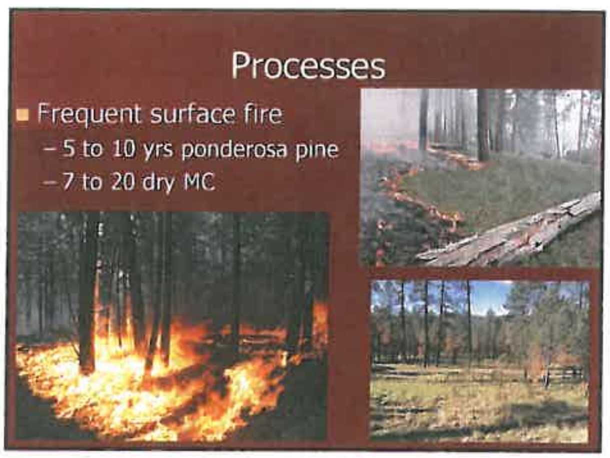
Grass/ seedlings
Blackjack
Poles
Yellow pine



Age and Function

Large tree components
- Big trees
- Snags
- Logs
- Woody debris


Composition and Function
Grass/forb/shrub
openings


Processes
Frequent surface fire
– 5 to 10 yrs ponderosa pine
– 7 to 20 dry MC


Sustainability: Growth
of Tree Groups
(Aging Process)
Mid-aged forest
4
Young forest
3
Seedling-sapling
2
Mature forest
5
Grass/forb/shrub
1
Old forest
6

Concepts

- Desired Conditions are a work in progress
  - Will be adapted to new science/information
- Desired Condition characteristics are presented in ranges, not single targets, to account for variability across most of a landscape. For p pine:
  - Percent of area in openings, 30-60%
  - Typically 20 to 90 sq ft/BA per acre
  - Generally 3 to 7 tons woody debris per acre
- Desired Condition at three scales
  - Landscape
  - Mid scale
  - Fine scale

Links between desired conditions and ecological restoration

- The Desired Conditions fall within natural historic conditions
- Natural conditions are a good example of functioning, sustainable, and resilient ecosystems
- Attaining the Desired Conditions will achieve restoration objectives

Application of Desired Conditions

Characteristic	Current Condition	Desired Condition
Forest Openings	Few openings	Openings generally are 30% to 60% of area, 10% and 70% are extremes of range
Spatial distribution of trees	Even to random spacing, minimal to no tree groups	Groups of trees separated by openings
Tree ages	Primarily single- or two-aged forest	Balance of ages, young, mid, old

Challenges

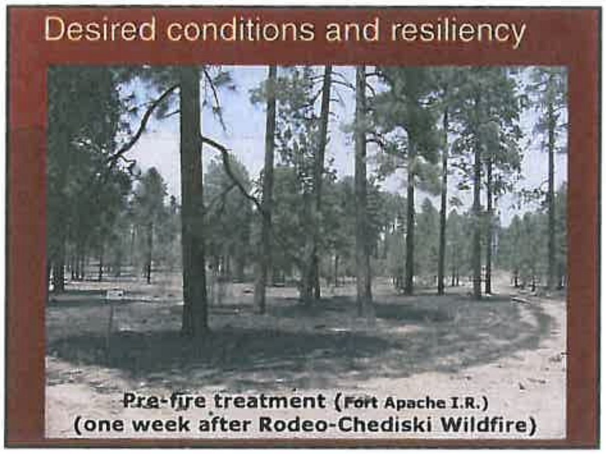
- Desired Conditions may not be attainable in a single treatment
- Operational feasibility (funding, workforce, industry capacity, etc.) may constrain our ability to achieve desired conditions everywhere
- Necessitates prioritizing landscapes and strategies for achieving desired conditions
- Maintenance of desired conditions

Outcomes of Desired Conditions

- Reduced severity of fire effects
- Reduced fire hazards and increased flexibility for managing fires
- Increased resilience to climate variability and change, insects, disease

Outcomes (cont)

- Sustainable old growth condition
- Restored hydrologic function
- Sustainable wood supply
- Improved forage production
- Enhanced visual quality
- Improved plant and animal habitat, biodiversity, foodwebs


Desired conditions and resiliency
Pre-fire treatment (Fort Apache I.R.)
(one week after Rodeo-Chediski Wildfire)

Desired Conditions: Habitat, Biodiversity, and Foodwebs

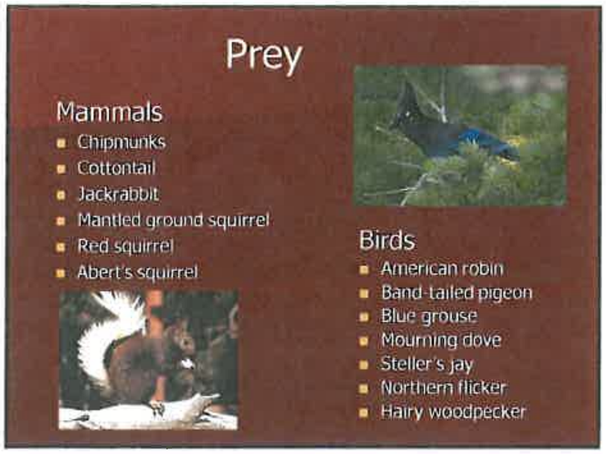
The northern goshawk as an example

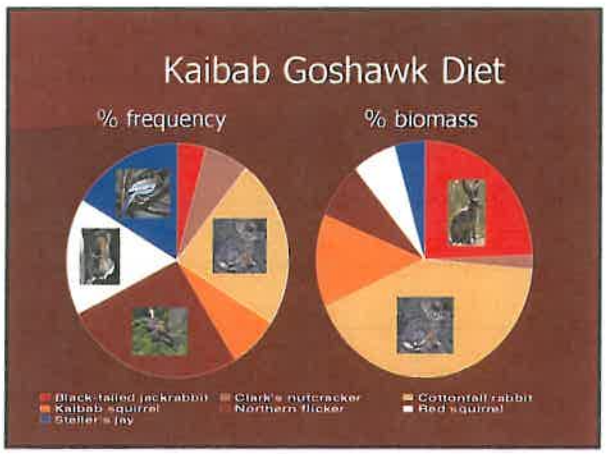
Morphological and Behavioral Characteristics

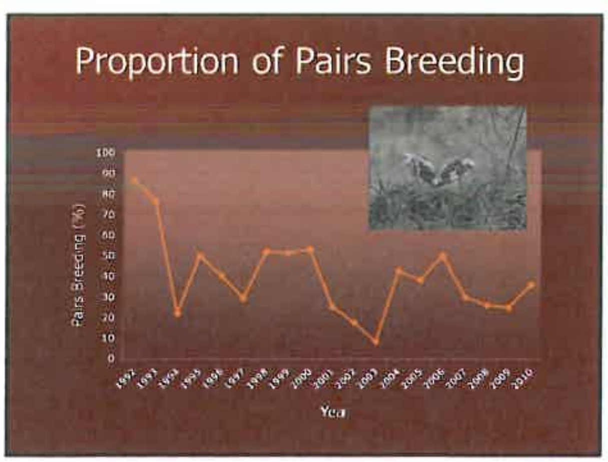
- Adapted to forest environments
- Long tail, short wings
- Sub-canopy forager
- Primarily perch hunter
- Short-sit, short-flight hunting behavior
- Searches for prey in low vegetation column
- Broad diet

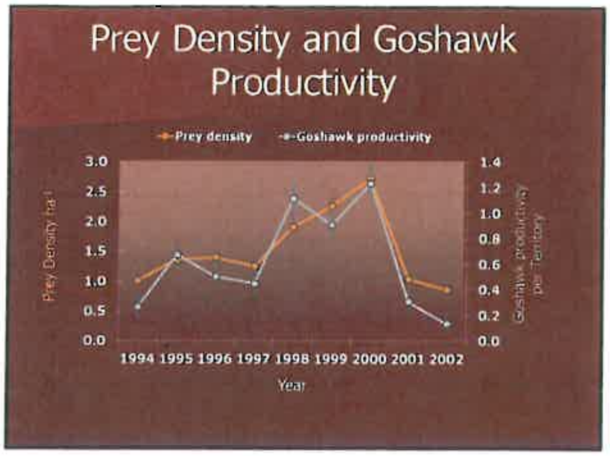
Foraging Habitat

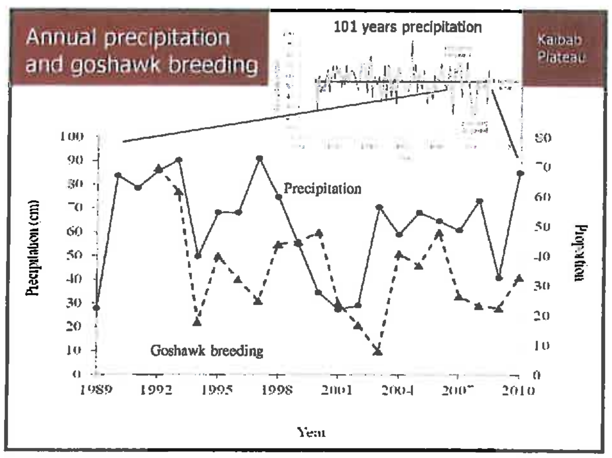
- Occupies many forest types
- Forest structure
  - Lifted crowns (mature forests)
  - Open understory (flight space)
  - Hunting perches
- Strong evidence of food limitation

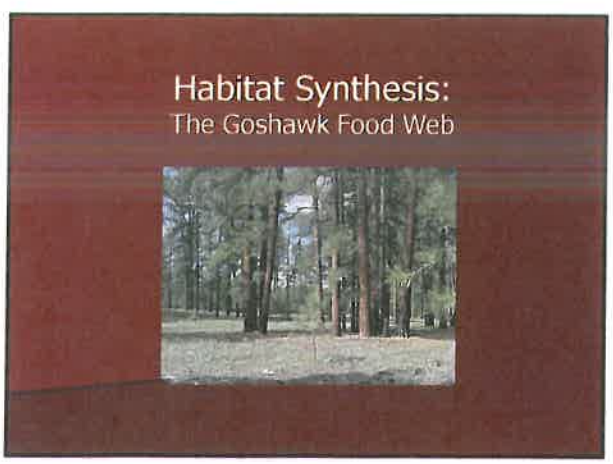

Prey
Mammals
Chipmunks
Cottontail
Jackrabbit
Mantled ground squirrel
Red squirrel
Abert's squirrel
Birds
American robin
Band-tailed pigeon
Blue grouse
Mourning dove
Steller's jay
Northern flicker
Hairy woodpecker


Kaibab Goshawk Diet
% frequency
% biomass
Black-tailed jackrabbit
Kaibab squirrel
Steller's jay
Clark's nutcracker
Northern flicker
Cottontail rabbit
Red squirrel


Proportion of Pairs Breeding
Pairs Breeding (%)
100
90
80
70
60
50
40
30
20
10
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

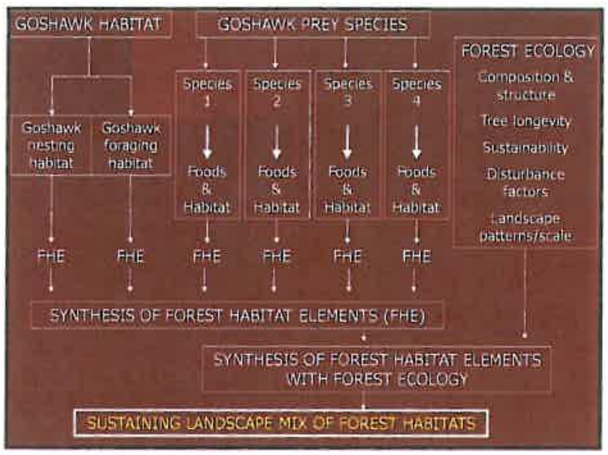

Prey Density and Goshawk Productivity
Prey density
Goshawk productivity
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1994 1995 1996 1997 1998 1999 2000 2001 2002
Year


Annual precipitation and goshawk breeding
101 years precipitation
Kaibab Plateau
Precipitation (cm)
Precipitation
Goshawk breeding
1989 1992 1995 1998 2001 2004 2007 2010
Year


Habitat Synthesis:
The Goshawk Food Web

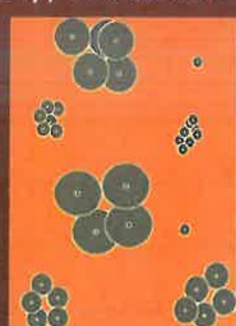
Management Recommendations for the Northern Goshawk in the Southwestern United States

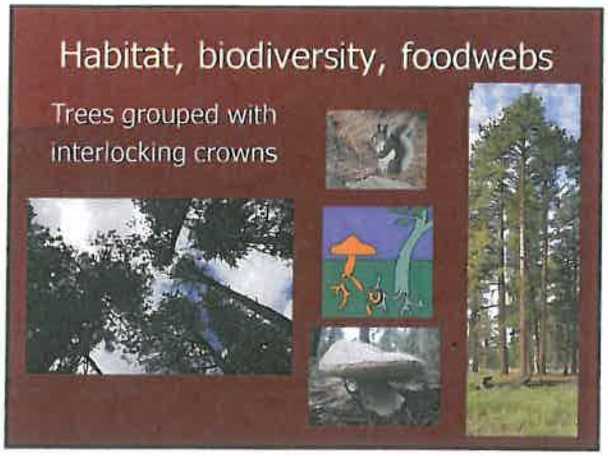
- Richard T. Reynolds
- Russel T. Graham
- M. Hildegard Reiser
- Richard L. Bassett
- Patricia L. Kennedy
- Douglas A. Boyce, Jr.
- Greg Goodwin
- Randall Smith and
- E. Leon Fisher

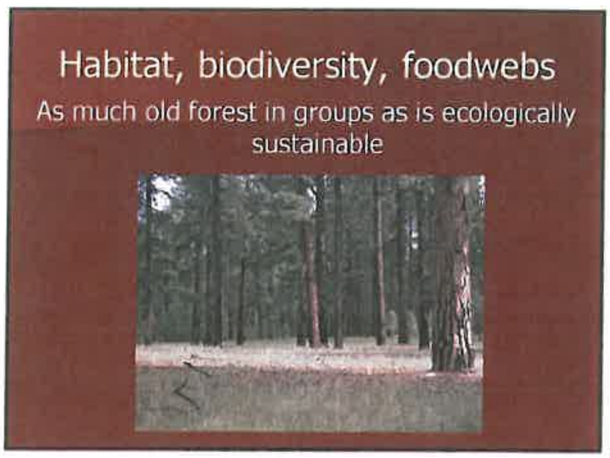


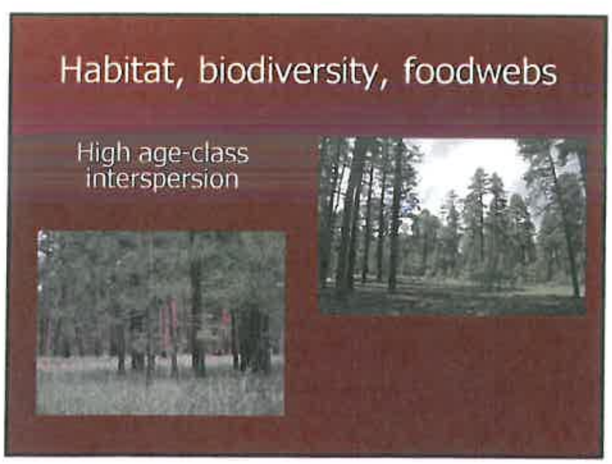
Habitat, biodiversity, foodwebs

- Trees grouped with interlocking crowns
- Grass-forb-shrub openings between tree groups
- All age classes and as much old forest as is ecologically sustainable
- High interspersion of age classes



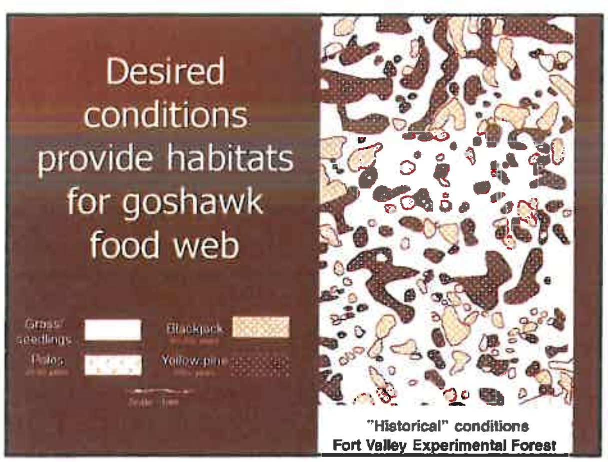

Habitat, biodiversity, foodwebs
Trees grouped with interlocking crowns


Habitat, biodiversity, foodwebs
As much old forest in groups as is ecologically sustainable


Habitat, biodiversity, foodwebs
High age-class interspersion


Habitat, biodiversity, foodwebs
Large tree component provides:
– Snags
– Logs
– Woody debris


Habitat, biodiversity, foodwebs
grass/forb/shrub


Desired conditions provide habitats for goshawk food web
Grass/ seedlings
Blackjack
Poles
Yellow pine
"Historical" conditions
Fort Valley Experimental Forest

Unique elements

- Multi-species focus, not single species!!
- Food web approach
  - Information across trophic levels
- Desired conditions are:
  - Ecosystem specific, different DCs for different forest types

Unique Elements

- Landscape ecology
  - Multiple goshawk home ranges = landscape scale
  - 1,000-year planning horizon incorporates forest growth and succession
  - Spatial & temporal shifting mosaic of habitats
- Forest Restoration
  - Natural composition, structure, and pattern of forest use as guides for assembling habitats
  - Restores natural disturbances, processes, and forest health (productivity)

Summation

- Small groups of trees with interlocking crowns

- Scattered single trees
- Grass-forb-shrub open interspaces between groups

- Snags, logs, woody debris
- Spatial and temporal distribution of the above

The Southwestern Region of the Forest Service is currently preparing a manuscript for scientific publication titled:

A MANGEMENT FRAMEWORK FOR RESTORING RESILIENCY AND SUSTAINABLIITY OF FREQUENT-FIRE FORESTS IN THE SOUTHWEST

Richard T. Reynolds, Rocky Mountain Research Station, USDA Forest Service, 2150 Centre Ave., Bldg. A, Fort Collins, CO 80524, USA.

James A. Youtz, Southwestern Regional Office, USDA Forest Service, 333 Broadway SE, Albuquerque, NM 87102, USA.

Andrew J. Sánchez Meador, Lincoln National Forest, USDA Forest Service, 3463 Los Palomas Road, Alamogordo, NM 88310, USA.

Tessa Nicolet, Southwestern Regional Office, USDA Forest Service, 1009 East Highway 260, Payson, AZ 85541, USA.

Patrick L. Jackson, Southwestern Regional Office, USDA Forest Service, 333 Broadway SE, Albuquerque, NM 87102, USA.

Megan S. Matonis, Rocky Mountain Research Station, USDA Forest Service, 240 Prospect St., Fort Collins, CO 80526, USA.

This manuscript describes the desired conditions necessary to achieve restoration of frequent fire forests and their scientific basis. This manuscript is currently being reviewed internally within in the Southwestern Region of the Forest Service. Our current time line is to expand the manuscript review to external reviewers during May of 2012 and submit the manuscript to a scientific journal by June or July of 2012. In order to provide workshop participants with a preview of this manuscript we have included the Title, Abstract and Literature cited section in this workbook.

ABSTRACT— Many recent studies have shown that Southwestern forests have become increasingly susceptible to uncharacteristic severity of wildfires, insect and disease episodes, altered plant and animal demographies, and reduced biodiversity, ecosystem function, resilience, sustainability, and ecosystem services from these forests. Within the Southwest, these threats are most evident in frequent-fire ecosystems, primarily ponderosa pine and dry mixed-conifer forests. The composition and structure of vegetation in these forests have changed from historical conditions due to human activities, primarily community and resource developments and associated livestock grazing, logging, resulting in reduced frequency of low-severity fire. Changes include increased tree densities, reduced spatial and structural heterogeneity, loss of grass-forb-shrub communities, and associated losses of habitats, biodiversity, changed food webs and altered trophic interactions. We present a management framework for restoring the resiliency and sustainability of Southwestern frequent-fire forests; a framework based on the literature describing the natural ranges of variability and reference conditions of these forests in Arizona and New Mexico. Key ecosystem compositional and structural components of the framework are uneven-aged forest mosaics comprised of groups of trees, individual trees, open grass-forb-shrub interspaces between tree groups, snags, logs, woody debris, and the arrangement of these elements in space and time. The framework presents a vision for restoring the resiliency and sustainability of frequent-fire forests; the restoration of the compositions, structures, habitats, food webs, and the spatio-temporal feedbacks between pattern and process in these forests.

The framework recognizes and incorporates the natural spatial heterogeneity that occurs in these forests and presents management recommendations accommodating heterogeneity. The sources of spatial heterogeneity are different combinations in soils, elevation, slope , aspect, and

weather, and are manifested in differences in tree density, tree regeneration patterns (degree to which trees are grouped, numbers and arrangement of single trees, sizes of tree groups and openings), and numbers and dispersion of snags and logs. Such heterogeneity is evidenced in within- and among-stand reference conditions, which, when summed, comprise the natural range of variability of a forest type. The management recommendations encourage managers to recognize the spatial and temporal heterogeneity in these forests and to design treatments as informed by local site conditions (historical structures such as old trees, snags, logs, stumps) whenever possible, and to manage for a mix of vegetation structural stages within stands to sustain the desired compositions and structures over time.

Key words: Bio-diversity, ecologic function, food webs, frequent fire forests, grass-forb-shrub communities, habitats, landscapes, logs, management recommendations, mixed-conifer, Pinus ponderosa, ponderosa pine, resilience, restoration, snags, structure, sustainability, wildlife.

EXEUCTIVE SUMMARY

There is increasing recognition of the need to restore the resiliency and sustainability of forests in the Southwest United States. Many recent studies have shown that Southwestern forests have become increasingly susceptible to uncharacteristic severity of wildfires, insect and disease episodes, altered plant and animal demographies, and reduced biodiversity, ecosystem function, resilience, and sustainability of ecosystem services from these forests. Within the Southwest, these threats are most evident in frequent-fire forests, primarily ponderosa pine and dry mixed-conifer forests. The compositional and structural changes include increased tree densities, reduced spatial structural heterogeneity, loss of grass-forb-shrub communities, and associated losses of habitats, biodiversity, changed food webs and altered trophic interactions and have resulted from human activities; primarily community and resource developments and associated livestock grazing, logging, resulting in a reduced frequency of low-severity fire. We present a management framework for restoring the resiliency and sustainability of Southwestern frequent-fire forests; a framework based on a synthesis of the science describing the natural ranges of variability and reference conditions of these forests in Arizona and New Mexico. Key ecosystem compositional and structural components of the framework are uneven-aged forest mosaics comprised of groups of trees, individual trees, open grass-forb-shrub interspaces between tree groups, snags, logs, woody debris, and the arrangement of these elements in space and time. The framework presents a vision for restoring the resiliency and sustainability of frequent-fire forests; the restoration of the compositions, structures, habitats, food webs, and the spatio-temporal feedbacks between pattern and process in these forests. Additional outcomes include the provision of ecosystem services such as wood products, clean air and water, and recreation.

The framework recognizes and incorporates the natural spatial heterogeneity that occurs in these forests and presents management recommendations accommodating the heterogeneity. The sources of spatial heterogeneity are differences in soils, elevation, slope , aspect, and weather, and manifests in differences in tree density, tree regeneration patterns (degree to which trees are grouped, numbers and arrangement of single trees, sizes of tree groups and openings), and numbers and dispersion of snags and logs. Such heterogeneity is evidenced in within- and among-stand reference conditions, which, when summed, comprise the natural range of variability of a forest type. The natural range of variability is a "best" estimate of a functioning and resilient system because it reflects the evolutionary ecology of these forests and is a powerful tool for establishing a science basis for restoring the compositions and structures of forests and the ecological processes that operated in these forests before Euro-American influences on them.

The management recommendations in the framework encourage managers to recognize the spatial and temporal heterogeneity in these forests and to design treatments using local site conditions (historical structures such as old trees, snags, logs, stumps) as guides whenever possible. Also recommended is managing for an interspersed mosaic of different vegetation structural and successional stages that shifts over time (via ageing and succession) to provide plant and animal habitat adjacency and to sustain the desired compositions and structures at a fine scale (~10 acres). Because of the complex of species comprising the understory of Southwest frequent-fire forests, the framework focuses on the ecologies and life-histories of the dominant understory vegetation species. The framework, recognizing the importance of the types, frequencies, and severities of natural disturbances in shaping the composition and structure of frequent-fire forests, recommends using fire, perhaps the most influential of disturbances in these forests, as a tool in restoring the resiliency and sustainability of forests wherever feasible. However, when management objectives may be better met by silvicultural treatments, prescribed cutting methods such as group and single tree selection, perhaps in conjunction with fire, are recommended. In some cases, it may not be operationally feasible for management to exactly mimic natural processes and the structural reference conditions (tree sizes, ages, densities), especially within tree-groups. Nonetheless, the framework provides for close approximations of reference conditions and processes.

Here we describe our framework for the restoration of the resiliency and sustainability of frequent-fire forests and present the stand-level and landscape principles and concepts as well as the science supporting the desired restored conditions identified in the framework.

Bluewater Forest Restoration Project – Desired Condition Demonstration, Cibola National Forest

Purpose of Visit: *ERI*

- Discuss the concepts and various aspects of the desired conditions including: the degree of structural openness; the grass/forb/shrub matrix; the size (area, number of trees), shape, and spacing of tree groups; the interlocking crowns of trees within groups; the diversity and interspersion of tree structural (age, size) stages, and the sustainability of the desired conditions.
- Discuss the value of the desired conditions for wildlife habitat and food webs.
- Discuss how key elements of the desired conditions relate to natural disturbances.
- Discuss specific differing existing conditions that are moving towards the desired conditions.
- Discuss the ecological, social, and economic outcomes of achieving the desired conditions.

Project Area Background: *ERI*

- Demonstration site (stand 5A) represents a ponderosa pine forest growing on moderately-productive (average) site. This site has had fire exclusion since the early 1900s; with the exception of slash burning following cutting 25+ years ago.
- Past management: this site was cut 25+ years ago to remove diseased, dying and poorly-formed trees (sanitation/salvage cutting). Pre-treatment (2010) stand condition: uneven-aged structure/high-density, modeled fire behavior - high-intensity crown fire.
- Prescribed cutting treatment (focused on the desired conditions and restoration) were implemented during summer 2010. Prescribed burning treatments are scheduled for fall/winter 2011/12.
- Sandstone/shale soil parent materials.
- Plant association is variable (Ponderosa pine/Arizona fescue, Ponderosa pine/blue grama)

Demonstration Stand (post-treatment): *Jim Youtz (FS-RO)*

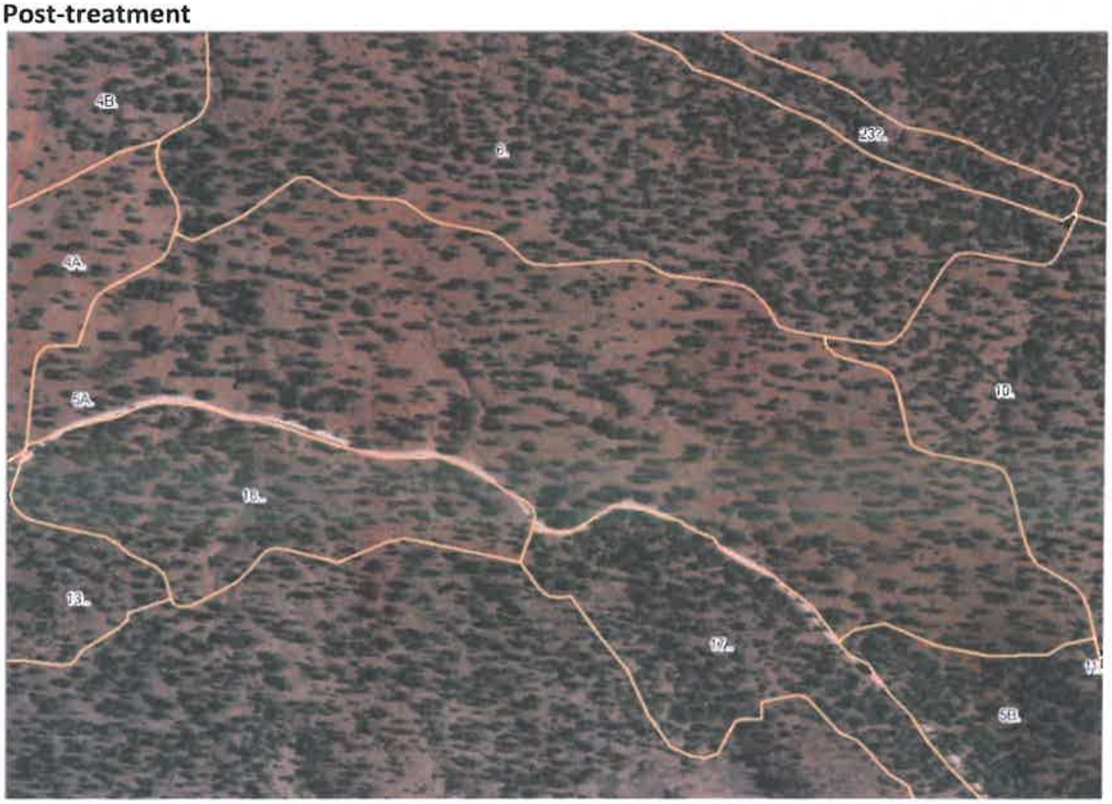
- Uneven-aged stand structure (3+ ages): within the stand, there are roughly balanced areas of young, mid, and old age trees with provision of suitable openings between tree groups for development of grass/forb/shrub component and localized recruitment of trees.
- Spatial patterns are <u>similar</u> to natural conditions
    - Mature tree groups with interlocking crowns
    - Fine–scale dispersion of tree groups
    - Grass/forb/shrub openings
- Small diameter woody debris abundance is higher than desired (pre-burning).
- Downed logs and snags are less than desired.
- Tree densities (within group and per unit area) are within desired ranges (overall avg. 40-80 sq. feet basal area).
- Seedlings have not yet established in desired locations.
- Desired grass/forb/shrub cover has not yet established.
- Modeled fire behavior is low-intensity surface fire.

Bluewater Forest Restoration Project – Desired Condition Demonstration Data

Aerial photos

Pre-treatment

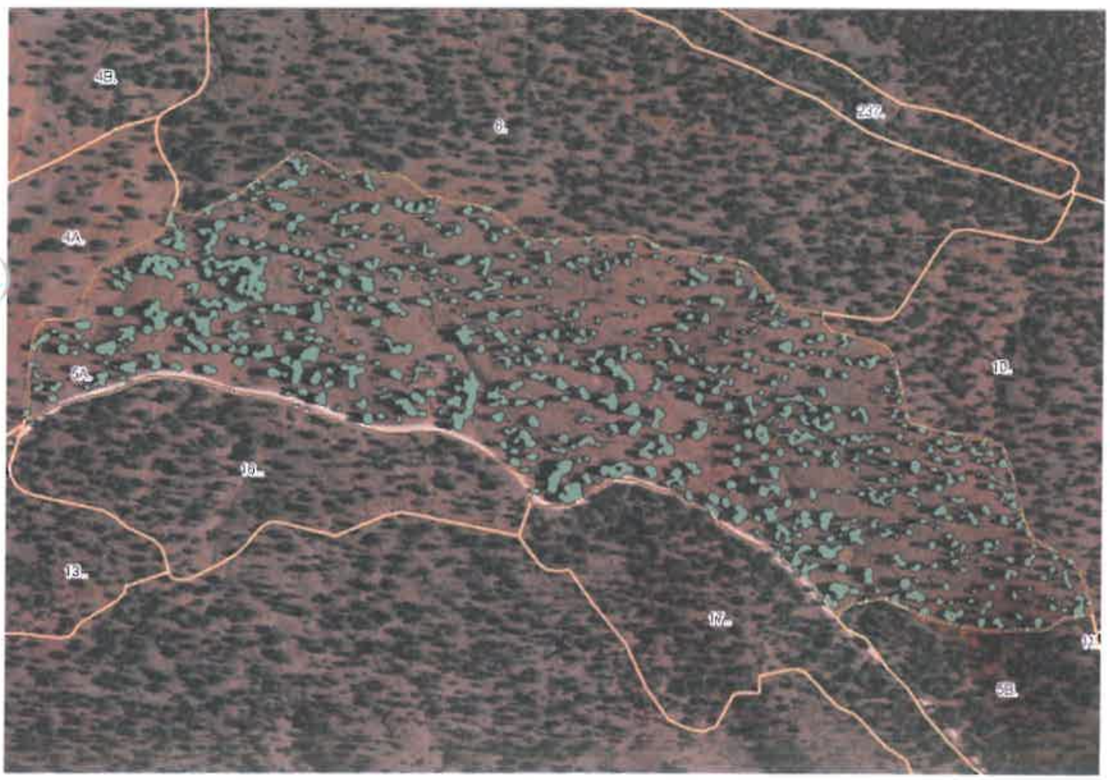
Post-treatment



Stand 5A exam data (post-treatment)

All Species Diameter Class	Trees/ Acre	Basal Area/ Acre
1 - 4.9 in	3.3	0.4
5 - 8.9 in	16.7	4.6
9 - 12.9 in	23.3	16.2
13 - 16.9 in	5.0	6.1
17 - 20.9 in	5.0	10.2
21 - 24.9 in	1.7	4.3
25 + in	1.6	6.1
Total	56.6	47.9

Current conditions (post-treatment) - spatial patterns



Spatial analysis results (Stand 5A)

- 48% of the area to be managed for tree cover
    - 28% of the area is currently represented under mid-old tree crowns (tree drip-line measurement)
    - 20% of the area to be managed for recruitment and/or development of tree seedlings/saplings

- 52% of the area to be managed as open grass/forb/shrub

Modeled future conditions

a. Forest structure (FVS simulation)

FVS SIMULATION: natural growth, no treaments

SIMULATION DONE: 10-11-2011

AVERAGE* SUMMARY STATISTICS BY COMMON CYCLE

year	trees/ acre	basal area	stand density Index	dominant ht	quadratic mean diameter	total cubic ft	merch. cubic ft	merc. board ft	years	cubic ft growth	cubic ft mortality
2011	57	47	72	48	11.6	786	676	3075	10	37	1
2021	198	57	118	53	7.2	1149	1017	4993	10	41	2
2031	195	71	141	58	8.2	1547	1387	7081	10	43	2
2041	264	87	176	63	7.8	1963	1786	9306	10	44	2
2051	259	102	200	67	8.5	2379	2185	11570	10	44	2
2061	269	118	226	70	9	2801	2574	13847	10	41	4
2071	261	131	244	73	9.6	3171	2930	15998	10	38	10
2081	240	139	252	76	10.3	3449	3246	17887	10	36	9
2091	223	147	259	78	11	3717	3547	19354	10	34	8
2101	210	154	266	79	11.6	3968	3815	20799	10	31	8
2111	199	161	273	81	12.2	4196	4057	22137	0	0	0

- This simulation assumes no treatments or fire occurrence for 100 years. Natural regeneration is imputed at intervals, based upon stand density and characteristic ponderosa pine development. Numbers of trees reflect in-growth without the thinning effects of fire or other management. The limited assumptions of this simulation (no fire occurrence or tree-cutting) does not imply management intent, but is presented to show projected growth without disturbances for discussion purposes.

b. Fire Behavior (Flam Map simulation –based on 2011 post-treatment conditions)

- Predicted surface fire on 99% of the area
- Predicted passive crown fire (torching) on 1% of the area

Table1. Historical forest structural characteristics of ponderosa pine (pine-oak shaded) forests of the Southwest, arranged by parent material and average tree density*.

Location	Parent Material	Elev. ft	Size/Age Reported	Ref. date	TPA range	TPA average	TPA stderr	BA (ft^2/ac) range	BA (ft^2/ac) average	BA (ft^2/ac) stderr	Citation
AZ-Coconino, Gus Pearson	Basalt	7398	Age	1875		15.0					White 1985
AZ-Coconino, Coconino (avg)[a]	Basalt	6907	Size	1910		16.0			38.1		Woolsey 1911
AZ-Coconino, GPNR[1]-6a[c]	Basalt	7400	Yes-S	1925		21.8			56.6		Pearson 1950
AZ-Coconino, Gus Pearson	Basalt	7300	No	1876		22.8			46.2		Covington et al. 1997c
AZ-Coconino, Bar M Canyon	Basalt	7000	No	1867	21-24	23.0			65.0		Covington & Moore 1994b
AZ-Coconino, Flagstaff-b	Basalt	7355	No	1880	1-58	23.7	4.0				Abella et al. 2011
AZ-Coconino, Gus Pearson	Basalt	7300	Age	1876		24.0					Mast et al. 1999c
AZ-Coconino, San Francisco Peaks	Basalt	8594	Age	1876		24.8	2.6		33.0	4.9	Cocke et al. 2005
AZ-GCPNM[2]-BLM, Mt. Trumbull	Basalt	7740	Age/Size	1870		25.2	3.5		38.8	6.1	Heinlein et al. 1999
AZ-Coconino, Coconino (max)[a]	Basalt	6907	Size	1910		34.5			81.2		Woolsey 1911
AZ-GCPNM-BLM, Mt. Logan-b	Basalt	7483	Age/Size	1870		38.3	5.8		46.2	7.8	Waltz & Fulé 1998
AZ-GCPNM-BLM, Mt. Trumbull	Basalt	6970	Size	1870	0-220	39.2	3.9	0-143	41.6	4.1	Roccaforte et al. 2010e
AZ-Coconino, Chimney Spring[a]	Basalt	7380	Size	1920		42.8					Biondi et al. 1994
AZ-Coconino, Coulter Ranch[a]	Basalt	7520	Size	1913	30-66	51.5	10.8	67-120	83.0	19.5	Sánchez Meador & Moore 2010
AZ-Dept. of Defense, Camp Navajo	Basalt	7592	Age/Size	1883		59.9	5.8		56.2	6.1	Fulé et al. 1997
AZ-A-S, Fort Apache, Malay Gap[b]	Basalt	7200	Age/Size	1952		124.0			70.1		Cooper 1960
AZ-Coconino, Woolsey[a]	Basalt	7052	Size	1874	18-51	33.1	4.6	40-79	61.5	5.6	Sánchez Meador et al. 2010
AZ-Coconino, Flagstaff-c	Cinders	7355	No	1880	7-74	22.5	6.2				Abella et al. 2011
AZ-GCPNM-BLM, Mt. Logan-c	Cinders	7115	Age/Size	1870	34-38	29.9	6.4	60-64	60.3	9.1	Waltz & Fulé 1998
AZ-Coconinio, Red Cinder	Cinders	7631	Age/Size	1885		74.1			65.3		Abella 2008
AZ-Prescott, Prescott (avg)[a]	Granitic	5320	Size	1910		27.7			25.5		Woolsey 1911

Minimum tree DBH recorded = 3.5in.[a], 4in.[b], 6in.[c], 10in.[d]
[1]Gus Pearson Natural Area
[2]Grand Canyon-Parashant National Monument

Table 1. Continued.

Location	Parent Material	Elev. ft	Size/Age Reported	Ref. date	TPA range	TPA average	TPA stderr	BA (ft^2/ac) range	BA (ft^2/ac) average	BA (ft^2/ac) stderr	Citation
AZ-S. Kaibab, Tusayan (avg)[a]	Limestone	7075	Size	1910		10.7			22.1		Woolsey 1911
UT-Zion National Park	Limestone	7096	Age	1881	3-25	14.0					Madany & West 1983
AZ-Coconino. Flagstaff-1	Limestone	7355	No	1880	14-34	22.0	2.2				Abella et al. 2011
AZ-Coconino & NPS, Walnut Cyn.[d]	Limestone	6808	Size	1876		29.1			39.2		Menzel & Covington 1997
AZ-N. Kaibab, North Kaibab	Limestone	7300	No	1881		55.9					Covington & Moore 1994a
AZ-N. GCNP, Powell Plateau	Limestone	7533	Age	1879	8-262	63.6	9.4	20-337	78.0	10.9	Fulé et al. 2002
AZ-N. Kaibab, Kaibab Plateau[c]	Limestone	7500	No	1929	40-55						Rasmussen 1941
NM-Cibola, Zuni (max)[a]	Rhyolite	6557	Size	1910		22.6			52.8		Woolsey 1911
NM-Cibola, Cibola[a]	Rhyolite	8382	Age/Size	1890	47-61	54.2	6.9				Moore et al. 2004
NM-Carson, Carson (max)[a]	Shale	6983	Size	1910		38.4			79.9		Woolsey 1911
CO-Uncompahgre Plateau	Shale	7500	Size	1875	30-90	55		20-90	55		Binkley et al. 2008

Minimum tree DBH recorded = 3.5in.[a], 4in.[b], 6in.[c], 10in.[d]

Table 2. Historical forest spatial characteristics of frequent-fire forests of the Southwest, arranged by cover type (PP: Ponderosa pine, PO: Pine-Oak, MC: Mixed-Conifer).*

Reference	Parent Material	Elev. ft	Cover Type	Ref. date	Group Density	Group Size	Trees per Group	BA in Groups	Citation
AZ-A-S, Fort Apache, Malay Gap[b]	Basalt	7200	PP	1952		0.16-0.32			Cooper 1960
AZ-Coconino, Gus Pearson	Basalt	7398	PP	1875		0.05-0.72	3-44		White 1985
AZ-Coconinio, Flagstaff	Varying	7800	PP	1880	1-33		2-25	28%-74%	Abella & Denton 2009
AZ-Coconino, Woolsey[a]	Basalt	7052	PP	1874	25-67	0.003-0.09	3-24	62%-75%	Sánchez Meador et al. 2011
AZ-Coconino, Coulter Ranch[a]	Basalt	7520	PO	1913		0.01-0.1			Sánchez Meador & Moore 2010
CO-Uncompahgre Plateau	Shale	8000	PP/MC	1875		0.1-0.25			Binkley et al. 2008
AZ/NM-Numerous N.F.[a]	Varying	8650	PP/PO/MC	1910	24-80	0.01-0.25	2-72	51%-85%	Sánchez Meador et al. *unpublished data*

Minimum tree DBH recorded = 3.5in.[a], 4in.[b]

Table 3. Historical forest canopy cover spatial characteristics of frequent-fire forests of the Southwest, arranged by cover type (PP: Ponderosa pine, PO: Pine-Oak, MC: Mixed-Conifer).*

Reference	Cover Type	Reference date	Method	Canopy Cover	Citation
AZ-Coconino, Gus Pearson	PP	1875	Standing age class	21.9%	White 1985
AZ-Coconino, Gus Pearson	PP	1876	Dendro-reconstruction	19.0%	Covington et al. 1997
AZ-Coconino, Chimney Springs	PP	1876	Standing size class	17.3%	Covington and Sackett 1986
AZ-N. GCNP, Powell Plateau	PP-oak	1879	Relict Site	15.4-79.2%	Fulé et al. 2002
AZ-Coconino, Woolsey	PP/PP-Oak	1874	Dendro-reconstruction	10.2-18.8%	Sánchez Meador et al. 2011
CO-Colorado Front Range, Cheeseman Lake	PP/MC	1900	FVS-reconstruction	12.9-21.5%	Fornwalt et al. 2002

***From: A management framework for restoring resiliency and sustainability of frequent-fire forests in the Southwest, USDA Forest Service, in draft 2012.**

East Fork Forest Restoration Demo Area, Santa Fe National Forest

Purpose of Visit: *ERI*

- View an area where different forest restoration approaches were implemented for demonstration, and discuss basis for treatment strategies.
- Discuss the concepts and various aspects of the desired conditions including: the degree of structural openness; the grass/forb/shrub matrix; the size (area, number of trees), shape, and spacing of tree groups; the interlocking crowns of trees within groups; the diversity and interspersion of tree structural (age, size) stages; and the sustainability of the desired conditions.
- Discuss forest entomology/pathology (reference and current conditions).

Background: *Bill Armstrong (FS-SFNF)*

- Demonstration sites represent ponderosa pine forests growing on highly-productive sites. Sites have had fire exclusion since the late 1880s, due to livestock grazing followed by active fire suppression.
- Unrecorded selection harvest is likely the only past management.

Demonstration Areas: *Bill Armstrong/Dave Huffman (NAU-ERI)*

- Uneven-aged structure (3+ ages). This site is in a designated goshawk post fledging family area (PFA) adjacent to historic nesting areas. Therefore, the objective was to favor older taller trees in groups to provide nesting/roosting sites. The original stand conditions, with smaller trees in dense suppressed groups, required thinning this younger age group to permit regeneration of the understory. Mature/old age trees were below desired proportional representation before treatment, therefore none were cut (yellow-bark trees range 95-160 years old).
- Post-treatment spatial patterns are similar to natural conditions
    - Tree groups with interlocking crowns
    - Fine–scale dispersion of tree groups
    - Grass/forb/shrub openings
- Many trees on this site have evidence of mistletoe infection. Since the primary management direction on this site is to provide habitat for goshawk, management of mistletoe during this treatment was not a primary concern.
- Slash was masticated, not yet burned. Large woody debris abundance is lower than desired.
- Tree densities (within group) are within desired ranges (overall averages 45-150 sq. feet basal area). Overall density remains higher than desired at 90-95 sq. feet basal area.
- Seedlings have not yet established in desired locations.
- Desired grass/forb/shrub cover has not yet fully established, will likely respond to prescribed burn of masticated material.
- Modeled fire behavior is low-intensity surface fire (some questions remain about ground fire intensity due to slash mastication?).
- How demonstrations differ:
    - Demo #1 represents a managed framework for restoration: roughly balanced area of grouped young, mid, and mature/old aged trees with provision of suitable openings for development of grass/forb/shrub component and localized recruitment of trees. Old age trees were below desired proportional representation before treatment, therefore none were cut. This treatment represents an approach to

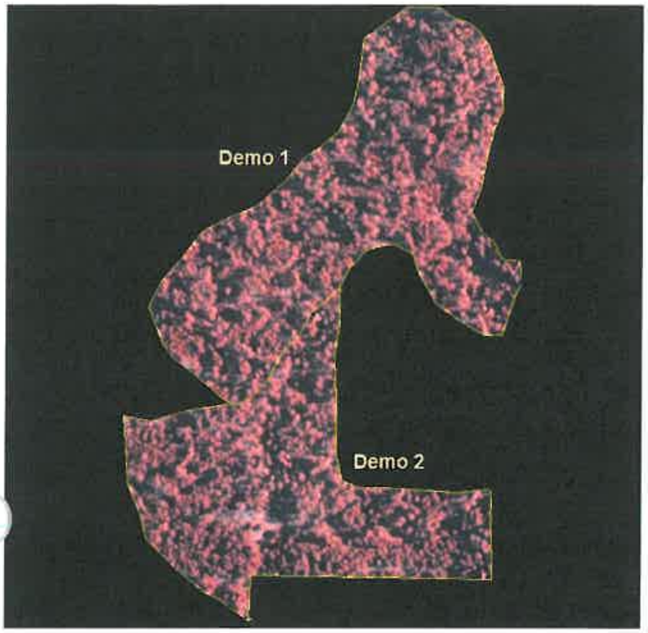
create and maintain structure to provide for habitat and to allow fire to be safely reinitiated, while providing opportunities for multiple-use strategies for maintenance of the restored forest landscape.

- Demo #2 represents a natural processes framework for restoration based on a reconstruction of historic stand structure based on observed site evidence. This results in an uneven-aged forest, but age structure is not balanced (more mid and old trees than young). This represents an approach to initiate a fire maintained restored forest landscape.

East Fork Forest Restoration Demo Area – Data *Bill Armstrong/Dave Huffman*

Aerial photos

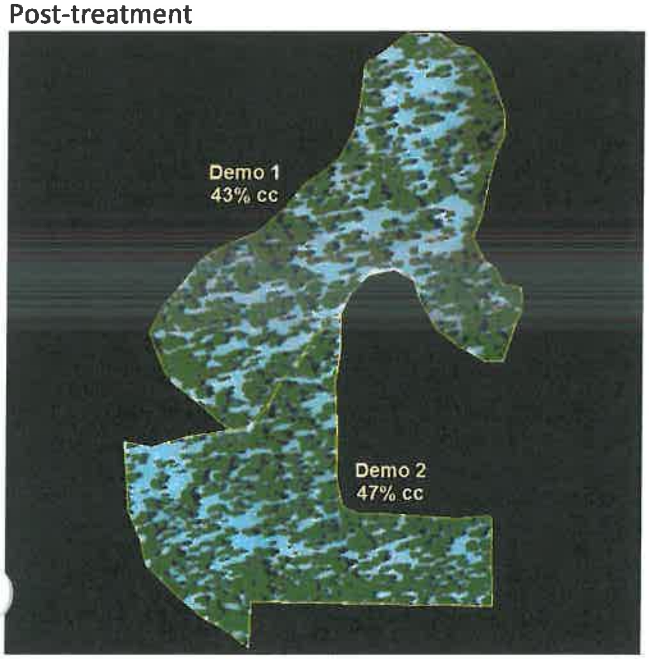
Pre-treatment:



Current conditions (post-treatment)

a. Spatial analysis from aerial photos

Post-treatment



Demo site #1

- 43% of the area represented under mid-old tree crowns (tree drip-line measurement)
- 57% of the area represented as open grass/forb/shrub

Demo site #2

- 47% of the area is currently represented under mid-old tree crowns (tree drip-line measurement)
- 53% of the area to be managed as open grass/forb/shrub (not including meadow areas)

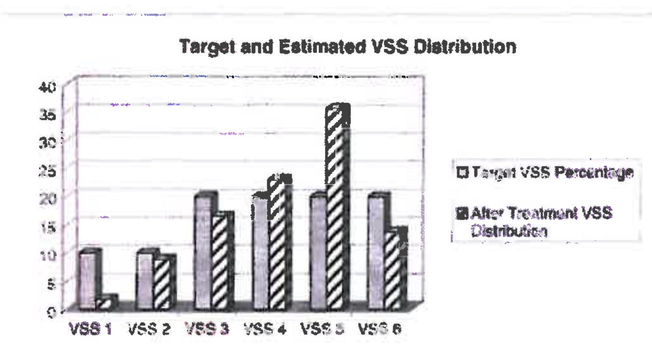
b. Stand exam data (2012)

Demo site #1, post-treatment

All Species Diameter Class	Trees/ Acre	Basal Area/ Acre (ft^2)
1 - 4.9 in	0	0
5 - 8.9 in	13.3	3.5
9 - 12.9 in	36.7	23.5
13 - 16.9 in	23.3	27.1
17 - 20.9 in	8.3	16.7
21 - 24.9 in	5	13.8
25 + in	1.7	6
Total	88.3	90.6

Demo site #2, post-treatment

All Species Diameter Class	Trees/ Acre	Basal Area/ Acre (ft^2)
1 - 4.9 in	0	0
5 - 8.9 in	3.3	.9
9 - 12.9 in	18.3	13.7
13 - 16.9 in	15	17.2
17 - 20.9 in	8.3	15.8
21 - 24.9 in	8.3	25.3
25 + in	3.3	17
Total	56.5	89.9



Tree group size distribution for demo #1

Forest entomology/pathology discussion (reference and current conditions) *Andrew Graves (FS-RO)*

- Understand how biological forest disturbance agents function in reference condition and contemporary forest landscapes.
- Discuss implications for forest resilience and sustainability

East Fork Even-aged Forest Discussion Area, Santa Fe National Forest

Purpose of Visit: *ERI*

- View two areas where past conditions and treatments have resulted in two different current conditions
- Discuss desired conditions and relationship to current sites

Background: *Bill Armstrong (FS-SFNF)*

- **Mature Forest Stand** (management history)
  - High-site ponderosa pine with fire exclusion since the late 1880s.
  - The site has had some undocumented selection harvest
  - The site was thinned from below, removing firewood and precommercial-sized trees in 2002. Some slash was piled and burned in 2003. Slash remains scattered in the drainages.

- **<u>Current conditions</u>**
  a. **stand exam data, 04/2012)**

Current averages per acre

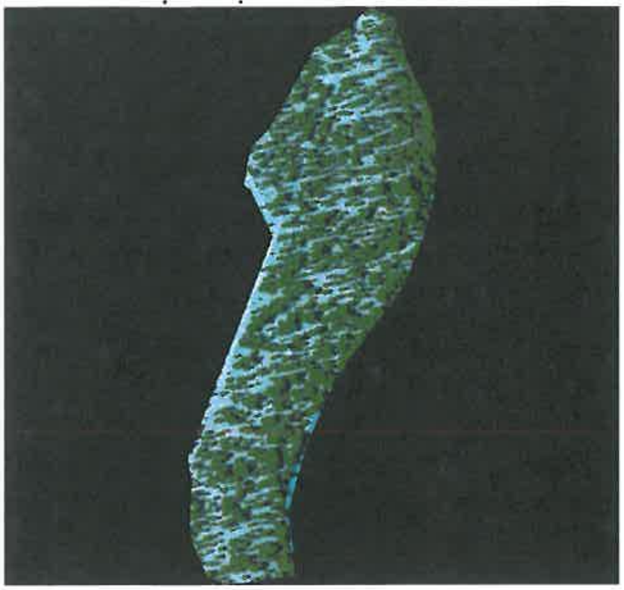
All Species Diameter Class	Trees/ Acre	Basal Area/ Acre
1 - 4.9 in	4.8	0.7
5 - 8.9 in	17.2	6
9 - 12.9 in	14.8	11.4
13 - 16.9 in	21.9	27.9
17 - 20.9 in	2.9	5.5
21 - 24.9 in	1.9	5.4
25 + in	4.5	20.9
Total	68	77.1

<u>Range of plot data:</u>

current trees per acre = 38 to 105

current basal area = 46 to 125 square feet/acre

b. spatial patterns



- 41% of the area is under tree canopy (even-distribution)
- 59% of the area is open grass/forb/shrub (small interspaces)

Discussion: where does this stand fit in the context of DCs, resilience and sustainability? *ERI-All*

- **Young Forest Stand**
  - The stand was a multi-storied ponderosa pine-dominated stand with some Douglas-fir on north aspect of drainages.
  - Due to extensive dwarf mistletoe infection, the stand received an overstory removal harvest in 1998 to release advanced regeneration.

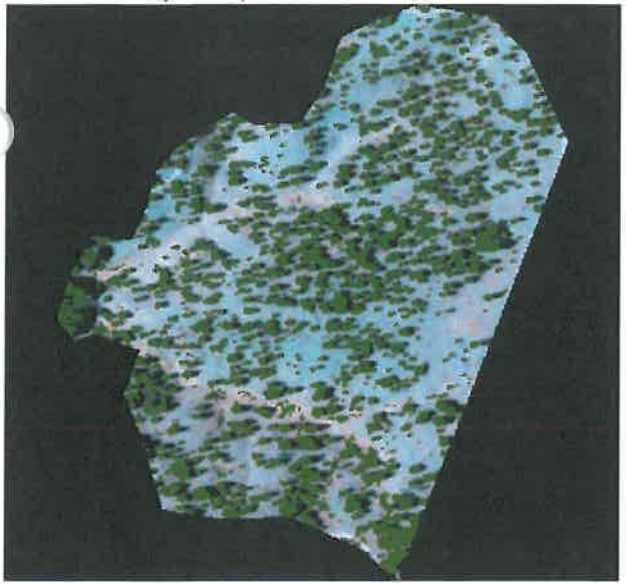
Current conditions

a. stand exam data, 04/2012)

Current averages per acre

All Species Diameter Class	Trees/ Acre	Basal Area/ Acre
1 - 4.9 in	0	0
5 - 8.9 in	22.5	6.3
9 - 12.9 in	32.5	20
13 - 16.9 in	10	10.3
17 + in	0	0
Total	67.5	38.9

b. **spatial patterns**



- 27% of the area is under tree canopy (9.6 acres)
- 73% of the area is open grass/forb/shrub (14.8 acres)

Discussion: where does this stand fit in the context of DCs, resilience and sustainability? ***ERI-All***

Monument Canyon Forest Research Natural Area, Santa Fe National Forest

Purpose of Visit: *ERI*

- View the oldest and longest-protected Research Natural Area in New Mexico (1930s).
- Discuss reference conditions at an intact old-growth ponderosa pine site with ongoing annual monitoring.
- Discuss restoration treatment and current conditions.
- Discuss maintenance of forest restoration treatments.

Background: *Kent Reid (NMHU)*

- **Reference conditions**
  - Among the best preserved old-growth ponderosa pine/dry mixed conifer sites in NM
  - Living trees to 1500s, tree-ring evidence to 1200s
  - Frequent fire ecosystem (MFI = 3.4 years/fire entire RNA)
  - Scaled fire history study 1598-2000, 200 cross-dated trees

- **Management history**
  - RNA status since 1930s, never logged
  - Fire exclusion since early 1900s
  - Adjacent to 8000-ac San Juan Fire Management Area (SFNF)
- **Pre-treatment conditions (see Table below)**
  - Density of the larger trees was normal for the Jemez
  - 35% of larger trees were dead in some areas where 20th century ingrowth was highest
  - Small tree density was among highest documented in the Southwestern Region
- **Research history (University of Arizona)**
  - Permanent plot network established 1998
  - Detailed fire history 2004
  - Ongoing annual tree-scale monitoring since 2002

Demonstration Restoration Treatment: *Kent Reid*

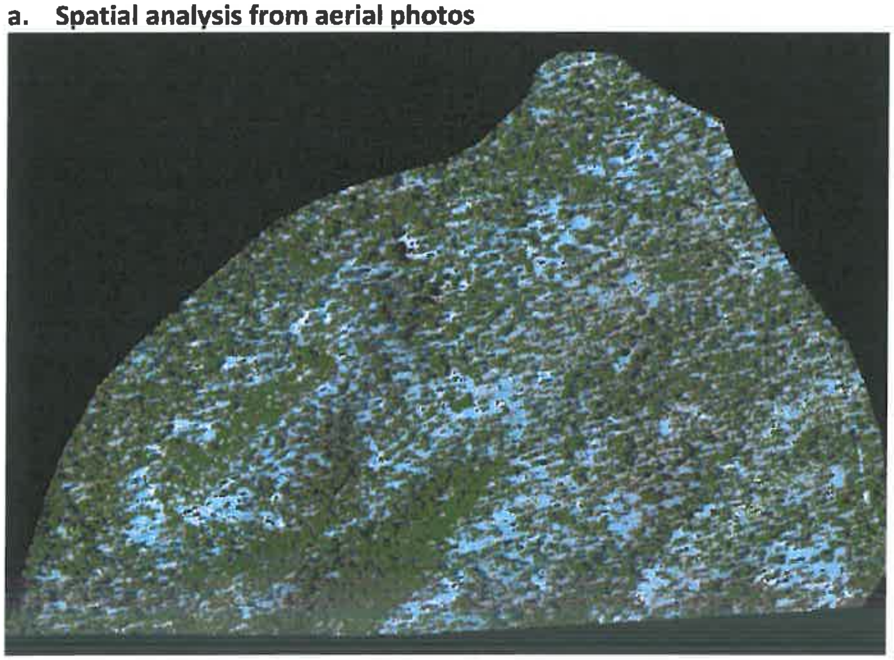
- **Treatment prescription and implementation (2006)**
  - Collaboration of SFNF and UA
  - Funded by CFRP, RMRS, JFSP
  - Design to facilitate restoration of surface fire regime
  - Mastication of trees $\leq$ 9 in dbh; utilized existing stand structure

Aerial photos

Pre-treatment:

Current conditions (post-treatment)

a. **Spatial analysis from aerial photos**



- 34% of the area represented under mid-old tree crowns (tree drip-line measurement)
- 76% of the area represented as open grass/forb/shrub (not including established tree regeneration)

b. Stand exam data

Pre-treatment (2002)

Diameter Class	Status	Trees/Acre
<1 in	Live	300
<1 in	Dead	10
<1 in	Both	310
>1in and <10in	Live	604
>1in and <10in	Dead	151
>1in and <10in	Both	754
>10 in	Live	46
>10 in	Dead	25
>10 in	Both	71
Total		1135

Post-treatment (2011)

All Species Diameter Class (dbh)	Trees/ Acre	Basal Area/ Acre (ft^2)
0 – 1 in	5	0.0
1 - 4.9 in	18	1.2
5 - 8.9 in	26	7.8
9 - 12.9 in	31	18.8
13 - 16.9 in	12	14.5
17 - 20.9 in	9	17.9
21 - 24.9 in	5	13.2
25 + in	2	11.4
Total	108	84.8

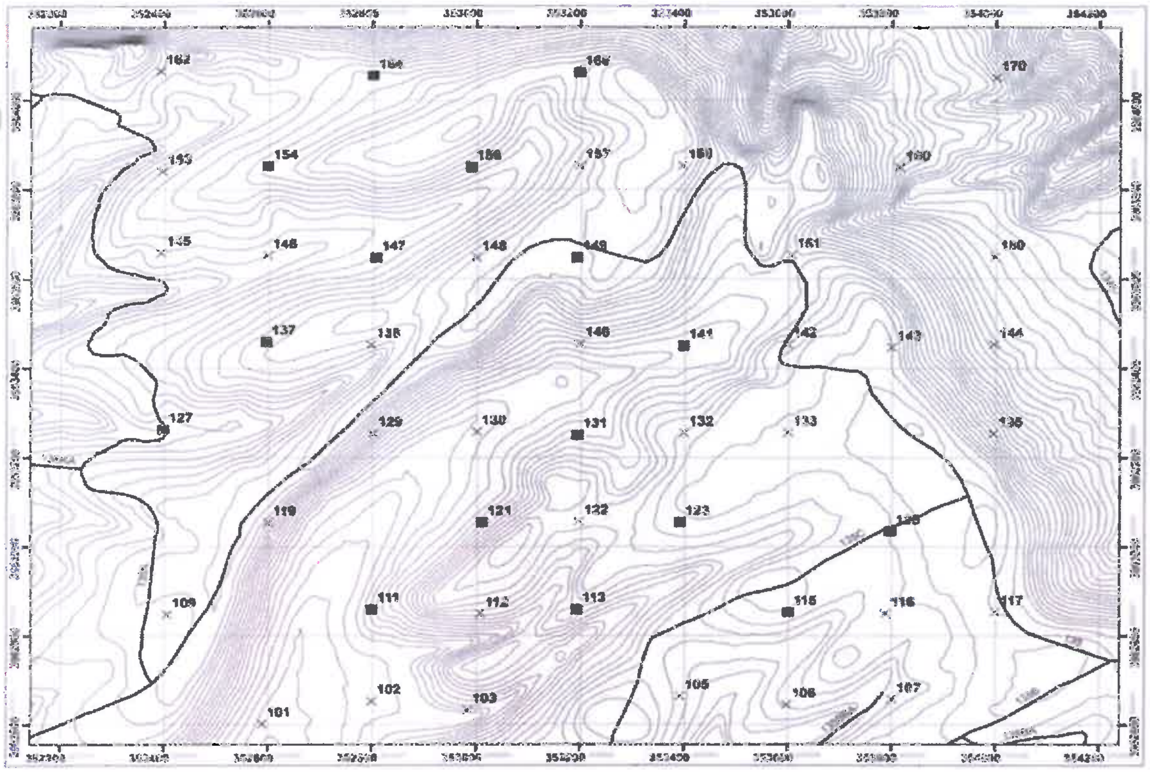
Post treatment (2011) observations

- Ponderosa pine comprised 81% of the basal area.
- Other species were white fir, Douglas-fir, limber pine, and aspen.
- Down woody debris ranged from 26 to 50 tons per acre, excluding masticate.
- Ponderosa pine regeneration was very patchy, and ranged to 63,000 stems per acre.

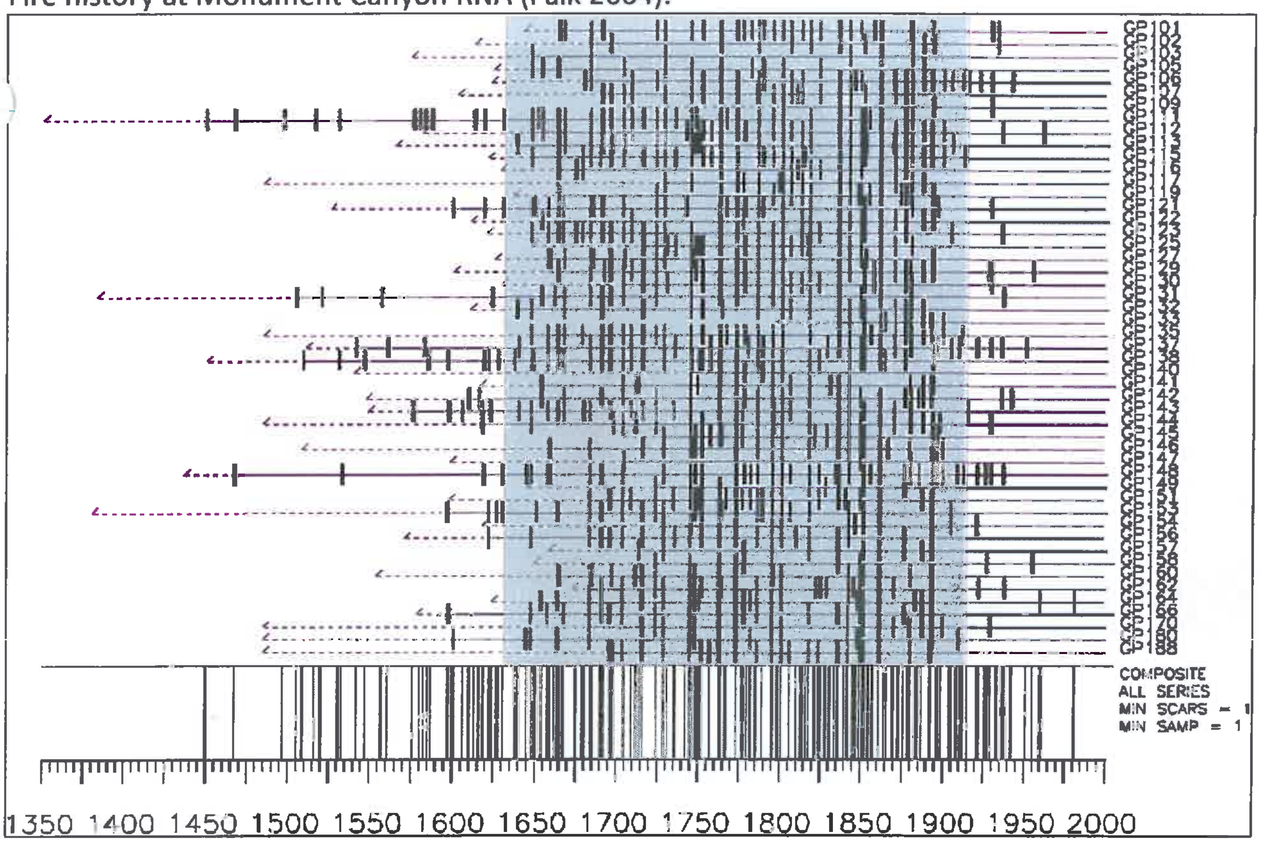
Post-treatment regeneration per acre (averages from 36 0.01-acre plots, 2011): Trees < 4.5' height

Species/ Class	Regeneration height <8"	8" – 2.5'	2.5' – 4.5'	Total
Ponderosa pine	6375	4308	1528	12,211
Dead ponderosa	19	64	14	97
Limber pine	0	<1	0	<1

Permanent plot network at MCN (Falk 2004):



Fire history at Monument Canyon RNA (Falk 2004):



1929 University of Chicago Botany Field Trip:

Dry Mixed Conifer Forest Ecology, San Antonio Creek, Santa Fe National Forest

Purpose of Visit: *ERI*

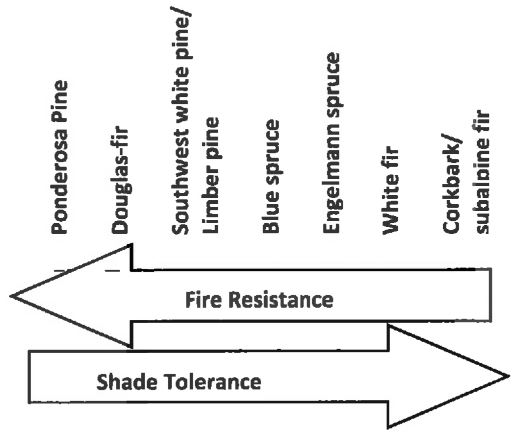
- Discuss classification and ecological differences between ponderosa pine, dry mixed conifer & wet mixed conifer forest types.
- View a dry mixed conifer forest site where the tree species composition and function has changed over time as a result of fire suppression and past vegetation management.
- Discuss desired forest species composition for dry mixed conifer forests, and relationships to ecological function.

Natural fire regimes of Southwestern forest types. Fire frequency refers to the mean number of years between fires, and fire severity relates to the effect of the fire on dominant overstory vegetation. Infrequent-fire forests (wet mixed-conifer and spruce-fir) are included for comparison to frequent-fire forests. *Jim Youtz (FS-RO)*

Forest Type (sub-type)	Fire Regime[1]		Fire Type[2]	Forest Structure	Seral Species	Climax Species
	Fire Frequency	Fire Severity				
Ponderosa pine (all sub-types)	Regime I 0-35 years	Low	Surface	Uneven-aged, grouped, open	**Dominant:** ponderosa pine	**Dominant:** ponderosa pine
Dry mixed-conifer	Regime I (common) 0-35 years	Low	Surface	Uneven-aged, grouped, open	**Dominant:** ponderosa pine **Subdominant:** aspen and/or oak (in sub-stand scale patches)	Shade-intolerant species under fire dis-climax historic conditions. **Dominant**: ponderosa pine **Subdominant**: Douglas-fir and Southwestern white pine or limber pine
(warmer/drier)	Regime III (rare) 35-100+ years	Mixed	Mixed	Uneven-aged, patched, open		
Wet mixed-conifer	Regime III (common) 35-100+ years	Mixed	Mixed	Uneven-aged, patched, closed	**Dominant** (depending on habitat type): aspen or Douglas-fir	Shade tolerant species. **Dominant** (depending on habitat type): white fir and/or blue spruce
(cooler/wetter)	Regime IV (rare) 35-100+ years	High	Stand-replacing	Even-aged, closed		
Spruce-fir (mixed, lower sub-alpine)	Regime III and/or IV 35-100+ years	Mixed / High	Mixed/ stand-replacing	Even-aged, closed	**Dominant** (depending on habitat type): aspen or Douglas-fir	Shade tolerant species. **Dominant** (depending on habitat type): Engelmann spruce and/or white fir Shade tolerant species.
Spruce-fir (upper sub-alpine)	Regime V 200+ years	High	Stand-replacing	Even-aged, closed	**Dominant** (depending on habitat type): aspen, Douglas-fir, or Engelmann spruce	**Dominant:** Engelmann spruce and corkbark fir or sub-alpine fir

[1] Schmidt et al. (2002)
[2] The Nature Conservancy (2006)

Relative shade and fire tolerance of common conifer tree species in mixed conifer and spruce-fir forests



Forest Ecology/Reference Conditions for Dry Mixed Conifer Forests in the Southwestern US:

Table 1. Historical forest structural characteristics of dry mixed-conifer forests of the Southwest, arranged parent material and average tree density*.

Location	Parent Material	Elev. ft	Size/Age Reported	Ref. date	TPA			BA (ft^2/ac)			Citation
					range	average	stderr	range	average	stderr	
AZ-Coconino, S. Francisco Peaks-E	Basalt	8318	Age	1892		20.9	3.4		39.6	3.9	Heinlein et al. 2005
AZ-Coconino, S. Francisco Peaks-W	Basalt	8318	Age	1876		21.0	1.7		54.0	6.1	Heinlein et al. 2005
AZ-A-S, Sitgreaves (max) [a]	Basalt	6300	Size	1910		31.0			66.9		Woolsey 1911
AZ-Coconino, S. Francisco Peaks	Basalt	9200	Age	1876		65.1	6.8		77.9	12.8	Cocke et al. 2005
AZ-A-S, Apache, Blue & White Mts.[b]	Basalt	8950	Size	1912		68.7			84.4		Greenamyre 1913
CO-San Juan, Middle Mtn.	Granitic	8520	Size	1870	51-59	57.3	4.0	43-60	47.9	4.6	Fulé et al. 2009
NM-Santa Fe, Jemez (max)[a]	Limestone	7013	Size	1910		35.6			91.2		Woolsey 1911
AZ-N. Kaibab, Kaibab Plateau[c]	Limestone	7500	Size	1909		45.3			60.7		Lang and Stewart 1910
NM-Lincoln, Alamo (max)[a]	Limestone	8650	Size	1910		46.5			97.9		Woolsey 1911
NM-Gila, Gila [a]	Limestone	9055	Age/Size	1890		65.6					Moore et al. 2004
NM-Santa Fe, Jemez [a]	Limestone	7825	Age/Size	1890	66-112	88.8	23.2				Moore et al. 2004
AZ-N. GCNP[1], Little Park	Limestone	8640	Age	1880		98.3	5.8		76.7	9.1	Fulé et al. 2003
AZ-N. GCNP, Swamp Ridge	Limestone	8143	Age	1879	36-151	99.4	5.2	65-235	124.1	7.8	Fulé et al. 2002
CO-Uncompahgre, Uncompahgre Plateau	Shale	8000	Size	1875	30-110	60		25-130	70		Binkley et al. 2008

Minimum tree DBH recorded = 3.5in.[a], 4in.[b], 6in.[c]

[1]Grand Canyon National Park

***From: A management framework for restoring resiliency and sustainability of frequent-fire forests in the Southwest, USDA Forest Service, in draft 2012.**

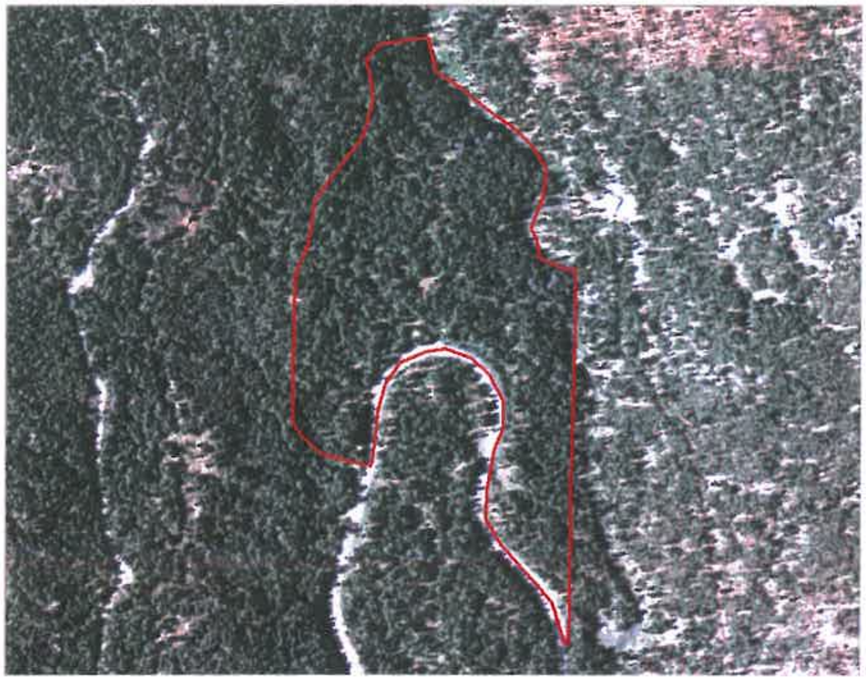
Table 2. Jemez Mountains fire scar dates. Period of reliability is the period when the number of samples was deemed sufficient to reliably estimate presuppression fire regime characteristics. Generally this was the period during which at least three or four samples recorded fire events. Sites are listed by forest types (PIPO = ponderosa pine, PIPO/MC = ponderosa pine/mixed conifer, and MC = mixed conifer).

Site name	Site code	Veg. type	Tree-ring date		Earliest fire-scar date	Latest fire-scar date	No. of fire-events (years)	Period of reliability	
			Earliest	Latest				Beginning date	Ending date
Monument Canyon Natural	MCN	PIPO	1408	1972	1493	1909	57	1648	1892
Ban-Group 3 (Apache Mesa)	BAN-GR3	PIPO	1459	1988	1480	1939	66	1614	1890
Pajarito Mountain Ridge	PMR	PIPO	1626	1993	1632	1912	39	1685	1875
Cerro Pedernal	CPE	PIPO	1380	1993	1522	1959	30	1598	1873
Continental Divide	CON	PIPO	1387	1979	1601	1899	54	1654	1870
Clear Creek Campground	CCC	PIPO	1538	1978	1548	1881	45	1664	1860
Capulin Canyon	CCP	PIPO/MC	1554	1990	1624	1955	44	1664	1893
Gallina Mesa	GAM	PIPO/MC	1531	1979	1558	1921	66	1663	1870
Cañada Bonito South	CAS	PIPO/MC	1378	1993	1480	1966	33	1672	1893
Camp May East	CME	PIPO/MC	1660	1993	1709	1880	11	1709	1879
Pajarito Mountain North-East	PME	MC	1702	1993	1773	1949	13	1801	1879
Pajarito Mountain North-West	PMW	MC	1617	1993	1669	1925	10	1841	1879
Camp May North	CMN	MC	1683	1993	1729	1880	7	1847	1879
Cañada Bonito North	CAN	MC	1655	1993	1685	1914	12	1801	1893

Fire return Interval Range = 3-16 yrs.

From: Ramzi Touchan, Craig D. Allen, and Thomas W. Swetnam, *Fire History and Climatic patterns in Ponderosa pine and Mixed Conifer Forests of the Jemez Mountains, NM*. Fire Effects in Southwestern Forests: Proceedings of the Second La Mesa Fire Symposium, Los Alamos, NM, March 29-31, 1994. USDA Forest Service, Rocky Mountain Research Station

Local Site Conditions: *Jerry Simon (FS-RO), Kent Reid (NMHU)*



Plant Habitat Type Association Classification: Blue Spruce/Dryspike Sedge[1]

Dominant seral[2] tree species:

- Ponderosa pine
- Southwestern white or limber pine
- Aspen on some sites

Dominant climax[3] tree species:

- Douglas-fir
- Blue spruce
- White fir

Common grass/forb shrub species:

- Dryspike sedge
- Screwleaf muhly
- Arizona fescue
- Gambel oak
- Common juniper
- Currants (*Ribes* species)

Species Composition

Tree Species (conifer)	Current age range of the most mature individuals on site	Estimated historic (1880) % of composition	Current composition (% of basal area)
Ponderosa pine	110 - 220 yrs. Avg. = 170	80%	45%
Douglas-fir	100-190 yrs. Avg. = 132	<20%	35%
Blue spruce	80-90 yrs. Avg. = 86	<1%	17%
White fir	75-120 yrs. Avg. = 98	<1%	3%

[1] 1997, USDA Forest Service, Plant Associations of Arizona and New Mexico, edition 3, volume 1: Forests
[2] Seral species will remain dominant under frequent disturbance conditions, such as characteristic frequent fire
[3] Climax species will develop and dominate over time when frequent disturbances do not occur (no frequent fire or cutting)

Treatment Demonstration

Jerry Simon, USFS-RO/ Kent Reid, NMHU
Monday, May 07, 2012

Marking Assumptions San Antonio Creek Dry Mixed ConiferArea

Leave trees are marked with orange flagging
Approximately 9.4 acres were flagged

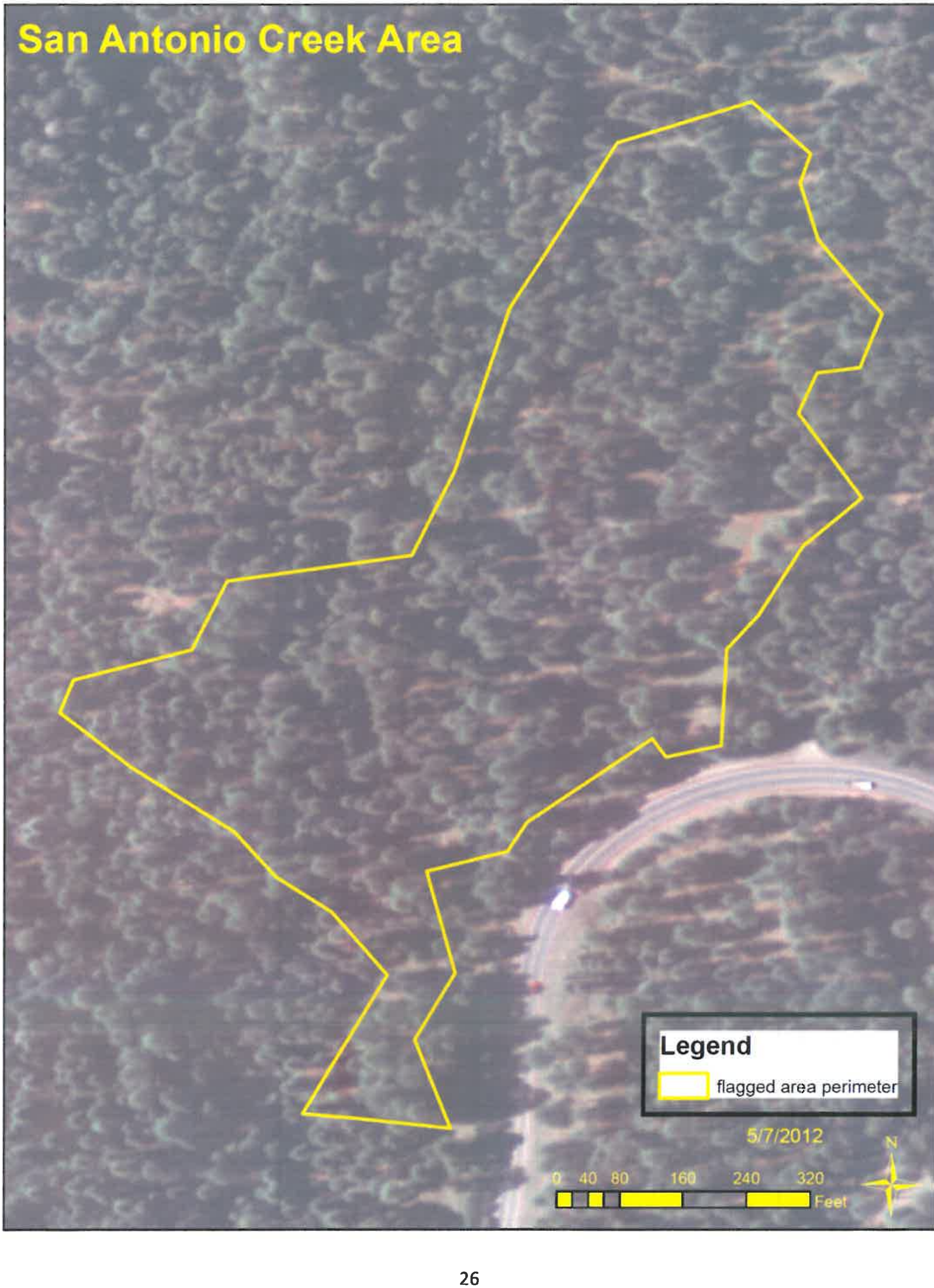
1. Retain most old ponderosa pine and Douglas-fir trees.
2. Move species composition toward historic conditions while retaining some species diversity.
3. Manage for deficit age classes of ponderosa pine and Douglas-fir
4. Look for opportunities to regenerate ponderosa pine and Douglas-fir by removing groups of spruce and white fir.

Most mature/old ponderosa pine and Douglas-fir were marked as leave trees, the exceptions being suppressed trees and severely mistletoe infested trees. Because there are so many large mature/old trees, within this sample flagged area, the resulting stand will be primarily made up of these large trees. A regeneration opening was created by removing a mistletoe pocket of overstory ponderosa pine trees. The objective being to create ponderosa pine seedlings free of mistletoe. In order to facilitate a more sustainable overall mix of age classes, additional trees would need to be removed to initiate tree regeneration if desired.

In the northwestern portion of the flagged area there were fewer mature/old ponderosa pine trees and more blue spruce and Douglas-fir. This area was marked as a larger leave tree group by spacing spruce and Douglas-fir leave trees to provide for forest cover and diversity. Alternately, ponderosa pine and Douglas-fir regeneration opportunities in the larger stand can be created by removal of young blue spruce/white fir groups. Where primary species were Douglas-fir, white fir, and blue spruce, the best formed Douglas-fir trees were retained with occasional blue spruce for species diversity. White fir trees were not intentionally marked for retention. Two Southwestern white pines were marked for retention one was marked to be cut because of severe form defects.

Tally for San Antonio Creek Dry Mixed Conifer demo area for
May 1012 Public Desired conditions tour
Leave trees (note DBH specifications are modified to conform to VSS classes)

	DBH	PIPO	PSME	ABCO	PIFL	PIPU	Total Trees Marked	Number Trees in VSS Class	Percent of Trees by VSS Class
	4				1		1	1	<1%
	5		6				6		
	6		6		1	1	8		
	7		11				11		
VSS 3	8		14				14		
	9	1	7				8		
	10	5	7			2	14		
	11	4	6				10	71	23%
	12	4	7				11		
	13	6	6				12		
VSS 4	14	5	3			3	11		
	15	7	3			2	12		
	16	14	3			1	18		
	17	13	3				16	80	26%
	18	9	6			1	16		
	19	7	2				9		
VSS 5	20	7	1				8		
	21	12					12		
	22	8					8		
	23	13	1				14	67	22%
	24	13					13		
	25	10	2				12		
	26	8					8		
	27	8	1				9		
	28	10	3				13		
	29	4	1				5		
VSS 6	30	5					5		
	31	4	2			1	7		
	32	3					3		
	33	3					3		
	34	1					1		
	35	2					2		
	36		1				1		
	37	1					1		
	38	1					1	84	28%
Total Trees		188	102	0	2	11	303		


San Antonio Creek Area
Legend
flagged area perimeter
5/7/2012
0 40 80 160 240 320
Feet
N

Region 3 FS Desired Conditions Workshop

Bluewater Forest Restoration Project- Desired Conditions Demonstration Stop Input Form

Cibola National Forest

Task: Break into small groups of 10-12 and walk through the treatment area with a member of the DC team. As you tour the treatment area, look at the treatment as it relates to the application of the desired conditions. Talk within your group and make notes on the following questions:

1. Does this site meet your expectations of desired conditions? Why or Why not?

2. What aspects (structure, composition and spatial characteristics) of the treatment (implementation of desired conditions) do you like and why?

3. What aspects of the treatment (implementation of the desired conditions) do you question and why?

4. What changes would you make to this prescription if you were implementing desired conditions to a similar stand (similar current stand conditions) on your forest and why?

5. Other comments:

After walking through the treatment area (15-20 minutes) re-convene as a large group and share your conclusions with the larger group. Break into smaller group again and walk through remainder of the stand. Repeat larger group discussion

Get directions   My places

4. Continue onto State Hwy 117

5. Take the ramp onto I-40 E

6. Take exit 159C to merge onto I-25 N toward Santa Fe

7. Take exit 233 toward Alameda Blvd/NM-528

8. Merge onto Pan American Frontage Rd N

9. Turn left onto Alameda Blvd NE
Destination will be on the right

Holiday Inn Express Hotel & Suites Albuquerque-N. Balloon Fsta Pk
5401 Alameda Blvd NE
Albuquerque, NM 87113

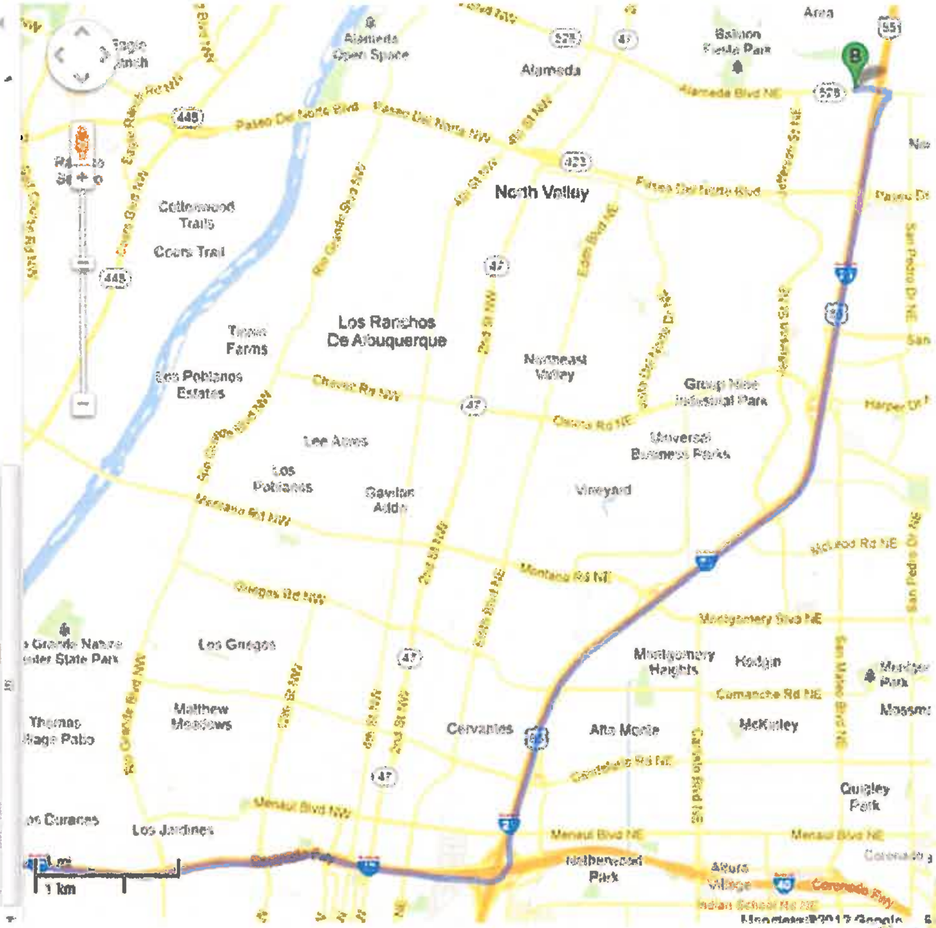
Save to My Maps

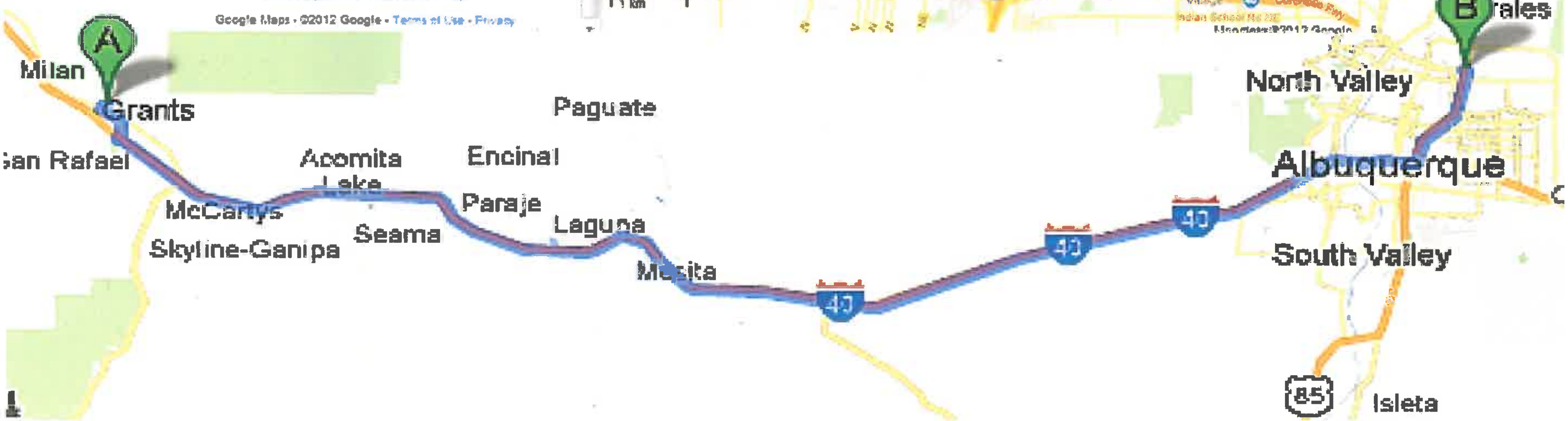
These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

Map data ©2012 Google

Report a problem - Maps Labs - Help

Google Maps - ©2012 Google - Terms of Use - Privacy





Working Papers in Southwestern
Ponderosa Pine Forest Restoration

Establishing Reference Conditions for Southwestern Ponderosa Pine Forests

April 2004

Ecological Restoration Institute
Northern Arizona University
P.O. Box 15017
Flagstaff, AZ 86011-5017
www.eri.nau.edu

Working Papers in Southwestern Ponderosa Pine Forest Restoration

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of southwestern ponderosa pine forests. These forests have been significantly altered through more than a century of fire suppression, livestock grazing, logging, and other ecosystem changes. As a result, ecological and recreational values of these forests have decreased, while the threat of large-scale fires has increased dramatically. The ERI is helping to restore these forests in collaboration with numerous public agencies. By allowing natural processes such as fire to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

Every restoration project needs to be site specific, but the detailed experience of field practitioners may help guide practitioners elsewhere. The Working Papers series presents findings and management recommendations from research and observations by the ERI and its partner organizations.

This publication would not have been possible without significant staff contributions and funding from the Bureau of Land Management. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

1: Restoring the Uinkaret Mountains: Operational Lessons and Adaptive Management Practices

2: Understory Plant Community Restoration in the Uinkaret Mountains, Arizona

3: Protecting Old Trees from Prescribed Fire

4: Fuels Treatments and Forest Restoration: An Analysis of Benefits

5: Limiting Damage to Forest Soils During Restoration

6: Butterflies as Indicators of Restoration Progress

What Are Reference Conditions, and Why Do They Matter?

Restoring southwestern ponderosa pine forests revolves around reintroducing a regime of frequent, low-intensity fires like those that historically maintained forest structure and function. Such fires were rare in the twentieth century, due to livestock grazing and widespread fire exclusion. The resulting buildup of woody fuels has caused a widespread crisis in forest health, the effects of which include huge and unnaturally severe crown fires, bark beetle outbreaks, and declining biodiversity.

Restoration treatments that include prescribed burning, often preceded by thinning to reduce fuel loads, have the potential to improve the ecological health of these forests. In order to wisely set the goals that underlie these treatments, it is useful for us to know as much as possible about past forest conditions, especially the "reference conditions" that existed before forest structure and function were altered by Euro-American settlers. Such conditions were not unchanging, but they sustained themselves across what has been called a "natural range of variability" (Falk 1990; Landres et al. 1999). They formed the "evolutionary environment" of southwestern ponderosa pine trees—a fairly stable environment, in other words, in which this tree species and many other plants and animals evolved and adapted. Restoring conditions similar to those of the evolutionary environment is not a matter of trying to return to the past; rather, it is the only way to assure the long-term health of these forests into the future.

This publication provides ideas about how to determine some reference conditions for southwestern ponderosa pine forests, using both physical and cultural evidence. For more detailed information about finding and determining reference conditions for a variety of ecosystems, consult Dave Egan and Evelyn Howell's book *The Historical Ecology Handbook* (2001), upon which this publication draws heavily.

Limitations of Reference Conditions

Reference conditions can serve as an important guide for future management, but it is important to emphasize that reference conditions are not the same as restoration goals. Some types of reference information, such as detailed data about understory vegetation, small trees, wildlife, and the degree to which native peoples burned forested areas, are simply not available for most periods in the past. Even where reference conditions are known, it is often not possible to fully re-create the conditions present before Euro-American settlement, as climate change, extirpation of native species, habitat fragmentation, and the introduction of nonnative species have irreversibly changed contemporary conditions. In many cases, it might not be desirable to return to presettlement conditions, due to considerations of wildlife management, recreation, aesthetics, and other modern needs. For example, dense thickets of small trees can provide cover for wildlife and visual screening along roads or near houses. Above all, each restoration treatment needs to be site specific.

Reference conditions will never provide a recipe for forest management, but they can help set restoration and management goals. They can "help (1) define what the original or preferred condition (composition, structure, processes, function) was compared to the present; (2) determine what factors caused the degradation; (3) define what needs to be done to restore the ecosystem; and (4) develop criteria for measuring the success of restoration treatments or experiments" (Egan and Howell 2001). Clues about reference conditions are a particularly powerful tool when multiple lines of evidence are used to create a fuller picture than one type of evidence alone could.

Physical Evidence

Some of the best clues about what forests were once like occur in the forests themselves, in the form of contemporary forest structure and old trees, alive or dead, that indicate how that structure has changed.

Old Forest Remnants

One of the best ways to understand what a given forest area might look like under a restored fire regime is to analyze nearby areas that are less degraded and therefore more closely resemble what presettlement forests looked like. Parts of the North Rim of the Grand Canyon, for example, have never been logged, have not been grazed by livestock for many years, if ever, and have experienced wildfires on a regular basis. Some other large protected areas, such as parts of the Gila Wilderness and El Malpais National Monument in New Mexico and Zion National Park in Utah, have also been examined for important clues to the past of southwestern forests. Small remnant sites that can help illustrate what forest structures were once like may also exist elsewhere, such as on or near steep slopes where topography made logging or grazing impossible.

Comparing nearby forest stands to those sites can help quantify the changes in forest structure that have resulted from modern management practices. It is important not to extrapolate too much from such sites, though, as forest structure and fire regimes can vary a great deal in a small area, especially where topography or other ecological conditions are varied.

Physical Remains of Old Trees

Trees present before Euro-American settlement are an obvious source of information about forest structure at an earlier time. While many of the trees standing at that time have either been logged or died naturally, their remains often persist for many decades in the arid climate of the Southwest. Searching for these remains can help establish some of the most accurate records of past forest structure.

Living trees. The bark of ponderosa pine trees generally begins to turn yellow at about a hundred years of age (White 1985). For that reason, it is often possible at a glance to gain a rough idea of a stand's age. Most restoration treatments being implemented in the Southwest call for retaining and protecting all yellow-barked pines, since these old trees are among the rarest resources in southwestern forests. Though no such guide exists for the Southwest, two useful publications that are available online detail how to determine the age of ponderosa pines in the Colorado Front Range (Huckaby et al. 2003a and 2003b).

Figure 1. *The thick, horizontal limbs of this old pine show that it grew in the open.*

The growth forms of ponderosa pines can also aid in reconstructing past forest structure. For example, trees grown in open conditions typically have full, rounded crowns and relatively long, thick branches (Figure 1), while trees grown in a closed forest more often appear long and narrow. These appearances persist even if stand conditions later change. A few old, open-grown pines surrounded by a sea of smaller, younger trees likely indicates that forest structure was once more open than it is now.

"Catfaces" or visible fire scars on old trees can provide valuable insights into the past fire history of forest stands (Figure 2). Such scars often preserve evidence of many fire events, which can be dated using the dendrochronological techniques described below.

Figure 2. *"Catfaces" such as this preserve records of past fires.*

A comparison of the species represented by old and young trees can also be telling. Near Flagstaff, for example, a study took place in ponderosa pine forest in which presettlement remains of fire-intolerant white fir (*Abies concolor*) were quite rare, yet the modern forest supports many young white firs (Fulé et al. 1997)—supporting the hypothesis that a lack of frequent fires in the twentieth century has changed both forest composition and structure.

Snags. Dead trees can stand for many years in the Southwest, particularly if they are large (Figure 3). They provide important wildlife habitat for such species as bats and cavity-nesting birds. Their size, age, and growth form provide the same sorts of clues to forest structure as living trees.

Figure 3. *Like a living tree, this snag records growth forms that shows how it grew.*

Figure 4. *Downed logs can remain on the forest floor for many decades, providing clues about old forest patterns.*

Downed logs. Especially where fire has long been absent, fallen logs can persist for decades on the forest floor (Figure 4). They can indicate the position, size, and age of old trees. In some parts of the Southwest it is possible to find stumps 16 or 32 feet away from remnants of tree tops, indicating that early loggers removed only the commercially valuable lower sections of trunk wood.

Stumps. Most of the Southwest's large ponderosa pines were cut during the nineteenth and twentieth centuries, but in many places their stumps still persist (Figure 5). Their size gives an idea of the size and species of the trees removed; their rings can be cross-dated to establish their age and growth rates; their spatial arrangement reflects forest structure before logging. The size of stumps can also reflect more modern forest history. Stumps cut before the introduction of chainsaws (generally in the first half of the twentieth century) are often chest-high, much higher than modern ones, as they were generally cut by loggers using handheld saws.

Stump holes. Where fires have passed or decay has occurred, the locations of large trees are often recorded for some time by the presence of stump holes (Figure 6) that show where trunks and roots grew.

Taken together, these records of old trees can be extremely valuable in reconstructing what was present at a time when frequent surface fires remained the primary architect of forest structure. In practice, field observations have often been combined

Figure 5. *Stumps record the locations of now-vanished trees, and their growth rings can provide data similar to those of standing trees.*

Figure 6. *Holes where stumps burned or decayed can persist for many years.*

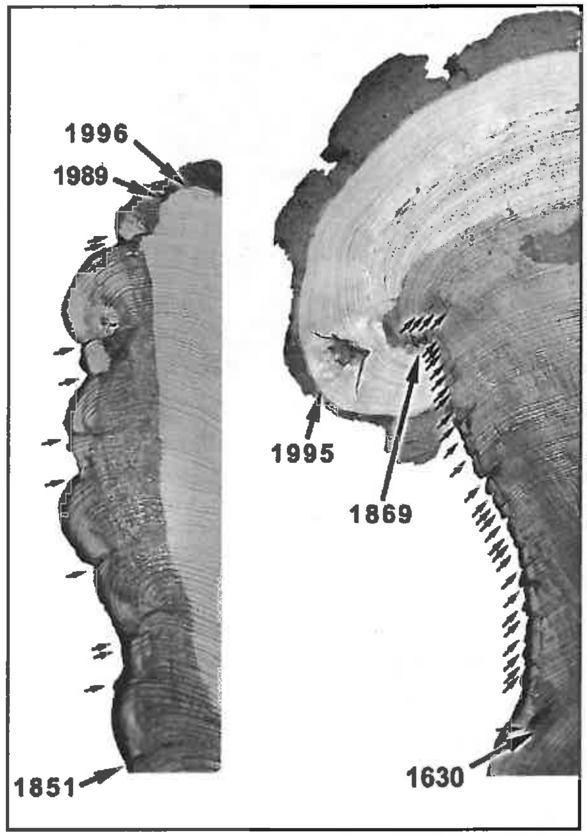
with dendrochronological dating of tree rings (see below). Even without that level of detail, modern-day observers of forest conditions can reconstruct a number of important aspects of historic forest structure, including tree density and size and to what extent trees grew in clumps.

Dendrochronology

In dry southwestern forests, trees often grow at differing rates in wet and dry years. A study of the growth rings preserved in their wood can provide a detailed look at past climate, fire regimes, and forest structure (Figure 7; Kipfmueller and Swetnam 2001). Dendrochronological techniques have been used to gain an increased understanding of past forest conditions at many sites in the Southwest (Swetnam and Baisan 1996).

By combining field observations of tree remains with dendrochronological cross-dating techniques, researchers have been able to reconstruct past stand conditions at a number of sites in southwestern ponderosa pine forests, including along the Mogollon Rim in central Arizona (Covington and Moore 1994), near Flagstaff (Fulé et al. 1997; Menzel and Covington 1997; Mast et al. 1999), at the Grand Canyon (Fulé et al. 2002), in the Uinkaret Mountains in far northern Arizona (Waltz et al. 2003), in the San Juan Mountains of southwestern Colorado (Romme et al. 2003), and in the Jemez Mountains in New Mexico (Allen 1998). Two excellent general guides to dendrochronology are Schweingruber (1988) and Stokes and Smiley (1996); there are also several good online guides, including **http://web.utk.edu/~grissino/default.html**, **http://www.plantbio.ohiou.edu/epb/instruct/ecology/dendro.htm**, and **http://www.ltrr.arizona.edu/dendrochronology.html**.

Figure 7. *Pine fire scars from Durango, Mexico (left), and Mount Trumbull in the Uinkaret Mountains of northern Arizona (right). Arrows indicate rings with fire scarring; outermost dates indicate when the fire scars were collected. In Mexico, fires continued at regular intervals through the twentieth century. In northern Arizona regular fires ceased with the onset of large-scale livestock grazing, with the last fire occurring in 1869. Photograph by Dan Boone/Northern Arizona University.*



Cultural Evidence

Written, photographic, and oral history evidence can provide significant insights into past conditions. Records of southwestern ecosystems are fairly accurate compared to those of many other parts of North America, since most of the Southwest was not explored or settled by Euro-Americans until the nineteenth century. As a result, many types of records can help indicate what southwestern forest conditions were like before the onset of heavy livestock grazing, logging, and fire exclusion.

Early Written Records

Various types of written records abound in libraries and archives, including records of early Spanish explorations, nineteenth-century survey expeditions, local histories, and the journals of early settlers. To find them, enquire at local or university libraries. Local historical societies may also be able to provide pointers about where to find resources for your area. Two bibliographic guides specific to the Southwest are Kaminkow (1975) and Rittenhouse (1971); look for them at a university library.

Many early written records are quite detailed and present a good description of what the landscape looked like. For example, Vernon Bailey wrote this account of the Jemez Mountains in northern New Mexico in 1904: ". . . generally an open park like forest with well spaced trees and clean grama turf beneath. The trees are large and symmetrical, often 5 feet in diameter and 80 to 100 feet high with beautifully smooth trunks" (quoted in Allen 2002). Such a description can be helpful in setting restoration goals. However, it is important to note that this is a *qualitative* rather than a *quantitative* description. It does not present any measurements of forest structure. It does not record the number of trees per acre, nor whether the trees are clumped or evenly spaced. It does not indicate what other plants besides ponderosa pines and grasses were present. In other words, it is not an exact description, and it is certainly not an exact restoration prescription.

It is also important to remember that historical accounts may utilize different species names than we know today; for example, ponderosa pine may be referred to either as yellow pine or western white pine.

General Land Office Surveys

Surveys of most lands in the Southwest were conducted in the nineteenth century by the federal General Land Office, the precursor of the Bureau of Land Management (BLM). These surveys identified and marked section corners and resulted in the recording of extensive data about the vegetation of areas surveyed, as surveyors were required to record basic descriptions of the vegetation they traversed along section lines. This information can be valuable in assessing how the structure or composition of forests and woodlands may have changed in the intervening decades. As an example, Arundel (2000) used GLO records from 1878 and 1879 to assess the distribution of forest stands and meadows, the percentage of various tree species, tree densities, and tree diameters in an area near Flagstaff—information that could be useful in setting restoration goals.

Copies of surveys for the southwestern states are generally available at state BLM offices. For an overview of the use of GLO data, see a helpful chapter by Whitney and DeCant (2001). Galatowitsch (1990) writes specifically about using GLO records in western landscapes.

Forest Service Records

After the establishment of the Forest Service in the early twentieth century, the new agency commissioned timber surveys of new national forests in the Southwest and elsewhere. The surveys were intended primarily to quantify how much usable timber was available. Some of them include considerable detail about the tree species present, the density and size of stands, and other forest conditions. Long-term plots set up by early Forest Service researchers on some southwestern national forests are a particularly rich source of data (Moore et al. in press).

To locate such inventories, contact the supervisor's office of the national forest in your area. The Forest Service report *Timeless Heritage* (Baker et al. 1988) has an extensive bibliography of early agency publications; so does the Web site of the National Archives at **http://www.archives.gov.** The online archive of the Forest History Society at **http://www.lib.duke.edu/forest/archmain.html** is also a valuable resource.

Oral Histories

A great deal of information about ecological conditions exists in the minds and memories of people who have not recorded their experiences in written form. Native Americans, ranchers, and other local residents often have long traditions of use and observation of the land that do not exist in writing, but may be of great relevance to contemporary management. Oral histories can, for example, reveal what sorts of land management practices were used in the past, and may give an idea of how ecological conditions have changed over time.

Local libraries and historical societies often have collections of transcribed interviews conducted in the past. The recording of formal oral histories properly requires a protocol, described by Fogerty (2001). When seeking oral history information from any informants, it is important to remember that it may take a good deal of time to build the trust necessary for a useful interview. Cultural sensitivity is key; for example, in some Native American communities certain stories are told only at certain times of year. It's also good etiquette to give something back, for example by making oral histories available to the community in which they were acquired.

Figure 8. *Photographs of the same forest stand before and after it was changed by modern land-management practices can help quantify changes over time, and can aid in setting restoration goals. Walker Lake, Coconino National Forest, Arizona, in the 1870s and 2003; 2003 photo courtesy of Dennis Lund and Neil Weintraub.*

Photographs

Historic photographs are among the most useful of records in understanding changing forest conditions. Photographs from the late nineteenth and early twentieth centuries can show what conditions existed before significant ecological changes took place. It can be particularly valuable to rephotograph the same landscape shown in a historic view; for example, images of Walker Lake on the Coconino National Forest show a greatly increased density of ponderosa pine between the 1870s and 2003 (Figure 8). Some researchers have also used aerial photographs taken in different decades to assess changes in forest density over time.

When looking at historic photographs it is important to consider the land uses that went on before the photos were taken. A photograph of a forest that was selectively logged or heavily grazed will not accurately represent what the forest structure was like before those land uses were instituted. Differences in photographic technology may also make scenes in historic photographs appear different than they do in today's photos; for example, many old film types were unable to record wide differences in exposures, with the result that areas that appear light-colored in a contemporary photo may be entirely washed out in an old one.

To find historic photographs, contact libraries, historical societies, and local offices of the Forest Service, BLM, or other federal, state, or tribal land management agencies. Two useful Forest Service Web sites with archival photos are **http://www.fs.fed.us/r3/about/history/photo.shtml** and **http://www.rmrs.nau.edu/imagedb/index.shtml.**

Conclusion

A variety of opportunities exist for uncovering reference conditions for southwestern ponderosa pine forests. By using several of the techniques described above, researchers and managers can develop converging lines of evidence. For example, written records may be lacking for a given area, but an examination of both historic photographs and contemporary forest structure can provide insights into historic conditions. Whatever is learned about reference conditions will not provide an easy recipe for restoration or management. It will, though, help establish how a forest area once sustained itself, which is an important step in deciding how to make forest conditions more sustainable once again.

References

Allen, C. D. 1998. A ponderosa pine natural area reveals its secrets. Pp. 551–552 in *Status and trends of the nation's biological resources*, vol. 2, ed. M. J. Mac et al. Reston, Va.: U.S. Geological Survey. **http://biology.usgs.gov/s+t/SNT/noframe/sw153.htm**.

Allen, C. D. 2002. Lots of lightning and plenty of people: An ecological history of fire in the upland Southwest. Pp. 143–193 in *Fire, native peoples, and the natural landscape*, ed. T. R. Vale. Washington, D.C.: Island Press.

Arundel, T. R. 2000. Using General Land Office survey records to determine pre-settlement forest conditions in north-central Arizona, 1878–1879. M. A. thesis, Northern Arizona University, Flagstaff.

Baker, R. D., R. S. Maxwell, V. H. Treat, and H. C. Dethloff. 1988. *Timeless heritage: A history of the Forest Service in the Southwest*. FS-409. Washington, D.C.: USDA Forest Service.

Covington, W. W., and M. M. Moore. 1994. Southwestern ponderosa pine forest structure: Changes since Euro-American settlement. *Journal of Forestry* 92(1):39–47.

Egan, D., and E. A. Howell, eds. 2001. *The historical ecology handbook: A restorationist's guide to reference ecosystems*. Washington, D.C.: Island Press.

Falk, D. A. 1990. Discovering the past, creating the future. *Restoration & Management Notes* 8(2):71–72.

Fogerty, J. E. 2001. Oral history: A guide to its creation and use. Pp. 101–120 in *The historical ecology handbook: A restorationist's guide to reference ecosystems*, ed. D. Egan and E. A. Howell. Washington, D.C.: Island Press.

Fulé, P. Z., W. W. Covington, and M. M. Moore. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. *Ecological Applications* 7:895–908.

Fulé, P. Z., W. W. Covington, H. B. Smith, J. D. Springer, T. A. Heinlein, K. D. Huisinga, and M. M. Moore. 2002. Comparing ecological restoration alternatives: Grand Canyon, Arizona. *Forest Ecology and Management* 170:19–41.

Galatowitsch, S. M. 1990. Using the original Land Survey notes to reconstruct presettlement landscapes in the American West. *Great Basin Naturalist* 50(2):181–191.

Huckaby, L. S., M. R. Kaufmann, P. J. Fornwalt, J. M. Stoker, and C. Dennis. 2003a. Field guide to old ponderosa pines in the Colorado Front Range. General technical report RMRS-GTR-109. Fort Collins, Colo.: USDA Forest Service. **http://www.fs.fed.us/rm/pubs/rmrs_gtr109.html.**

Huckaby, L. S., M. R. Kaufmann, P. J. Fornwalt, J. M. Stoker, and C. Dennis. 2003b. *Identification and ecology of old ponderosa pine trees in the Colorado Front Range.* General technical report RMRS-GTR-110. Fort Collins, Colo.: USDA Forest Service. **http://www.fs.fed.us/rm/pubs/rmrs_gtr110.html.**

Kaminkow, M. J. 1975. *United States local histories in the Library of Congress: A bibliography.* Baltimore: Magna Carta.

Kipfmueller, K. F., and T. W. Swetnam. 2001. Using dendrochronology to reconstruct the history of forest and woodland ecosystems. Pp. 199–228 in *The historical ecology handbook: A restorationist's guide to reference ecosystems,* ed. D. Egan and E. A. Howell. Washington, D.C.: Island Press.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. *Ecological Applications* 9:1179–1188.

Mast, J. N., P. Z. Fulé, M. M. Moore, W. W. Covington, and A. Waltz. 1999. Restoration of presettlement age structure of an Arizona ponderosa pine forest. *Ecological Applications* 9:228–239.

Menzel, J. P., and W. W. Covington. 1997. Changes from 1876 to 1994 in a forest ecosystem near Walnut Canyon, northern Arizona. Pp. 151–172 in *Proceedings of the Third Biennial Conference of Research on the Colorado Plateau,* ed. C. van Riper III and E. T. Deshler. National Park Service transactions and proceedings series NPS/NRNAU/NRTP-97/12. Washington, D.C.: USDI National Park Service.

Moore, M. M., D. W. Huffman, P. Z. Fulé, W. W. Covington, and J. E. Crouse. In press. Comparison of historical and contemporary forest structure and composition on permanent plots in southwestern ponderosa pine forests. *Forest Science.*

Rittenhouse, J. D. 1971. *The Santa Fe Trail: A historical bibliography.* Albuquerque: University of New Mexico Press.

Romme, W. H., M. Preston, D. L. Lynch, P. Kemp, M. L. Floyd, D. D. Hanna, and S. Burns. 2003. The Ponderosa Pine Forest Partnership: Ecology, economics, and community involvement in forest restoration. Pp. 99–125 in *Ecological restoration of southwestern ponderosa pine forests*, ed. Peter Friederici. Washington, D.C.: Island Press.

Schweingruber, F. H. 1988. *Tree rings: Basics and applications of dendrochronology*. Dordrecht, the Netherlands: D. Reidel.

Stokes, M. A., and T. L. Smiley. 1996. *An introduction to tree-ring dating*. Tucson: University of Arizona Press.

Swetnam, T. W., and C. H. Baisan. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pp. 11–32 in *Fire effects in southwestern forests: Proceedings of the Second La Mesa Fire Symposium*, ed. C. D. Allen. General technical report RM-286. Fort Collins, Colo.: USDA Forest Service.

Waltz, A. E. M., P. Z. Fulé, W. W. Covington, and M. M. Moore. 2003. Diversity in ponderosa pine forest structure following ecological restoration treatments. *Forest Science* 49(6): 885–900.

White, A. S. 1985. Presettlement regeneration patterns in a southwestern ponderosa pine stand. *Ecology* 66:589–594.

Whitney, G. G., and J. P. DeCant. 2001. Government Land Office surveys and other early land surveys. Pp. 147–172 in *The historical ecology handbook: A restorationist's guide to reference ecosystems*, ed. D. Egan and E. A. Howell. Washington, D.C.: Island Press.

For More Information

Read more about reference conditions and forest restoration at **www.eri.nau.edu**, or call 928-523-7182.

Written by Peter Friederici

Reviewed by Steve Buckley, Hanna J. Cortner, W. Wallace Covington, Dave Egan, Don Falk, Peter Z. Fulé, Margaret M. Moore, Susan Olberding, and Diane Vosick

Series Editor Peter Friederici

Northern Arizona University is an Equal Opportunity/Affirmative Action Institution
NAU Creative Communications/A53901/1M/04-04

Ecological Restoration Institute
Northern Arizona University
P.O. Box 15017
Flagstaff, AZ 86011-5017
www.eri.nau.edu

2ERI 35AE

Workshop Evaluation Form

DESIRED CONDITION WORKSHOP

May 9-10, 2012

1. **Have we adequately described and demonstrated the major principles, concepts and characteristics of the desired conditions? Yes or No Please explain.**

2. **What are your thoughts about the barriers and/or opportunities you see with the development and implementation of the desired conditions presented at this workshop?**

3. **The Regional Forester Perspective on DC, Landscape Scale Restoration by Corbin Newman was:**

   5 (Helpful) 4 3 2 1 (Not Helpful)

   Comments:

4. **The Setting the Stage for Desired Condition Dialogue by Wally Covington was:**

   5 (Helpful) 4 3 2 1 (Not Helpful)

   Comments:

5. **The Desired Condition Description presentation by the DC Team was:**

   5 (Helpful) 4 3 2 1 (Not Helpful)

   Comments:

6. **The Panel Discussion was:**

   5 (Helpful) 4 3 2 1 (Not Helpful)

   Comments:

7. **The Field Trips were:**

   5 (Helpful)   4   3   2   1 (Not Helpful)

   Comments:

8. **The written materials were:**

   5 (Helpful)   4   3   2   1 (Not Helpful)

   Comments:

9. **Overall, was the information presented at this conference relevant and useful to you? If not, please explain or recommend changes.**

   5 (Helpful)   4   3   2   1 (Not Helpful)

   Comments:

10. **How will you use what you have learned from this workshop?**

11. **Any other comments?**

Thank you for completing this evaluation form!