

**Short Guide
for Developing
CFRP RESTORATION
PRESCRIPTIONS**



Melissa Savage
Tori Derr
Alexander Evans
Eytan Krasilovsky
Ken Smith
Henry Carey

January 2008

New Mexico Forest Restoration Series
WORKING PAPER

1

New Mexico Forest Restoration Series
WORKING PAPER 1

**Short Guide for Developing
COLLABORATIVE FOREST RESTORATION PROJECT
RESTORATION PRESCRIPTIONS**

Publication Date:
December 2007

Authors:
Melissa Savage, Tori Derr, Alexander Evans,
Eytan Krasilovsky, Ken Smith, Henry Carey

Reviewers:
The authors thank the following reviewers for comments that greatly improved this document: David Borland (US Bureau of Land Management), Anne Bradley (The Nature Conservancy), John Phillips (US Forest Service, Region 3 CFRP), Kent Reid (New Mexico Forest and Watershed Restoration Institute), William Romme (Colorado State University), Todd Schulke (Center for Biological Diversity), Jim Youtz (US Forest Service, Region 3).

Produced with funding from the Collaborative Forest Restoration Program and the McCune Charitable Foundation

Please contact New Mexico Forest and Watershed Restoration Institute for reproduction policies. All material copyright © 2007.

New Mexico Forest and Watershed Restoration Institute
New Mexico Highlands University
PO Box 9000
Las Vegas, NM 87701

New Mexico Forest and Watershed Restoration Institute

*forest***GUILD**

4CORNERS INSTITUTE

Crane Collaborations

Table of Contents

2	Introduction
2	What is good forest restoration?
7	How to successfully engage in the process of developing an appropriate prescription
7	<i>Proposal Development Phase</i>
8	<i>Project Implementation Phase</i>
10	Desired future conditions
10	Developing Prescriptions for Four Southwestern Forest Types
10	<i>Ponderosa Pine Forest</i>
12	<i>Piñon-Juniper Forests</i>
14	<i>Southwestern Mixed Conifer Forest</i>
16	<i>Bosque Forest</i>
17	Conclusion

Short Guide for Developing CFRP Restoration Prescriptions

Introduction

The purpose of this short guide is to provide information to assist Collaborative Forest Restoration Program (CFRP) grant recipients in designing a restoration prescription that will move forests toward healthier, more natural conditions. Forest stands vary considerably from place to place because of forest type, site history and forest structure. CFRP project collaborators should develop a prescription specific to the site to be treated. A prescription should be based on current conditions, targeted desired future conditions and restoration goals.

One important goal of ecological restoration should be to return natural processes, such as cool fires, to forests so that eventually, forest health can be maintained naturally, without continuing human intervention. Restoration goals will be based on a project's forest type, history of human impacts, and current forest structure. The recommendations made here are general, and should adapt them when designing prescriptions for a site.

“One important goal of ecological restoration should be to return natural processes, such as cool fires, to forests so that eventually, forest health can be maintained naturally, without continuing human intervention.”

When developing a restoration project, you should take into account the social and economic conditions of an area. These conditions might include issues that relate to job creation, workforce training, business development, and community support for restoration. Again, it is important to identify what your goals are, and the steps needed to accomplish these goals. Many projects strive to develop a local economy based on restoration, with the necessary business infrastructure and workforce to accomplish this. These issues are discussed in depth in a publication titled “Social and Economic Issues in Landscape Scale Restoration,” published by the New Mexico Forest and Watershed Restoration Institute.

What is good forest restoration?

Decades of human activities have changed forests in damaging ways. Forest restoration projects should help bring ecological integrity back to these forests. The most dramatic change in Southwest forests is the large increase in numbers of trees. High densities of small trees now fuel hot crown fires in many forests that did not experience crown fires in the past. One of the main goals of forest restoration is the reduction of the threat of catastrophic wildfires. The removal of dense thickets of small trees and of dead wood on the ground are crucial to lowering unnatural wildfire risk.

A single focus only on removing excess fuels and trees is not the same as ecological restoration. Fuel reduction is only one component of restoration. Restoration also involves changing the structure of the forest, to include an appropriate size and age structure, groupings of trees, decomposing wood on the ground, and small or large scattered meadows. It also involves reestablishing cool

“**Restoration of natural processes will return natural integrity to forests so that in the future they will not require an intensive and expensive restoration re-entry.**”

fires where appropriate, fostering a healthy grass and forb cover, caring for soils and waterways, recovering native species, and protecting wildlife. Ecological restoration aims to change forest structure, but also to protect the health of the ecosystem as a whole. Restoration of natural processes will return natural integrity to forests so that in the future they will not require an intensive and expensive restoration re-entry.

Restoration prescriptions should aim to:

- **Change the structure of the forest that exists on the site.** Most forest restoration projects will aim to reduce the number of trees on the site. The target forest structure must be based on the current condition of the forest stand. When designing a prescription, you should build on important features, such as large trees, small openings in the forest, and existing clumps of trees. These features help make the forest resistant to crown fires, and are important for wildlife species. In some forests, a patchy arrangement of clumps of trees creates sunny openings on the forest floor and allows understory plants to flourish.
- **Restore natural fire and other processes.** Natural processes help maintain healthy forests. For example, cool fires that burned on the forest floor were common in ponderosa pine and many piñon-juniper stands in the past. Cool, frequent fires burn patchily in the forest, killing some but not all of the seedlings and saplings. If cool fires are not restored to a thinned forest, trees will rapidly regenerate and begin to make the same thickets of young trees. The forest will soon become dense enough to burn in a crown fire again and restoration efforts will be set back. Returning surface fires usually starts with a prescribed fire, gentle enough to burn safely even in wildland-urban interfaces. Eventually, low fuel levels should allow naturally ignited fires to burn safely.

Some Southwestern forest types experienced crown fires in the past as a natural part of their history. Spruce-fir forests, a high-elevation forest type, usually burned in hot fires every few centuries, and restoration is not necessary or appropriate in such forests.



In bosque forests where flooding was a typical process, the return of some occasional surface water flow will help cottonwood and other native trees regenerate. This may involve diverting water temporarily into the bosque, for even brief periods of time.

- **Lower the threat of crown fires.** Dense thickets of trees, especially small trees in the understory, support hot crown fires that kill trees and threaten human communities. This is true in ponderosa pine and many piñon pine/juniper forests where the suppression of fire has allowed many young trees to establish. Lowering the threat of crown fire involves thinning overly dense stands of young and small trees, which carry fire into tree crowns. In bosque forests, the threat of harmful fires can be reduced by removing thickets of non-native trees like Russian Olive and tamarisk that can carry fire into the crown of cottonwood trees.
- **Make the restoration treatment fit the forest type.** There are many forest types in the Southwest: ponderosa pine, piñon-juniper, mixed conifer, bosque, and others. Each of these types has very different structures and conditions, although all share a recent vulnerability to crown fire. Guidance for developing specific restoration prescriptions for these forest types is given in sections below.
- **Make the restoration treatment plan fit the site.** Within forests types, density and diversity once varied across the landscape. “One plan that fits all sites” is not a good approach to restoration. Find out as much as possible about what the forest stand was like in the past. Use patterns of living old trees, historical photographs, management records, early forest surveys, and other historical information, as well as ecological data from monitoring to help understand site history. Consider incorporating variable thinning rates across a site, for example by thinning to a lower density of trees on ridges to break up fuel continuity.
- **Protect wildlife habitat.** Keep features such as small groups of young trees, large dead and down logs, large snags, and clusters of mature trees with interlocking crowns, so that wildlife can thrive after restoration treatments. Some wildlife depends on plants that produce seeds, berries or acorns, so protect oaks and other fruiting plants.
- **Protect the soil.** Try to minimize short-term impacts caused by treatments, such as erosion and compaction of the soil by vehicles. Leaving some slash on the ground after treatment may help protect the soils while understory plants recover from the impact of treatment. For example, you may scatter branches on the ground in piñon-juniper stands, or lay tree boles along the contour of steep slopes in ponderosa pine stands.
- **Foster an understory of grasses and forbs.** Overly dense forests may lack a ground cover of shrubs, grasses and forbs because they do not receive enough sun and moisture. Sometimes the ground is only covered with dead tree needles or is mostly bare. Make a healthy cover of grasses and other plants a major restoration objective because understory plants fulfill many roles, including: 1) carrying cool surface fires, 2) providing wildlife habitat and food, 3) protecting the soil, and 4) contributing to species diversity. Use a thinning approach – such as the use of chainsaw cutting or low-impact machinery – that does not disrupt understory plants. Prescribed fires help remove thick needle cover to allow plants to reestablish.

- **Keep old growth trees and a variety of tree structures.** In general, it is not appropriate to cut large and old trees to achieve the goals of ecological restoration. Large and old trees contain critical genetic, structural, and habitat qualities. Also protect large dead trees, or snags, since they provide unique and vital wildlife habitat. Keep some small trees so that they can grow into the canopy over time. For most forest types, especially ponderosa pine, restore or maintain an all-age structure: one with some young trees, some middle-aged, and some large old trees.
- **Take care to ensure that invasive plants don't become abundant.** Invasive plants are aggressive, often non-native plants that thrive in disturbed places. Increases in non-native plants can have a negative impact on restoration work, altering fire intensity and competing with native plants. Preventing the establishment of invasive plants is key to controlling them. Wash equipment before each treatment. Avoid reseeding, as seed mixes can be contaminated with invasives. Hand-pull invasive plants when populations are still low, or carefully apply biodegradable herbicides. Consider pre-treatment removal of invasives to prevent expanded populations in a completed restoration site.
- **Protect the restored site from livestock grazing.** Defer grazing until the grasses and other understory plants fully recover to provide long-lasting positive effects. Depending on how favorable the local weather is for the establishment of understory plants, it may take 2 to 5 years for robust establishment. Project collaborators should fully discuss grazing issues during project development.
- **Reduce the amount of dead and down fuel.** Live trees make up most of the biomass that fuels crown fires. Nevertheless, since there have been few or no fires for many decades in most forests, there also can be a large number of dead trees and piles of branches on the surface of the ground that can help carry a hot fire. Some forest types have more dead surface fuels than others. Bosque forests, for example, can have many tons of debris from non-native trees and large dead cottonwoods that need removal to lower fire risk.





- **Consider the whole project landscape.** At some project sites, you may not need to treat the whole area to get good forest restoration. Place prescriptive treatments strategically on a site for maximum impact and take advantage of the fact that project sites usually vary in slope steepness, forest structure, soils, and other factors. For example, ridgetops are both drier than lowlands and struck more often by lightning. Before fire suppression, stands of trees on ridgetops were often less dense than surrounding forest. You can thin ridgetop stands to a lower density or basal area than the rest of the site to get maximum impact from treatments. Strategically placed treatments within a project can be both economical and ecologically effective at restoring a larger landscape without having to treat every single acre.
- **Foster heterogeneity.** Change the restoration prescription to fit the forest as it changes across the project site. Biological communities vary across the landscape and treatments should as well.

- **Treat streamside corridors differently from surrounding forest.** A forest stand growing along a waterway may need a different treatment plan from the surrounding forest. Because the soil is usually wetter, stands along creeks were often historically denser. Leave a higher density of native trees along streamsid es to protect soil and water resources. Vegetation left along waterways can provide habitat for wildlife and a corridor that allows wildlife to travel through the landscape.
- **Use low impact treatment techniques.** Use the least disruptive techniques when planning restoration treatments. Prescribed fires may be enough to reestablish natural conditions in some places, but in most places mechanical thinning of trees is needed before the introduction of prescribed fire. Avoid wounding bark on trees that will remain in the forest. Use low impact logging techniques that will minimize erosion, disruption of surface runoff, re-establishment of understory plants, and other detrimental ecosystem effects.
- **Consider that restoration may take time.** Restoration takes many years. Land managers and collaborators may need to revisit sites for years to come. Land managers should develop a plan for prescribed fire and managed natural fire in many forest types. In bosque forests, project managers may need to repeat efforts to remove invasive non-native tree species. Forests may need active management and more than one treatment until natural processes like fire or flooding begin to take over the job of maintaining healthy forests.

For more information on restoration in Southwestern forests go to:

- The New Mexico Restoration Principles
<http://www.fs.fed.us/r3/spf/nm-restor-principles-122006.pdf>

How to successfully engage in the process of developing an appropriate prescription

Site specific restoration involves using ecological objectives and stakeholder perspectives in the development of prescription specifics. A multiparty process helps in collaboratively developing a site specific prescription.

It is important to choose an appropriate site for restoration, one with a forest stand that will improve with restoration activities. Proposals should include a careful description of current site conditions, including tree structure, density and composition, fuel levels, insect damage, wildlife information, and any information that describes conditions of the project area in the past. An important feature of a site-specific restoration is that it considers the ecological conditions at the exact site identified for treatment. Baseline monitoring can provide much of this information. Collect baseline monitoring data prior to developing a prescription and visit the site with all members of the multiparty team to discuss the baseline data. Develop a prescription that takes into account the variability and unique characteristics of the site.

In general, there are two stages in developing a site-specific restoration prescription: 1) steps that occur during proposal development and 2) those that occur during project implementation, after the grant is awarded.

Proposal Development Phase

To successfully engage your project partners in writing a prescription, begin planning during the proposal development stage. At this early stage in a CFRP project, you can develop a workplan and budget for prescription development. Make sure to engage a multiparty team that includes land owners, land management agencies, and diverse stakeholders in the following steps to:

“ To successfully engage your project partners in writing a prescription, begin planning during the proposal development stage.”

- Select priority areas that are appropriate for restoration, in collaboration with land management entities, communities, and interested parties
- Identify opportunities to build on existing restoration efforts in the area
- Identify opportunities to build on existing wood utilization efforts
- Clarify which areas are “NEPA ready” or otherwise have environmental or cultural clearances as well as those that will need these completed during the timeframe of the project.

- Collect baseline ecological data on the site(s) to be treated and analyze it with the multi-party team. Use this information to characterize current conditions and to design desired future conditions. The CFRP offers extensive assistance with collecting monitoring data
- Develop a coherent Budget and Workplan that show how your proposed project incorporates multiparty monitoring and baseline monitoring data in the development of a site-specific prescription
- Use a multiparty process to develop the prescription using baseline monitoring data, restoration targets that are measurable, and results of post-treatment monitoring to influence future prescriptions
- Develop a clear overall plan for restoration that:
 - describes current conditions
 - describes past conditions from a time when the forest was healthy
 - develops desired future conditions using historical conditions as a guide
 - identifies treatment activities based on desired future conditions
 - plans for adaptation of treatments as needed during implementation

Project Implementation Phase

- Hold a multiparty meeting, preferably at the site, to review baseline data as it relates to the restoration goals and prescription
- Collaboratively develop and write the prescription for the first treatment site
- Implement the restoration treatment
- Collect and analyze post-treatment data
- Convene the multiparty team at the site to evaluate successes and shortcomings of the prescription and to develop any future stand's prescription based on lessons learned from the first treatment
- Repeat these steps for all sites that are part of the restoration area

Below is an example of a workplan and timeline from a CFRP project that used this process:

<u>What will be done?</u>	<u>Who will do it?</u>	<u>When will it be done?</u>
Develop a plan during the proposal development phase to engage a multiparty team in the identification and prioritization of sites for restoration	Grantee with Multiparty Team	Proposal Development Stage
Form the multiparty team and develop a monitoring plan	Multiparty team (Grantee, Chimayo YCC, Earth Works Institute, Ranger District, BLM, TLG, Stewardship block holders)	Proposal Development Stage
Collect existing NEPAs and other environmental or cultural clearances	Grantee	Proposal Development Stage
NEPA and Cultural Clearances for TLG land	Ecological Consultants, Inc.	Project Year 1
Collect baseline multiparty monitoring data	Grantee, Chimayo YCC, Earth Works Institute., Multi-party monitoring team	Project Year 1
Collaboratively write prescription for first treatment site	Ranger District, BLM, TLG, Grantee, Stewardship Block holders, and Multiparty team	Project Year 1
Mark the treatment areas	Ranger District, BLM, TLG, Grantee	Project Year 1
Implement restoration treatment	Contractor	Project Year 2
Collect and analyze post treatment data	Grantee, Multiparty team	Project Year 2
Review post-treatment data with the multiparty team and revise future prescriptions as necessary	Ranger District, BLM, Grantee, Multiparty team	Project Year 2
Repeat Process for additional treatment areas		Project Year 3

Desired future conditions

CFRP guidelines require that each proposal include a statement of desired future conditions for the project area. A desired future condition is a description of best possible ecological and socio-economic conditions for a particular site. Treatments over the course of project implementation should bring the forest on your site closer to desired future conditions.

The ecological desired future conditions should reflect the site's characteristics, especially the original forest structure on the site, as well as soil productivity, potential vegetation, and climate. The desired future conditions should include ecological processes, such as cool fires, and should acknowledge that forests will continue to change over time. You can develop the ecological characteristics of desired future conditions, such as tree density and composition, using studies of historic conditions or similar sites currently in good health.

Developing Prescriptions for Four Southwestern Forest Types

Most CFRP projects are restoring one or more of the following four forest types. Within each forest type there can be considerable variability in structure and species composition. Each CFRP project should carefully evaluate project site characteristics when developing a prescription. Experience from past restoration work suggests the following rules of thumb for treating the following forests types.

Ponderosa Pine Forest

Ponderosa pine forests in the Southwest have become too dense with small trees over the last century because of overgrazing by livestock, suppression of cool surface fires, and logging of the largest trees. Meadows that in the past were scattered throughout the forest have become filled with young trees that have moved in from the forest edge. The forest floor is now covered with a layer of dead pine needles instead of grasses and other plants. Dead standing trees, especially large ones, are not as numerous as they once were.



Some recommendations for developing an ecological prescription for ponderosa pine forests are as follows:

- *Remove small trees and keep the larger trees.* The New Mexico Restoration Principles recommend that forest restoration objectives favor the presence of both abundant large diameter trees and an appropriate distribution of age classes on the landscape, with a wide distribution of older trees. It is generally advisable to maintain ponderosa trees larger than 16 inches DBH (diameter at breast height) and other trees with old-growth morphology (such as yellow-barked ponderosa pine or any species with large dropping limbs, twisted trunks, or flattened tops), regardless of size.¹
- *Incorporate prescribed fire into the prescription.* Cool surface fires were part of the history of almost all ponderosa pine forests in the region. Without these fires a thinned forest will soon revert to a dense, crown-fire-prone stand, perhaps in less than ten years. In the best case, lightning will start natural cool fires often enough to keep fuel load down. These natural ignitions will benefit the forest if they are carefully managed. Otherwise, land managers will need to burn the forest periodically with a prescribed fire.
- *Develop density and basal area targets that reflect local site history.* For example, adult tree density from 40 to 100 trees per acre is probably appropriate on most ponderosa pine sites in the Southwest. You can typically vary density across a project site, with lower density on ridges or near roads, and higher density in areas of wildlife concern, such as goshawk nesting habitat.
- *Create clumps of trees—perhaps 6 to 12 mature trees together—throughout the site to benefit wildlife.* Tree crowns should touch or nearly touch within clumps, but be isolated from tree crowns outside the clump. Aim for two to three or more clumps per acre. Tree clumps are at less risk of crown fire if surrounded by areas of lower tree density.
- *Foster the growth of an understory.* For the most part, the understory will recover on its own, when there is more sunlight and water available after thinning. Leaving some of the branches from thinning treatments strewn on the ground will help understory plants reestablish. Spreading slash on the ground before a prescribed burn rather than piling and burning may also help. Intense heat from burning piled slash can kill seeds in the soil beneath slash piles. Consider collecting seed from adjacent forest for use on the restored project.
- *Avoid reseeding.* Even native seed mixes are usually contaminated by weedy species. Most sites have enough native plants to naturally reseed the site.
- *Reduce surface fuels.* The majority of fuels in most ponderosa pine stands are small, living trees. Thinning treatments will produce large amounts of dangerous fuels from these trees, which must be removed from the site to prevent a hot fire. Cut wood may be

¹The New Mexico Restoration Principles: <http://www.fs.fed.us/r3/spf/nm-restor-principles-122006.pdf>

removed for wood products, firewood, or composting materials. Every last bit of slash need not be removed; leaving some slash is valuable for protecting soils, fostering understory, and providing wildlife habitat. But enough must be removed to allow a cool fire that does not rise to the canopy. Removing slash greater than four inches in diameter also reduces the likelihood of attracting bark beetles to the stand.

- *Rake away needles from base of large old trees.* Pulling thick pine needle mats and branches three feet away from the base of large tree trunks can protect trees from fire-caused mortality. In general, you probably need to do this only before the first fire.
- *When possible, close small unused dirt roads that are eroding.* Many of these roads will erode into gullies without an understory cover. Eroding roads may need rehabilitation, such as trenches to guide storm water off the road, or branches strewn on the surface to assist revegetation.
- *Preserve large snags for wildlife use.* Lightning, insect mortality, and prescribed burns will create new snags in the future.
- *Incorporate cutting treatments that consider the needs of wildlife.* Include some areas of higher tree density for habitat and travel corridors, and protect tree and shrub clumps. Where appropriate, consult guidelines that protect habitat for Northern goshawks.

For more information on ponderosa pine forest restoration go to:

- <http://www.eri.nau.edu/joomla/content/category/5/32/134/>
- <http://www.nmhu.edu/nmfwri/pdf/prescriptions%20combined.pdf>

For information on Northern goshawk habitat restoration guidelines go to:

- <http://fsweb.r3.fs.fed.us/for/silviculture/goshawk.html>

For more information on bark beetles go to:

- <http://www/fs/fed/us/r3/resources/health/beetle/index/html>



Piñon-Juniper Forests

Piñon-juniper forests in the Southwest are more diverse than ponderosa pine forests in structure and fire history. In general, there are three broad categories of piñon-juniper ecosystems: savannas, shrublands, and persistent woodlands.

Piñon-juniper or juniper savannas are usually found on low hills or valleys with deep soils, where precipitation comes mostly during summer monsoons. Savannas have low tree densities because of limited water or because cool fires burn through them frequently. There is some debate on types and frequencies of fire in piñon-juniper savannas.

Piñon-juniper shrublands have higher densities of trees than savannas, although densities vary from scattered trees with a thick understory to dense trees with a sparse understory. Shrubland trees tend to be short with multiple stems. Although there is debate, the current consensus is that shrublands historically experienced moderately frequent, mixed-severity fires which were carried by trees and shrubs. These fires were often patchy, burning some clumps within a stand.

Piñon-juniper persistent woodlands tend to have older and denser trees within them. Fires are less frequent in persistent woodlands, and these woodlands may be relatively stable for 100 to 1000 years. When fires burn through persistent woodlands they tend to be large, severe fires that kill many trees and start the growth of a new stand. Persistent woodlands usually grow on rugged upland sites with rocky soil.

Recommendations for developing an ecological prescription for piñon-juniper ecosystems include:

- *Restoration of piñon-juniper should try to identify the type of ecosystem – savanna or shrubland – and use the ecosystem type to guide the prescription.* You may identify the ecosystem type with assistance from land managers, university staff, or New Mexico State Forestry. Soil erosion and site degradation can justify proactive management in savannas and shrublands – even where it is difficult to show that densities have changed.
- *No restoration treatments should occur in persistent woodlands.* Since persistent piñon - juniper woodlands likely experience high-intensity fires only infrequently, they probably do not need restoration to a past condition. Fuel reduction treatments may be appropriate in order to protect structures and communities from the occasional hot fires that burn naturally in this type of woodland.
- *In savannas, reintroduce low intensity fires.* If there are large areas of bare soil, you may need to lop and scatter slash in order for the fire to carry through the stand. In time, understory plants will recover sufficiently to carry cool fires across the surface.
- *In shrublands, thin trees and distribute the slash on the ground to help protect soil and encourage grass and shrub growth.*
- *Plan for follow-up treatments in sites with juniper.* Some juniper species, such as alligator juniper, resprout from the stump after being cut. You will need to follow initial treatments with prescribed fire or additional thinnings.
- *Preserve large snags for wildlife.*

For more information on piñon-juniper forests restoration go to:

- <http://www.fs.fed.us/rm/sd/pinyonjuniper.pdf>
- http://www.forestguild.org/rg_sw_pinon_juniper.html
- http://ag.arizona.edu/OALS/watershed/highlands/pinyon_juniper/pjtrements.html
- <http://www.werc.usgs.gov/fire/lv/pj/lakemead/>

For more information on how to determine the type of piñon-juniper forest on a site, go to:

- http://www.cfri.colostate.edu/docs/P-J_disturbance_regimes_short%20synthesis_5-07.pdf

Southwestern Mixed Conifer Forest

In contrast with other forest types, there is less certainty about the structures of mixed conifer forest in the past, making it more difficult to develop prescription targets. Mixed conifer forests contain a variety of tree species generally at elevations between 8,000-10,000 feet. The most common tree species include Douglas-fir, white fir, blue spruce, and aspen. Other tree species include Engelmann spruce, subalpine fir, ponderosa pine, limber pine, Southwestern white pine, and Gambel oak.



Current scientific research suggests that the structure and species in Southwestern mixed conifer forests have changed greatly over the last century. Many mixed conifer stands now appear to be much denser than they were historically. In some cases, fire suppression has led to an unnatural increase in white fir, which is susceptible to fire. In the past, fires in mixed conifer forests occurred less frequently than in ponderosa pine forests, on the order of several decades. Fires in mixed conifer forests varied in severity from low-intensity fires to patchy crown fires in small areas. Drier stands of mixed-conifer – those that are dominated by ponderosa pine and Douglas-fir – are more likely to need restoration than wetter and higher stands – those dominated by spruce and large white fir.

Some recommendations for developing an ecological prescription for mixed conifer forests include:

- *Develop a site specific thinning treatment.* Because there are many tree species in mixed conifer forests, there are a wide variety of appropriate thinning treatments. Individual tree, group, or patch thinning systems can encourage regeneration of tree species that are fire tolerant. You may need to create large open areas in order to help shade intolerant species grow into the canopy. For example, Douglas-fir seedlings require full sunlight to flourish.
- *Thin dense trees.* You should thin dense mixed conifer forests to a level safe for cool fires. Current tree densities require thinning in order to allow safe prescribed or managed natural fires.
- *Re-establish low intensity fires.* In many areas, particularly those with high fuel loads, an early spring prescribed burn, when the site is still wet, is most appropriate. Prescribed fire may also be effective in the fall when coarse woody material is still moist from the rainy season.
- *Reduce unnatural high densities of white fir.* Many mixed conifer stands currently have large numbers of small white fir. In many mixed conifer forests, white fir has established in densities that are historically unnatural. Since white fir can grow to large sizes quickly, it may also be appropriate to remove some larger diameter white fir.
- *Encourage aspen trees where groups exist.* Aspen trees needs light to regenerate, so you should remove most if not all other trees from an aspen patch. Keep cows, deer, and elk away from regenerating aspen by constructing fences or enclosing an area with tall brush piles.
- *Preserve large snags for wildlife.*

For more information on mixed conifer forest restoration go to:

- http://www.forestguild.org/rg_sw_mixed_conifer.html
- http://www.forestguild.org/rg_sw_aspen.html
- http://www.cfri.colostate.edu/docs/aspen_change.pdf
- <http://www.ncrs.fs.fed.us/gla/reports/ecology-mgt-aspen.pdf>
- <http://www.cpluhna.nau.edu/Biota/mixedconifer.htm>
- <http://ag.arizona.edu/OALS/watershed/highlands/mixedconifer/mcmanagement.html>

For a case study of a mixed conifer case study, visit New Mexico Forest & Watershed Restoration Institute's website:

- <http://www.nmhu.edu/nmfwri/managers.html>



Bosque Forest

Southwestern streams and rivers have unique ecosystems along their banks called bosques. In the past, bosques included cottonwood stands, dense young willow and native olive patches, and wetland areas with rushes and cattails. This mosaic of vegetation was home to a diverse group of animals and birds.

Most lowland streamside communities are now highly dense stands of invasive trees such as tamarisk, Russian olive and Siberian elm trees. When these non-native trees invade bosques, they reduce diversity, increase fire danger, and use more water than native vegetation. Other problems in bosques

include lowered water tables and increases in woody fuels on the ground. The dense thickets of invasive plants and woody debris are of special concern because they have increased the risk of crown fire in bosques. These fires burn with high intensity under current conditions, and cause widespread mortality of all trees in the bosque, including large cottonwood trees. Historically, fires were not a natural part of the bosque ecosystem, and prescribed fires are not considered appropriate in this forest type.

Some recommendations for developing an ecological prescription for bosque forests include:

- *Remove invasive species.* Cut and remove invasive non-native species such as tamarisk, Siberian elm, and Russian olive trees. You will need to use follow up treatments with hand-pulling or conservative use of safe herbicides to prevent these invasive trees from reestablishing at the site.
- *Remove large amounts of dead, down wood.* You should eliminate large pieces of wood by removing them from the site, by using a chipper, or by piling and burning. A hydro-ax or Fecon head machinery allows you to chunk trees into varying sizes.
- *Restore natural river flow and flooding.* When restoring natural river flow is not possible, you may provide artificial water flow by diverting irrigation channels.
- *Replant native species if needed, including cottonwood trees, willows, New Mexico olive, and other species.*

For more information on bosque forest restoration go to:

- http://www.forestguild.org/rg_sw_bosque.html
- <http://www.nm.nrcs.usda.gov/technical/tech-otes/pmc.html>
- <http://nmdaweb.nmsu.edu/animal-and-plant-protection/tamarisk-saltcedar/NM%20Tamarisk-Watershed%20Plan.html/>

Conclusions

Developing a good restoration prescription is a key part of all CFRP projects. Time and care in prescription development can result in a more successful project. Forest structures that better support the natural disturbances typical of a forest type are critical to the success of forest restoration in the long term. The reduction of the threat of hot crown fires is an important goal of restoration treatments, but it is just as important to reestablish cool fires in ponderosa pine, piñon-juniper and mixed conifer forests. Natural processes eventually can take over the job of maintaining forest health, reducing the need for intensive management in the long term.

Every project needs to develop a prescription that fits the forest structure at the project site. A site-specific prescription, based on trees species and density, topography, soil conditions, and forest history, will best move a stand toward desired future conditions. Ecological data collected for monitoring is also invaluable in developing a good prescription. Good prescriptions will help protect human communities from unnatural crown fires and restore the ecological integrity of New Mexico's forests.

For further guidance for ecological restoration refer to:

The New Mexico Restoration Principles

- <http://www.fs.fed.us/r3/spf/nm-restor-principles-122006.pdf>

The website of the Ecological Restoration Institute of Northern Arizona University

- <http://www.eri.nau.edu/joomla/>

For guidance on incorporating socio-economic issues into prescriptions refer to:

Social and Economic Issues in Landscape Scale Restoration, Forest Restoration Series, Working Paper 2, New Mexico Forest and Watershed Institute, <http://www.nmhu.edu/nmfwri/>

Short Guide for Monitoring CFRP projects or Handbook 5: Monitoring Socioeconomic Effects of CFRP projects, <http://www.nmhu.edu/nmfwri/>

New Mexico Forest and Watershed Restoration Institute

The New Mexico Forest and Watershed Restoration Institute at New Mexico Highlands University is dedicated to providing state-of-the-art information about forest and watershed restoration to the public, federal and state agencies, tribes, and private landowners in New Mexico. To accomplish this, the Institute collaborates with citizen stakeholders, academic institutions, NGOs, and professional natural resources managers to establish a consensus concerning prescriptions and monitoring protocols for use in the restoration of forests and watersheds in an ecologically, socially, and economically sound manner. Through research and collaboration, the Institute promotes ecological restoration and forest management efforts in ways that 1) will keep New Mexican homes and property safe from wildfire, 2) will lead to a more efficient recharge of New Mexican watersheds, and 3) will provide local communities with employment and educational opportunities.