USA: Arizona: Restoration of Ecosystem Health in Southwest Forests Project

Overview

The Restoration of Ecosystem Health in Southwest Forests project was initiated in 1995 to develop the scientific basis for ecological restoration of southwestern forests and woodlands at both operational and landscape scales. The majority of the work has been focused in the Greater Mount Trumbull Ecosystem within the Grand Canyon/Parashant National Monument. This innovative collaboration between Department of Interior (BLM, NPS, BIA), state (Northern Arizona University, Game and Fish, State Forestry) has resulted in one of the foremost development and application sites for designing, implementing, monitoring, and evaluating restoration-based hazardous fuel reduction and ecological restoration projects. The work at Mount Trumbull represents an expansion and enhancement of collaborative partnerships and worked specifically in four project areas: piñon-juniper restoration, piñon-juniper herbaceous revegetation, cheatgrass abatement and monitoring, and ponderosa pine restoration.

1. piñon-juniper restoration””although piñon-juniper woodlands form an important vegetation type on millions of acres of Federal lands, surprisingly little research and testing has been done to restore degraded, fire-susceptible habitats. BLM and ERI designed and implemented piñon-juniper restoration and fuels management experiments in association with the Greater Grand Canyon/Parashant Ecosystem and related sites. The experimental sites

include treatment and control areas, with permanent plots to measure vegetation and fuels. The range of natural variation (reference conditions) of the piñon-juniper forest structure is being established and used to guide treatment design.

2. Piñon-juniper herbaceous revegetation””experimental trials to revitalize the native plant community and stabilize soils through increased plant cover. This work was designed to monitor, implement, and evaluate alternative methods of plant community restoration, utilizing by-products of thinning treatments such as slash and mulch. The efficacy of seeding and soil amendments is being contrasted in a controlled, two-factor study. Evaluation and monitoring results will be useful for large areas of piñon-juniper woodlands on the Arizona Strip and the Colorado Plateau.

3. Cheatgrass abatement and monitoring- Cheatgrass is a serious symptom of poor land health. Cheatgrass out competes valuable forage and increases the risk of wildfire. This project will monitor the response of cheatgrass to different management scenarios and analyze the role of the biophysical environment to its spread. The goal is to provide management recommendations to land managers and other stakeholders that will help avoid ongoing and future invasion by cheatgrass.

4. Ponderosa Pine Restoration and Hazardous Fuel Reduction Monitoring- permanent monitoring plots in restoration-treated and control landscapes were re-measured in 2005, five years after the completion of thinning and burning treatments. Changes in forest structure, large tree mortality, tree growth, regeneration, and fuels were assessed.

Quick Facts

Project Location:
Greater Mount Trumbull, 36.4085925, -113.1288222

Geographic Region:
North America

Country or Territory:
United States of America

Biome:
Temperate Forest

Ecosystem:
Temperate Forest - Coniferous

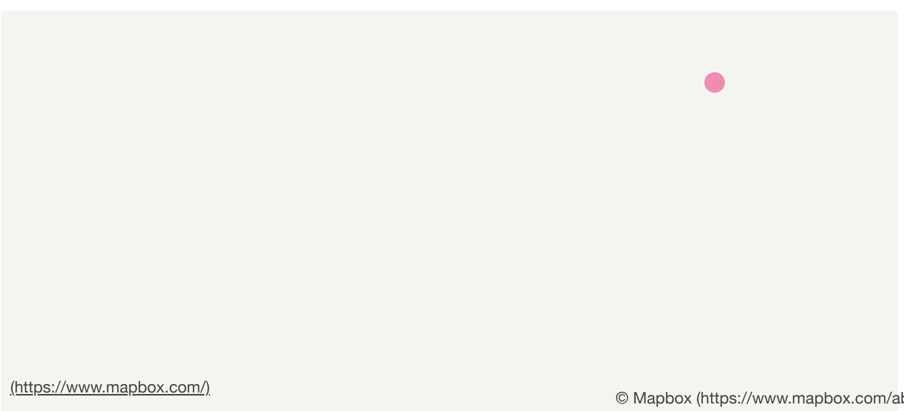
Area being restored:
4,000 acres

Project Lead:
Department of Interior

Organization Type:
Governmental Body

Project Partners:
Northern Arizona University, AZ Game and Fish, AZ State Forestry

Location



TIMEFRAME

Project Stage:
Completed

Start Date:
1995-01-01

End Date:
2006-12-31

DEFINING THE PROBLEM

Primary Causes of Degradation

Agriculture & Livestock, Invasive Species (native or non-native pests, pathogens or plants), Mining & Resource Extraction, Other

Degradation Description

With the widespread arrival of the Mormon settlements in the 1870s large-scale grazing completely altered the abundance of grasslands in the region. The elimination of fine fuels by grazing immediately altered the fire regime of the region, eliminating an essential component for fires to move across the landscape. Continued fire exclusion through the late twentieth century coupled with continued grazing during that time was responsible for the extensive growth of small-diameter ponderosa that choked the forests by the 1990s. The Uinkarets are distant from anything, even today, and as a consequence saw little early impact on the overall structure of the ponderosa forests found there because of logging. The distance and lack of infrastructure or rail links precluded widespread logging, although in the late 1800s small-scale logging operations were undertaken, providing some larger logs for the Mormon temple in St. George, Utah. Few ponderosa piness larger than 50″ in diameter were extracted at the time because of the limitations of the saws being operated. However, once truck logging took off in the early 1900s the Uinkarets saw significant timber extraction. The elimination of fuels and then continued fire suppression can best be seen with the data that in pre-settlement times tree density has been figured at 32-40 trees per acre, while forest density was 280 to 1200 trees per acre by the 1990s. Another consequence of the extensive growth of small-diameter ponderosa were marked decreases in both plant abundance and diversity. In the piñon-juniper woodlands aerial photography taken in the 1940s and again in the 1990s indicated significant encroachment of the overstory trees which had a marked influence on the abundance of understory vegetation. Various lines of evidence, including these historical and contemporary aerial photographs, diameter and age distributions, and dendrochronological reconstructions indicated a transition from previously more open stand conditions existing in the late 1800s to closed conditions found in the 1990s. These changes appear to be linked to intensive livestock grazing, exclusion of naturally occurring fire, and climate. Site characteristics suggested degradation of ecological integrity in two main forms: (1) low plant species diversity with communities dominated by dense pinyon and juniper overstories; (2) reduced soil O horizons, particularly in intercanopy openings.

PLANNING AND DESIGN

Reference Ecosystem Description

The historic structure of the ecosystem mirrored that of most semi-arid ponderosa ecosystems in the southwestern United States, with widespread grassland understory vegetation coupled with open, park-like forests of ponderosa pines. The old-growth ponderosa often exceeded 30 meters in height and there was a significant component of oak scattered throughout. The ecosystem is a mixture of Great Basin cold desert species like piñon pine and sagebrush with more ponderosa, oak, and blue grama. Growing in elevation driven bands of vegetation, the lower elevations of the Uinkarets were dominated by piñon-juniper woodlands. These woodlands were likely less dense than contemporary woodlands and had a higher abundance of grasses and forbs.

Project Goals

The forest restoration prescription in the ponderosa pine forest was designed to rapidly emulate the historic forest structure, pre-dating European settlement and fire exclusion that began around 1870. In the later piñon-juniper restoration the objective of the project was to evaluate the effectiveness of treatment in reducing stand density to levels similar to presettlement conditions and increasing understory diversity, and to look at the constraints and limitations that might hinder similar restoration attempts.

Monitoring

The project does not have a monitoring plan.

Stakeholders

The Arizona Strip, which surrounds and includes the Uinkaret Mountains, is largely managed by the Bureau of Land Management (BLM). In 2000, President Clinton designated part of the Uinkarets as part of the Grand Canyon-Parashant National Monument, leaving the management of the monument to the BLM. In 1995, the Ecological Restoration Institute (ERI) at Northern Arizona University initiated the collaboration with both the BLM and the Arizona Game and Fish Department. The underlying interest in the overall project was to reduce the severe wildfire danger posed by the explosive growth of the ponderosa pine trees since Euro-American settlement and restore historic reference conditions.

PROJECT ACTIVITIES

Description of Project Activities:
Four experimental blocks were established, representing the heterogeneity of the landscape in terms of vegetation, topography, and past management history. Each block was divided into two units, randomly assigned to be either a control or restoration treatment. Briefly, block 1 (EB1) was dominated by ponderosa pine on shallow lava soils. Block 2 included abundant Gambel oak on basalt-derived clay soils. Block 3 was pine-oak forest at the highest elevation on cinder soils. Block 4 consisted of dense, young ponderosa trees and some pinyon (Pinus edulis) and juniper (Juniperus osteosperma), on basalt-derived clay soils. New Mexican locust (Robinia neomexicana) was scattered across most of the units. Twenty

permanent monitoring plots were established in each control and treatment area, for a total of 40 plots per experimental block. Overstory trees taller than breast height (4.5 ft) were tagged and measured on a fixed-area plot. Measurements included species, diameter at breast height (dbh), and condition class Trees below breast height and shrubs were tallied by condition and height classes on a nested subplot. Dead woody biomass and forest floor depth were measured on a 49.9 ft planar transect in a random direction from each plot center. As they proceeded to the treatment phase, all living trees predating 1870 were retained. Wherever evidence of pre-1870 remnant conifer material was encountered (i.e., snags, logs, stumps, stump holes), three younger trees of the same species within a 30-60 ft radius were selected as replacements. Fire-susceptible deciduous species, oak and locust, were not thinned. Thinning was carried out by commercial contractors and BLM crews in 1999. Block 4 was so dense that not all the trees marked for retention could be safely thinned and burned. Slash was lopped and scattered. Deep duff layers were raked 1-3 ft away from boles of all pre-1870 trees and snags. Treatment units were burned in the winter of 1999-2000. All plots were remeasured in May-July, 2000, and five years later, May-June, 2005. Measurements of tree height and crown base height were added, and crown scorch and bole char were measured. In the piñon-juniper restoration, ERI based their restoration treatment on an approach described by Jacobs and Gatewood (1999, 2002), because of their demonstrated success at reestablishing understory diversity in a piñon-juniper ecosystem of New Mexico. The process entailed thinning trees to low densities, scattering slash, and seeding with native grasses. ERI modified the prescription, however, in order to focus on restoring site-specific overstory density and spatial arrangement. Additionally, it was desired to establish a broad array of understory life forms (i.e., grasses as well as forbs and shrubs). The treatment implemented on restoration units was the following: 1) thin piñon and juniper trees less than 25 cm DRC, except for trees retained to replace presettlement evidence (i.e., dead tree structures >25 cm DRC) at a 2:1 ratio by species; 2) lop slash to 1 m (3.3 ft) or less in length and scatter material to cover bare soil; 3) seed with native plant species. Using tree increment cores, linear regression of establishment date and DRC data suggested that piñon pine trees less than 25 cm DRC were likely to be less than 130 years of age and therefore postsettlement in origin. Age-diameter relationships for juniper were and cores did not cross-date well. Retaining two postsettlement-aged trees to replace each dead presettlement structure was used as a conservative approach to restoring historical densities and also allowed for posttreatment mortality. Selection of replacement was based on species, size, form, and proximity to structure being replaced. Thinning was completed November, 2003. Selection of native plant species for seeding was based on observations of local occurrence, baseline data from belt transects, and community data reported in relict site literature. ERI researchers selected four common grasses, one forb, and four shrub species. Grasses: Bouteloua curtipendula ,Bouteloua gracilis, Elymus elymoides, Oryzopsis hymenoides, Sporobolis cryptandrus Forbs: Lupinus argenteus Shrubs: Amelanchier utahensis, Atriplex canescens, Ephedra viridis, Rhus trilobata. Researchers broadcasted the seed at a rate that approximated common standards for range rehabilitation. However, they chose to seed both in early spring and late summer in order accommodate germination and establishment requirements for both cool and warm season species. Using site preparation methods such as plowing or disking before seeding was not feasible. Nor did they harrow or rake the restoration units after the seed was broadcast, but instead utilized thinning slash to provide cover and mulch for the seeds.

PROJECT OUTCOMES −

Ecological Outcomes Achieved

Eliminate existing threats to the ecosystem:

Five years after completion of the initial phase of forest restoration treatments at Mt. Trumbull, forest structure was substantially altered by tree mortality. Many of the changes were not statistically significant, however. Basal area, tree density, and canopy cover in the treated units declined not only in the immediate treatment period but also in the subsequent five years. Declining tree density per se was not inconsistent with the treatment objectives because a surplus of ponderosa pine trees was retained. Compared to pre-fire-exclusion reference conditions (1870), basal areas in the treatment units were still >100% or more higher in 2005 indicating that the thinning prescription left an adequate margin of replacement trees. Although tree mortality in general does not necessarily constitute a problem, mortality of larger and older ponderosa pine trees is of concern, because these trees form important habitat elements, conserve genetic diversity over centuries, contribute to aesthetic qualities of the forest, and simply take a long time to replace. Future development of forest structure will depend on the balance between continued mortality, growth of surviving trees, and new regeneration. Lingering effects of treatment-related damage may cause additional mortality, but most studies of fire-caused mortality indicate that the great majority of deaths are evident within 3 years after fire so it is expect that future mortality in the treated units would not differ from that in the controls. Regeneration was highly skewed toward sprouting species, which commonly respond vigorously to disturbance and may come to dominate the forest, although they are susceptible to fire and can be controlled with repeated burning. Since ponderosa seed trees remain well distributed across the Mt. Trumbull experimental sites and duff depth was significantly reduced by treatment, facilitating pine seedling establishment, it is likely that ponderosa regeneration will be successful in the coming years. The findings of post-treatment mortality and limited pine regeneration may be applied to suggest changes in treatment methods. For valued and vulnerable ecosystem components such as old trees, it would be useful to adopt any practices that might reduce the stress of treatment activities.

Factors limiting recovery of the ecosystem:

An extended and severe drought period emerged from 1996 to 2002 and even under these difficult circumstances, however, overall forest structural impacts were relatively controlled, suggesting that restoration treatments may help pine-oak, and piñon-juniper forests persist through climatic shifts. An unintended response to these restoration treatments was a rapid expansion of nonnative cheatgrass into the treated areas. This invasion occurred between the summers of 2002 and 2003. There are two additional factors that might be relevant to the invasion of cheatgrass at Mt. Trumbull. First, the summer of 2002 was a severe drought year. Second, cattle were reintroduced onto Mt. Trumbull that same summer for the first time since the initiation of the restoration treatments. Throughout much of the treated landscape, cheatgrass has become the dominant understory species. Cheatgrass infestations of this magnitude and extent have not been documented in any other Southwestern ponderosa pine site, even following severe wildfires. However, within the matrix of cheatgrass domination, there remain patches of native-dominated vegetation. Data suggest that a narrow suite of native species are dominating these remnant patches.

Socio-Economic & Community Outcomes Achieved

Economic vitality and local livelihoods:
This work explicitly served the stated goals of both the Clinton and Bush Administrations, the Department of Interior, the Bureau of Land Management, the Healthy Forest Initiative, Healthy Forest Act, National Fire Plan, and Western Governor's 10-year Comprehensive Strategy by developing the scientific basis for restoration-based hazardous fuel reduction and transferring that knowledge to the various stakeholders responsible for developing treatments. The large-scale nature of the project allowed for extrapolation to larger ecosystems and has become influential in planning across the western United States.

KEY LESSONS LEARNED

Key Lessons Learned

The findings of post-treatment mortality and limited pine regeneration may be applied to suggest changes in treatment methods. For valued and vulnerable ecosystem components such as old trees, it would be useful to adopt any practices that might reduce the stress of treatment activities. Even though ERI found no correlation between delayed mortality and heat effects (canopy scorch, bole char), prescribed burning of broadcast slash has been experimentally linked with tree death in other Mt. Trumbull study sites. This source of damage can be controlled by slash compression before burning or by removing or piling slash. A possible approach to the death of big trees would be to retain additional large trees during thinning, either through raising the ratio of replacement trees or through a diameter cap on cutting. However, there are tradeoffs to consider, because the spatial pattern of restoration thinning was designed to emulate the clumpy pattern of pre-fire-exclusion forests. One ERI researcher presented a stem-mapped example from the Mt. Trumbull area to illustrate how the selection of young replacement trees within a specified radius of remnant pre-1870 material resulted in the retention of trees close to where tree patches had been before as well as the re-opening of historical forest gaps. Understory plant productivity in such gaps can reach orders of magnitude higher than productivity under trees. Since the biggest trees within the search radius were already the ones selected for retention, a rule specifying retention of more large trees would inevitably result in crowding or eliminating many gaps. The thinning guidelines already successfully discriminated between pre-1870 and younger trees, conserving the former category, and retained trees displayed high growth rates.

In the case of the piñon-juniper restoration there is still much that is not known regarding the historic ecosystem structure and dynamics at the two piñon-juniper sites at Grand-Canyon Parashant Monument, the implemented treatment appeared to be effective at reducing stand density and altering overstory species composition to levels more characteristic of the late 1800s. The treatment was also an attempt to gain conditions generally desired by Bureau of Land Management staff and the public. These conditions included a productive, diverse plant community, reduced fuel hazard, and conservation of large, old piñon and juniper trees. Results indicated that live canopy fuel levels were reduced, which likely reduced crown fire hazard. Old trees were also conserved. These additional goals represent a balance between strict-sense emulation of historical patterns and consideration of present human values. Taken as whole, therefore, this experiment can be described as a “good”� restoration.

LONG-TERM MANAGEMENT

Long-Term Management

The only planned future treatment for the experimental units in ponderosa pine is repeated prescribed burning. Concern about the possibility of additional damage to old trees must be weighed against the role of surface fire in thinning the fire-susceptible oak and locust sprouts. Although in an idealized situation it might be attractive to view fire as the natural agent for maintaining open forest structure with minimal human guidance, the Mt. Trumbull forest is still quite removed from reference conditions and prescribed burns differ in many ways from the free-burning wildfires of the past. Therefore it may make sense for managers to use fire gently by minimizing it near vulnerable old trees, perhaps focusing on thinning sprouting trees with spot or ring ignition patterns. Continued monitoring will be essential for evaluating the progress of the restoration activity. In most respects, the results have been positive in terms of forest structure, except for the undesired mortality of a relatively high proportion of large pine trees and the low level of pine regeneration.

In pinyon-juniper ecosystems, plant community development is relatively slow and five to ten years is a likely minimum time over which to monitor treatment effects. Permanent plots established in the study allow for future measurements to be conducted and more definitive evaluations to be made concerning these restoration goals.

FUNDING

LEARN MORE

Other Resources

Publications:
Peer reviewed:
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Jerman, J.L., P.J. Gould, and P.Z. Fulé. 2004. Slash compression treatments reduced tree mortality from prescribed fire in southwestern ponderosa pine. Western Journal of Applied Forestry 19(3):149-153.
Meyer, C.L., T.D. Sisk, and W.W. Covington. 2001. Microclimatic changes induced by ecological restoration of ponderosa pine forests in northern Arizona. Restoration Ecology 9:443-452.
Moore, M.M., W.W. Covington, and P.Z. Fulé. 1999. Reference conditions and ecological restoration: a southwestern ponderosa pine perspective. Ecological Applications 9(4) :1266-1277.
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Waltz, A.E.M., and W.W. Covington. 2004. Ecological restoration treatments increase butterfly richness and abundance: mechanisms of response. Restoration Ecology 12(1): 85-96.
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.

Not peer-reviewed:
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Moore, K., B. Davis, and T. Duck. 2003. Mt. Trumbull ponderosa pine ecosystem restoration project. USDA Forest Service Proceedings RMRS-P-29. pp.117-132.
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Waltz, A.E.M., and W.W. Covington. 2001. Butterfly response and successional change following ecosystem restoration. USDA Forest Service Proceedings RMRS-P-22. pp.88-94.

CONTACTS

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