

Restoration of degraded piñon-juniper savanna at Bandelier National Monument

Principal Investigators

Brian Jacobs, Bandelier National Monument, National Park Service
Sam Loftin, Rocky Mountain Experiment Station, U.S. Forest Service

Introduction

At Bandelier National Monument, revegetation activities emphasize restoration of degraded piñon-juniper savanna sites where severe erosion is threatening natural and cultural resource values across thousands of acres. Historic land use practices (particularly livestock grazing and 100+ years of natural fire suppression) reduced herbaceous plant cover and allowed tree densities to increase. As a result, accelerated soil erosion rates now appear to preclude natural recovery and threaten the continuing existence of thousands of prehistoric cultural sites.

Experimental revegetation work at Bandelier was initiated in 1992 by Chong (University of New Mexico) and Allen (National Biological Survey). Their work evaluated the effects of tree density reduction, slash and straw mulch application, summer seeding and fertilization on the establishment of native grasses on a degraded piñon-juniper savanna site. Preliminary results suggest tree density reduction, slash mulching and seeding were necessary treatments for native grass establishment. Without the addition of seed material, no new establishment was observed indicating an inadequate soil seed bank. Adequate precipitation and suitable microsites were found to be important for successful seed germination; bare soil sites associated with micro-drainages showed better establishment than needle litter 'island' sites. Straw mulch and fertilizer may have increased survival of germinates and probably benefitted existing herbaceous vegetation.

Additional experimental revegetation work (i.e. development of practical methodologies appropriate for the restoration of degraded piñon-juniper savanna sites at Bandelier) will be initiated in 1994 by Jacobs (Bandelier National Monument) and Loftin (Rocky Mountain Experiment Station) and is the subject of the current proposal. The proposed work will build on the preliminary results of Chong and Allen, test some additional treatment combinations and attempt to scale up field revegetation activities.

Beyond the emphasis on restoration of degraded piñon-juniper savannas, Bandelier has also begun to reclaim sites impacted by existing or former developments such as old fire roads and horse corrals. The first major projects, reclamation of the Burnt Mesa fire road and the Headquarters horse corral are test sites for the reclamation of degraded developed sites at Bandelier. Heavy

equipment was used to decompact soils and recontour natural gradients. Hand collected native seed was used to supplement existing vegetation and the soil seed bank. Heavy brushing of the old fire road corridor was used to prevent human and animal traffic from impacting vegetative recovery. While reclamation of developed sites has not been conducted in a rigorous experimental fashion, activities and results are being documented.

Major factors limiting restoration at Bandelier include: 1) restrictions on methodology as imposed by cultural, natural and wilderness values, 2) poor site conditions characterized by sparse vegetation, low organics, low nutrients, limited seed source and soils prone to frost heave and high rates of erosion, and 3) unreliable precipitation for plant establishment.

Objectives

The primary objective of the restoration program at Bandelier is to re-establish native herbaceous cover onto degraded piñon-juniper savanna sites, thereby slowing accelerated erosional processes and enhancing site stability for the long term protection of archeological resources. The purpose of the current proposal is to experimentally evaluate which of several possible restoration treatments has the most potential for success at Bandelier. The feasibility of a large scale restoration program at Bandelier will also be assessed.

Methodology

Two general study areas have been identified at Bandelier for piñon-juniper restoration trials in 1994: site 1 = Frijoles Mesa, 1/2 mile west of the Bandelier entrance station; and site 2 = lower Alamo Mesa, 1 mile southeast of Yapashi ruin (see figure 1). An additional study site was identified on the Santa Fe National Forest (SFNF): site 3 = SFNF north of Guaje Canyon. The SFNF study site will allow larger scale testing of methodologies under less restrictive conditions and will facilitate collaborative piñon-juniper savanna restoration efforts with local land managers.

Restoration study areas were selected on the basis of 1) relative herbaceous cover, 2) density and age structure of woody overstory (i.e. piñon and/ or juniper) 3) type and severity of erosion, 4) proximity to cultural sites, 5) accessibility, 6) visibility to general public, 7) suitability for replicated plot establishment, and 8) representation of a variety of site conditions (i.e slope, aspect, soil type).

Major restoration treatments to be applied at each site will include: 1) thinning of the piñon-juniper overstory and use of the needle litter/ slash as mulch, 2) stabilization/ preparation of the soil surface using the imprinting technique (raking will also be used on pumice patches to get seed material below the rock mulch), 3) seeding using native seed material, and 4) soil amendments (i.e. fertilization).

Restoration treatments will be applied in various combinations at each site; some combinations will include the absence of one or more treatments (i.e. seeding and soil amendments). All plots will receive a minimum treatment consisting of reduction of the woody overstory, scattering of the needle litter/ slash and imprinting (except as noted below under treatment combinations). Controls will be adjacent untreated areas of equal size and comparable pre-treatment condition. All treatment plots at each site will be replicated (three replicates) to facilitate interpretation of results.

While the sequence of site activities is based mostly on practical considerations (i.e. imprinting needs to occur before slash is scattered over the site), the sequence of events will be kept consistent among all plots within each study site. In general the sequence of activities at a site will be in the following order: 1) study area identification, 2) study site delineation and cultural/ environmental clearance, 3) plot establishment and pre-treatment characterization/ documentation, 4) overstory thinning with stockpiling of slash, 5) imprinting, needle litter scattering, seeding (with raking on pumice patches), 6) slash scattering across site, 7) slash burning in the fall of the second year, and 8) post-treatment documentation.

One complete set of treatment combinations will be applied per experimental replicate in a randomized fashion. Following is a listing of the treatment combinations to be applied within each replicate:

0 = control (no treatment)
1 = thin/ slash/ litter
2 = thin/ slash/ litter/ seed
3 = thin/ slash/ litter/ imprint
4 = thin/ slash/ litter/ imprint/ seed
5 = thin/ slash/ litter/ imprint/ seed/ slash burning
(Treatment combinations are illustrated in figure 2)

Plots will be 15 meters square and cover 225 square meters. All treated plots will be spaced 1-2 meters from adjacent plots and surrounded by a 5-10 meter thin/ slash buffer. All imprinted plots will be surrounded by a 1-2 meter imprint buffer. Total area treated at any one study site would be one to two hectares. The relatively large plot size is necessary to minimize edge effects and test methodologies on a practical scale. Four corner stakes will be the only plot markers; 24 inch aluminum stakes indicating restoration project (i.e. RES), site number (i.e. 1-3), replicate number (i.e. 1-3), treatment (i.e. 0-5), and stake position (i.e. N, S, E, W) will be used. RES1 10N = Restoration site 1 (RES1), replicate 1 (1), control plot (0), North corner (N).

The following data will be collected on each plot: 1) general plot data (site, replicate, treatment, UTM location, elevation, slope, aspect), 2) transect vegetation sampling (two diagonal 'LTER' vegetation transects using the corner stakes), 3) quadrat

vegetation sampling (cover estimates by species and seedling counts using square half meter quadrats at stratified/ randomized points), 4) large scale photo points (taken from each corner stake toward the plot center along the LTER vegetation transects), 5) small scale, fixed height, overhead photo points (taken of each half meter vegetation quadrat).

Plots will be established as time, labor and soil moisture (necessary for good imprinting) permit. The application of seed to designated plots will be in the fall, since fall application often affords seed some protection under a snow pack. In addition, the snow weight and slow spring melting can incorporate seed into the soil surface. Hand collected seed will fulfil dormancy requirements through overwintering on site and spring soil moisture is typically more reliable and less erosional than the summer monsoons.

The piñon-juniper overstory will be reduced by hand pruning branches to three inch diameter; larger branches and the trunk will be cut with a chainsaw (considered the minimum tool for this work). Based on recent results from water relation studies in piñon-juniper woodlands by Breshears (Los Alamos National Lab), an optimal spacing between mature tree individuals of from 15 to 20 meters is suggested for restoration of the piñon-juniper savanna type. Because of the relatively small plot size, most of the woody overstory will have to be removed within the treated area to meet these spacing criteria; smaller individuals and Juniper will be removed preferentially to achieve these lower densities. In addition, individuals of under-represented woody species at a site will be maintained when possible. Limbs will be further cut up to increase surface cover and provide an average brush depth of 12-18 inches. Additional slash pruned from trees outside study sites may be needed to ensure the amount of slash on individual plots is sufficient and even between treatments (i.e. not an uncontrolled variable).

Imprinting is a site preparation technique used to temporarily stabilize bare soil with little vegetative cover. Various mechanical devices are used to press a waffle-like pattern into the soil surface that can slow erosional processes and increase water infiltration by creating catchments for seed, litter, soil and water; these catchments then serve as favorable microsites for germinating plant materials. Plant materials are provided a window of opportunity for establishment on otherwise harsh sites. Imprinting has been evaluated against other plant establishment techniques, such as seed drilling, and was shown to be a promising alternative for arid land restoration. Imprinting on the experimental plots at Bandelier will be accomplished using a hand tool device manufactured by the Imprinting Foundation. This hand tool creates a single 4 inch long by 2 inch deep print into the soil surface. Prints can be applied at regular intervals with the recommended spacing using about a foot between prints.

Imprinting must be done when the soil is moist enough to give a

good print. Some soil types such as pumice patches may not respond to the use of an imprinter. In the case of pumice patches, raking may be used to place seed material into soil contact below the rock mulch layer.

Due to the lack of herbaceous plants (and thus seed material on many disturbed sites) the introduction of herbaceous seed material is often essential for a successful revegetation effort. However, the potential of the existing vegetation and seed bank at each restoration site will be assessed through non-seeded trials. Potential seed reserves in the soil at each restoration site will also be assessed through germination of seed/ litter bank soil samples under greenhouse conditions. On selected study sites, soil nutrients and soil moisture will also be assessed. A small amount of soil will be sampled from each 15 meter square plot for nutrient and soil seed bank analysis; total soil sampled per plot will consist of 5 cores (20 centimeters deep x 2 centimeters wide). Each restoration sites will also be outfitted with a rain gauge to assess cumulative rainfall over the growing season.

Revegetation seed materials for the 1994 experimental trials will include both hand collections of locally native seed materials (80%) and commercially available native seed material with origins in New Mexico (20%). The use of commercial seed is considered necessary for the purposes of the current experimental trials to ensure that some viable seed of known quality/ quantity is present on the seeded plots. All seed material used at each site will be derived from the same source and applied in equal amounts and variety.