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Working Papers in Southwestern
Ponderosa Pine Forest Restoration

Understory Plant Community Restoration in the Uinkaret Mountains, Arizona

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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, like the restoration treatments being implemented in the Uinkaret Mountains, 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.

Background

The herbaceous plant community, consisting of shrubs, grasses, sedges, and forbs, is a vital part of ponderosa pine forest ecosystems. Restoration treatments have tended to focus directly on tree patterns and reintroduction of fire. For restoration to be successful, however, the natural diversity and productivity of the understory plant community must be regained, and invasive or exotic understory species must be removed or maintained at tolerable levels. This document offers preliminary recommendations for understory restoration based on monitoring and observation in the Uinkaret Mountains and other ponderosa pine restoration sites in northern Arizona.

Setting Goals

Understory restoration must always be viewed in the context of the natural ecological characteristics of the ecosystem. In ponderosa pine ecosystems it is often feasible to gain a detailed understanding of historical reference conditions, as defined in Moore et al. (1999). It may not be possible to reconstruct historical understory conditions as precisely as those of the overstory, but some reference conditions can be deduced from direct measurements of relatively undisrupted sites, historical data, or reconstructions of past conditions (Springer et al. 2001).

An understanding of reference conditions and ecological linkages has allowed us to set the following goals for understory restoration in the Uinkaret Mountains:

Regain native species richness and community composition. Historical species composition and abundance are largely unknown; however, plant cover should consist predominantly of native species that typically provide more resources for wildlife than nonnative species.

Regain historic understory plant cover. Total plant cover at two reference sites on the North Rim of the Grand Canyon was 35 and 37 percent. In the Uinkaret Mountains, total plant cover in unrestored forest areas is typically very low. It has risen substantially in units that have been treated, approaching that at North Rim sites.

Regain the ability to carry surface fire. Frequent, low-intensity ground fires played a decisive role in maintaining the structure of southwestern ponderosa pine forests prior to Euro-American settlement. The herbaceous understory should be sufficiently dense to carry periodic fire. It is also essential for preventing erosion and holding soils in place following fires.

Reestablish a shrub component. Though historic levels are unknown, shrubs currently exist at very low levels in most of northern Arizona's ponderosa pine forests. It may be possible to learn about previous levels by examining old photographs and other historical records.

What to Measure

The ERI has measured the following parameters at restoration sites to determine to what extent understory restoration goals have been met. These parameters should be measured for years following treatment in order to evaluate how they are affected by successional change within the understory community.

Species richness and diversity. The ERI has used the Simpson's diversity index, a weighted measure of richness and abundance, as well as overall species counts within plots. The index rose from 0 prior to treatment of the seeded part of one plot (96-1) to 14.1 after treatment, while a total of 96 species has been inventoried in the unit's treated and untreated portions after treatment.

Species composition. Resource goals are typically best met when a high percentage of understory species are native rather than invasive.

Total plant cover. Total cover has increased in the treatment units at Mount Trumbull. Cover in a seeded unit rose from 0 pre-treatment to 44 percent after treatment, and that in an unseeded unit rose from 6 percent to an average of 25 percent. A target of 33 percent cover has been set by using the North Rim sites as reference points, and this goal has nearly been reached in some units.

Ability to carry fire. The BLM has suggested a target of 500 to 1,500 pounds per acre of understory vegetation in order to carry surface fire. This figure, though, will vary widely depending upon such site-specific variables as soil type and moisture.

Shrub coverage. Coverage of shrubs is monitored together with the herbaceous community, using measures of total cover and Simpson's diversity index.

Operations

Restoration plots in the Uinkarets have been monitored for understory response following thinning and burning. Some plots have been left unseeded, but others have been treated with a seed mix. Vegetative response has varied widely according to such factors as precipitation, seed presence in the soil seed bank, and the soil temperature reached in fires.

The reseeding mix includes seeds of perennial grasses, shrubs, and early successional forbs (see Table) purchased from suppliers in Utah and Colorado and collected locally. An initial 20 percent rate of germination was increased to 40 percent by covering the mix, which is accomplished by dragging a weighted bar over the seeded ground behind an all-terrain vehicle or Bobcat. The BLM will rest restored areas from livestock grazing for at least three or four years. Monitoring of treated and control blocks will continue to allow precise analysis of the effects of various restoration treatments.

Significant operational challenges remain before reseeding and understory restoration can be carried out on a large scale. It has often proven expensive to acquire appropriate seed mixes, especially from local sources. Collecting from local sources is preferred because it helps preserve local genetic material, but there are typically only small numbers of plants to serve as seed sources. Control of exotic or invasive species such as mullein (*Verbascum thapsus*) and cheatgrass (*Bromus tectorum*) is also an ongoing problem, and further research is needed to address this issue.

Table. Species reseeded in restoration units, 1996-2001

		Price per pound
Cool-season perennial grasses		
Agropyron smithii	Western wheatgrass	$3.50-$10.00
Agropyron trachycaulum	Slender wheatgrass	$1.20-$6.00
Bromus marginatus	Mountain brome	$1.80-$3.50
Elymus cinereus	Basin wild rye	$9.75
Elymus elymoides	Squirreltail	$22.00-$40.00
Festuca arizonica	Arizona fescue	$10.50-$20.00
Koeleria cristata	Prairie junegrass	$16.94-$27.00
Oryzopsis hymenoides	Indian ricegrass	$4.80-$8.75
Poa ampla	Big bluegrass	$9.00
Poa canbyi	Canby bluegrass	$9.50
Poa sandbergii	Sandberg bluegrass	$9.00
Stipa comata	Needle-and-thread grass	Collected locally
Warm-season perennial grasses		
Bouteloua curtipendula	Sideoats grama	$5.50-$6.50
Bouteloua gracilis	Blue grama	$6.25-$14.00
Schizachyrium scoparium	Little bluestem	$7.75-$13.50
Sporobolus cryptandrus	Sand dropseed	$3.75-$6.75
Perennial forbs		
Eriogonum umbellatum	Sulfur buckwheat	$63.00
Geranium caespitosum	Purple geranium	$50.00
Linum lewisii	Blue flax	$9.00
Mahonia repens	Oregon grape	$40.00-$52.00
Oenothera caespitosa	Tufted evening-primrose	$30.00
Penstemon barbatus	Beardlip penstemon	$85.01
Penstemon pachyphyllus	Thick-leaf penstemon	$40.57
Annual forbs		
Gilia aggregata	Scarlet gilia	$35.00
Shrubs		
Amelanchier utahensis	Utah serviceberry	$80.00
Artemisia frigida	Fringed sagebrush	$60.00
Purshia tridentata	Antelope bitterbrush	$15.53
Rhus trilobata	Skunkbush sumac	$14.20
Ribes cereum	Wax currant	$82.24
Rosa woodsii	Arizona rose	$36.00
Sambucus cerulea	Blue elderberry	$32.92
Symphoricarpos oreophilus	Mountain snowberry	$47.05

Recommendations

Experience at Mount Trumbull has allowed the ERI to specify the following preliminary management recommendations.

- **Include native perennial grasses in seed mixes.** Perennial grasses are important understory plants that help carry low-intensity fire, but they are present only in low numbers in the soil seed bank in the Uinkaret Mountains. The use of mixes that includes such native species as mountain brome (*Bromus marginatus*), western wheatgrass (*Agropyron smithii*), and squirreltail (*Elymus elymoides*) has aided in perennial grass recovery. It appears that most of these grasses require at least two to three years, or a year of favorable moisture, to germinate.
- **Include seeds of native forbs that colonize quickly or add nitrogen to the soil.** Forbs that germinate and grow quickly may be able to outcompete undesirable nonnative species.
- **Collect seed from local seed sources.** Utilizing local sources of seed whenever possible, including seed collected by hand near treatment sites, will help minimize changes to the genetic material of native species.
- **Cover seed to improve germination rates.** Germination rates double when reseeding mixes are lightly covered with soil.
- L**imit livestock grazing.** Rest from grazing following treatment will allow establishment of herbaceous species, which may take several years.
- **Limit spread of invasive species.** Invasive plant species such as cheatgrass pose a significant threat to the diversity of some restoration sites, and action should be taken to limit their spread.
- **Monitor successional change.** Understory cover and species composition continue to change in the years following treatment. Some invasive species, such as mullein, appear to decline after an initial surge of growth. Others, such as cheatgrass, may persist for years.

References

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For More Information

Southwest Exotic Plant Information Clearinghouse
(http://wapiti.wr.usgs.gov/swepic/index.html) is a cooperative interagency effort that compiles and disseminates information about invasive plants of the Southwest.

Ecological Restoration Institute, http://www.eri.nau.edu or 928-523-7182.

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NAU Creative Communications/A48089/1M/05-02

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