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Ecological Restoration Institute Mt. Trumbull Research Summary May 2006



Photo by John Paul Roccaforte

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Post-treatment mortality affects forest structure after ecological restoration treatments, Mt. Trumbull, Arizona, USA

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Abstract

Forest restoration in pine-oak forests is intended to reduce severe fire hazard and emulate natural ecosystem structure and function. We remeasured a replicated experimental site five years after treatments. Severe drought prevailed through the period. Basal area, tree density, and canopy cover declined in the treated units at a faster rate than in controls. Delayed mortality, not evident right after treatment, reduced density modestly (13% in treated units, 10% in controls) but disproportionately affected large trees ("large" ponderosa with diameter at breast height [dbh] ≥ 37.5 cm, other species dbh ≥ 20 cm). In treated units, 10.9 large trees ha⁻¹ died, of which 10 trees ha⁻¹ were ponderosa, while 6.2 trees ha⁻¹ died in control units, of which 4.6 trees ha⁻¹ were ponderosa. Compared with reference conditions, the experimental blocks remain higher in pine density and, in 3 of the 4 blocks, in basal area. Pine trees grew significantly faster in treated units than in controls, enough to reach the reference level of basal area in 6 years. Although mortality of large trees is a concern, the treated units have vigorous growth and low crownfire hazard, indicating that they will be relatively resistant to future drought and fire events.

Key Words

Ponderosa pine, Gambel oak, mortality, fire, thinning, fuel

Acknowledgments

Thanks to the Arizona Strip District, Bureau of Land Management, especially Aaron Wilkerson, Tim Duck, Ken Moore, Kathleen Harcksen, Dennis Curtis, and McKinley-Ben Miller, and the staff and students of the Ecological Restoration Institute, especially Mike Stoddard and Scott Curran. Funding for remeasurement and analysis in 2005 was provided by the USDI Bureau of Land Management, Assistance Agreement No. PAA 017002, Task Order No. AAW040001.

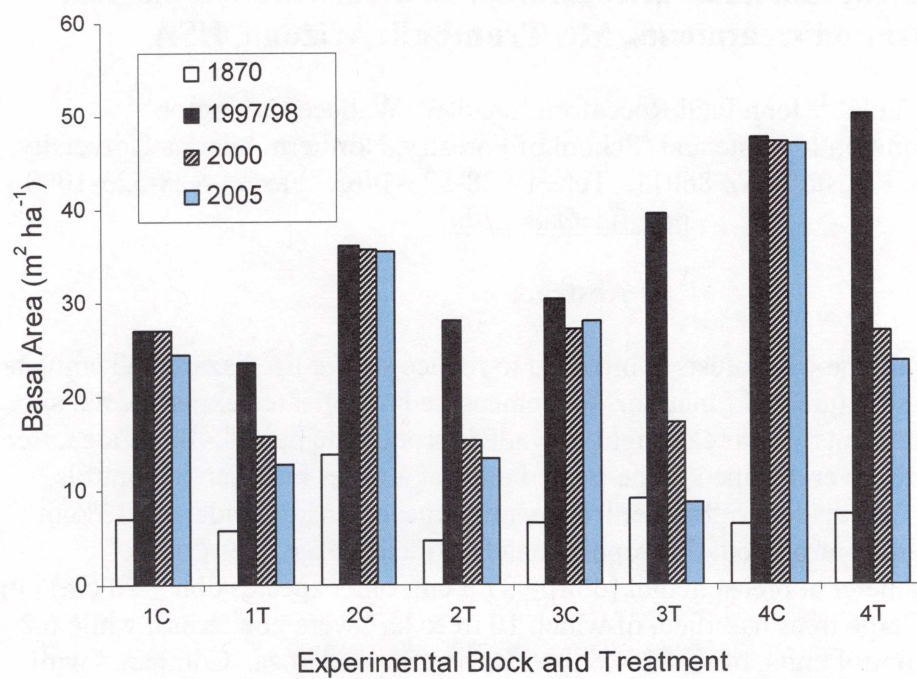


Figure 2. Basal area changes on four experimental blocks at Mt. Trumbull, Arizona, in 1997-98 (pre-treatment), 2000 (post-treatment), and 2005. Basal area in 1870 was reconstructed by Waltz et al. (2003).

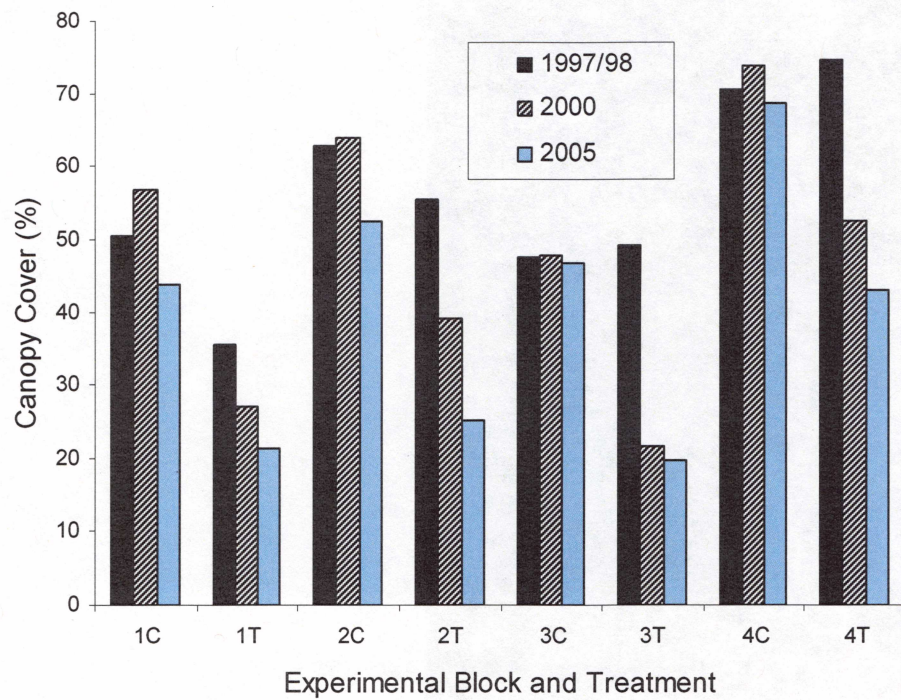


Figure 3. Canopy cover changes on four experimental blocks at Mt. Trumbull, Arizona, in 1997-98 (pre-treatment), 2000 (post-treatment), and 2005.

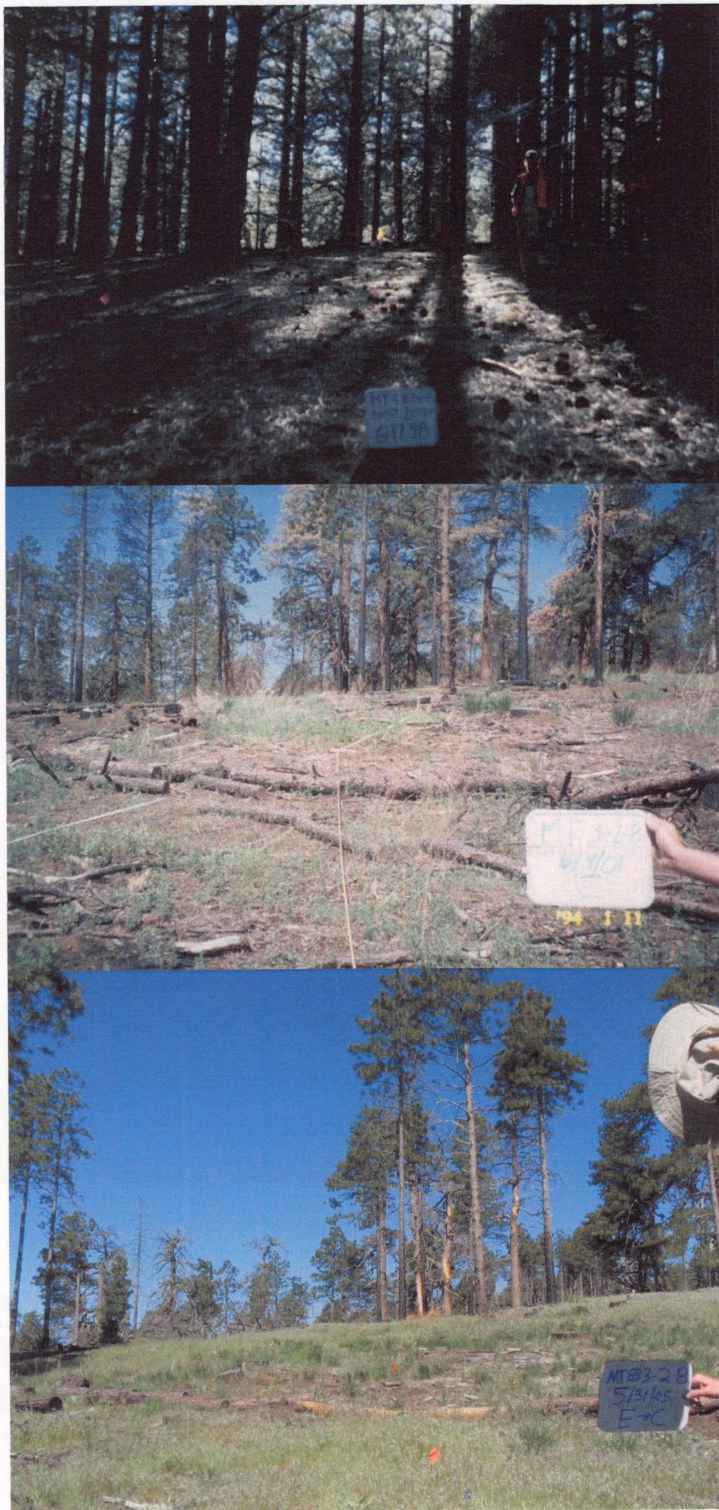


Figure 4. Changes on a single experimental plot from 1998 (pre-treatment, top), through 2001 (first year after thinning and burning), to 2005 (five years after treatment). In 2005, residual trees formed a patchy, savanna-like forest structure. Grasses in the foreground include both exotic and native species.

Monitoring Landscape-Scale Restoration Treatment Implementation and Effectiveness

John Paul Roccaforte

Research Specialist, Ecological Restoration Institute

In the early 1990's, researchers at Northern Arizona University initiated an experiment on a 10-acre study site outside Flagstaff, AZ to determine the effects of thinning and burning treatments on ecosystem structure and function. While the study proved to be valuable, the next step was to "scale up" from stand-scale studies that examined tens of acres to landscape-scale studies that examined thousands of acres. In 1995, the Ecological Restoration Institute (ERI) and the Bureau of Land Management began a collaborative effort to implement landscape-scale restoration treatments in a ponderosa pine ecosystem at Mt. Trumbull. The primary goal of the Mt. Trumbull Ponderosa Pine Ecosystem Restoration Project was to restore forest structure and ecosystem processes within the historical range of variability, as well as reduce fuel loads, disrupt fuel continuity, and reduce the likelihood of stand-replacing crown fires.

The project was set up under an adaptive management framework; therefore, implementation and effectiveness monitoring were important components. Prior to treatment in 1996 and 1997, the ERI installed 117 permanent plots across the Mt. Trumbull landscape (Figure 1); we remeasured each plot following treatment in the summer of 2003. The study area is approximately 3000 acres, half of which is a contiguous, "untreated," densely-treed area (control). The other half (treated area) was intended to be treated with thinning and burning treatments. The primary goals of this study were to determine if restoration treatments were carried out as planned (implementation) and if they accomplished the overall goals of the project (effectiveness).

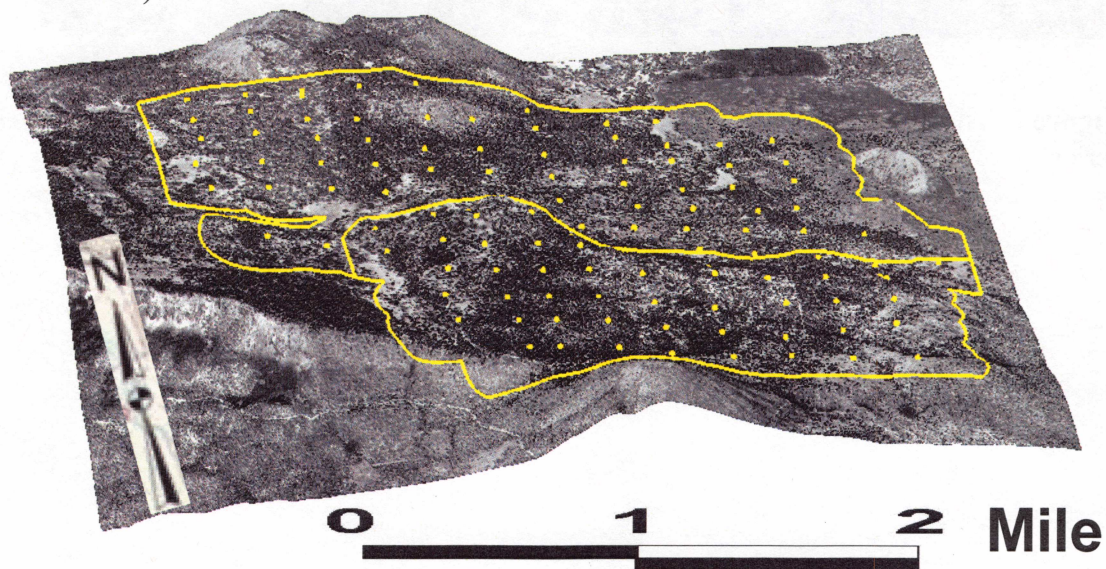


Figure 1. A 3-dimensional view of the study site (~1200 ha) shows permanent plot locations (yellow dots). The treated area is in the north part of the study area; the control is in the southern part.

The success of treatment *implementation* was variable. Most of the area originally planned for restoration was treated in some manner by 2003; however, only 70% received the full planned treatment (thin and burn). Although pine density decreased significantly in the treated area, the projected residual density was exceeded by 111-256%. Thirteen percent of the presettlement pines died in the treated area by 2003 slightly exceeding the 10% maximum allowable mortality outlined by managers; however, 9% percent of the presettlement pines died in the control. Restoration treatments decreased canopy fuel load (CFL) and canopy bulk density (CBD) in the treated area, while slight increases occurred in the control. These changes in canopy fuels are visually evident in the treated area (Figure 2). Predicted outcomes were consistent between the two fire behavior models (FlamMap and Nexus): under extreme drought and wind conditions, active crown fire hazard was reduced in the treated area (Figure 3). In contrast, the models show little change in active crown fire hazard in the control over the same time period.



Figure 2. The reduction in canopy fuels is visually evident in this before/after photo series.

Crowning Index (Km/h)

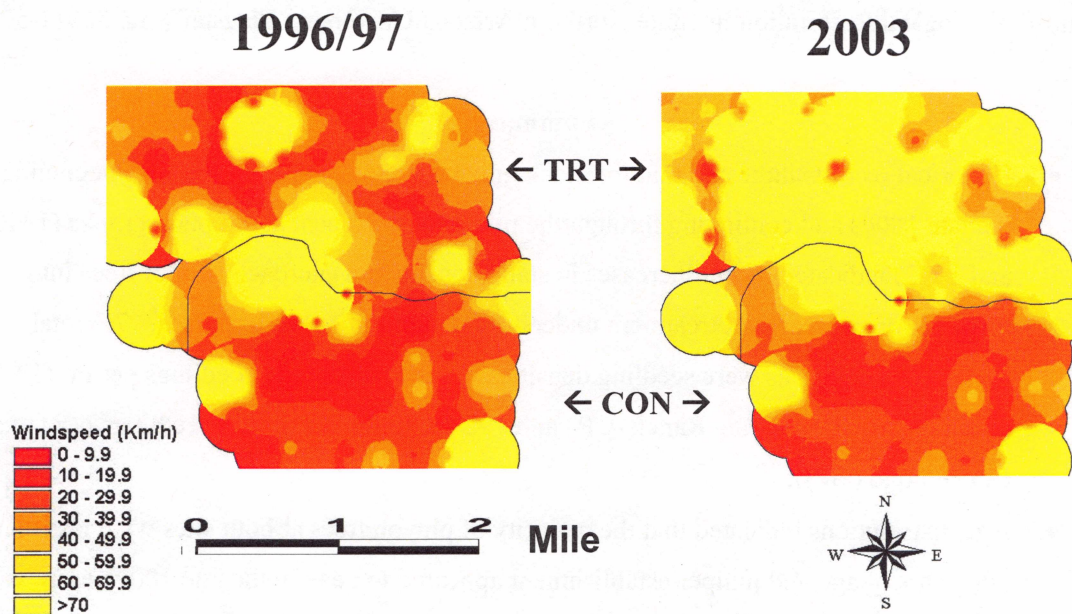


Figure 3. Fire behavior modeling output from Nexus shows that higher windspeeds are necessary to sustain active crown fire in the treated area in 2003; hence, active crown fire hazard was reduced following treatment. Alternatively, little change in potential fire behavior occurred in the control over the same time period.

Although restoration treatments were not implemented perfectly, they were *effective* in attaining the overall project goal of restoring more open forest structure conditions while preserving most of the presettlement trees. Furthermore, canopy fuels and active crown fire hazard were substantially reduced, allowing for the reintroduction of low-intensity surface fires. From related finer-scale studies, there is reason to expect that these changes will result in improved ecosystem function, increased vigor of old and young trees, improved resistance to insect outbreaks, and increased productivity of herbaceous understory productivity. However, treatments have also resulted in the loss of some old trees from prescribed fire activities and the spread of the invasive *Bromus tectorum*. The ERI will continue to address these and other challenges in the future. Although the treatments implemented were different than originally planned, the diversity of treatments created a variety of ecosystem conditions which will benefit a wide range of plants and animals, as well as humans.

More information about this study can be found on the web at:

<http://hdl.handle.net/2019/267>

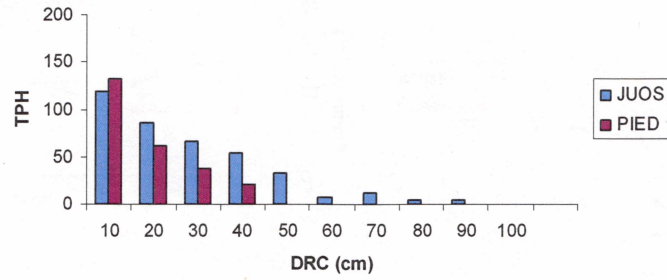
Pinyon-Juniper Ecosystem Restoration Demonstration

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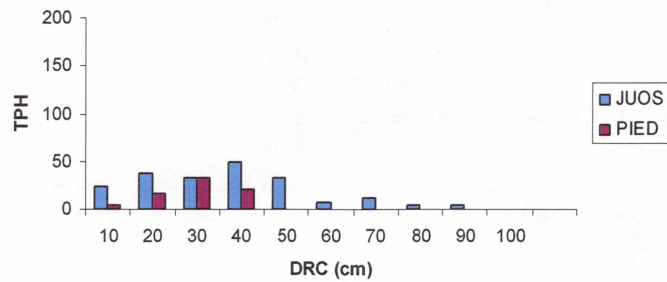
Summary

- Historical records indicated that livestock grazing was intensive on the sites beginning in the late 1800s and continuing through the mid 1900s. Repeat aerial photographs (1940 and 1992) indicated recent increases in stand density and encroachment of trees into formerly open areas. Pretreatment understory communities were sparse ($< 7\%$ total herbaceous cover) as were seedling densities in seed banks (151 seedlings per m^2 (14 seedlings per ft^2) at Craig Ranch (CR) and 192 seedlings per m^2 (18 seedlings per ft^2) at Goose Pond (GP)).
- Age distributions indicated that the majority of pinyon trees at both sites were less than 100 years of age and juniper establishment appeared to peak in the late 1800s-early 1900s. Before experimental treatments were implemented, a bark beetle outbreak at GP resulted in $>50\%$ pinyon mortality, which was positively related to tree size and age.
- The demonstration treatment consisted of thinning small trees (< 25 cm diameter at root collar), lopping and scattering thinned trees, and seeding native understory species.
- Thinning and mortality reduced overstory density from 638 and 832 trees per hectare pretreatment (258 and 337 TPA) to 280 and 251 post-treatment (113 and 102 TPA) at CR and GP, respectively. Post-treatment densities were similar to those suggested for the late 1800s by dendrochronological stand reconstructions. Thinning small diameter pinyon increased relative importance of juniper at both sites.
- Live canopy fuels were reduced by treatment at CR and by thinning plus beetle-related mortality at GP. Although thinning slash was lopped and scattered, woody surface fuels were not significantly different between treated and control units at either site. This result was likely due to the small size of thinned trees and the large interspace areas into which slash was scattered.
- Treatment had no immediate effects on herbaceous cover or species richness, however, both of which appear to be increasing in treated areas.
- Frequency of most seeded species increased by 2005.
- Further monitoring is necessary in order to clearly evaluate the restoration and conservation benefits of this treatment.

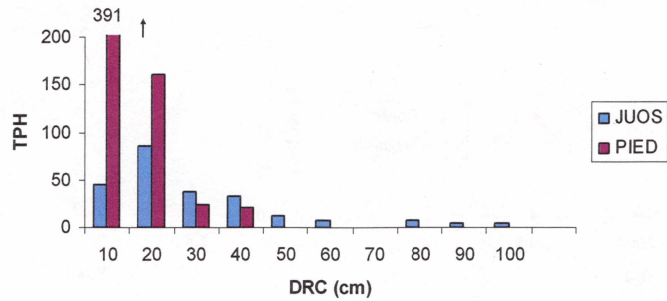
CR 2002



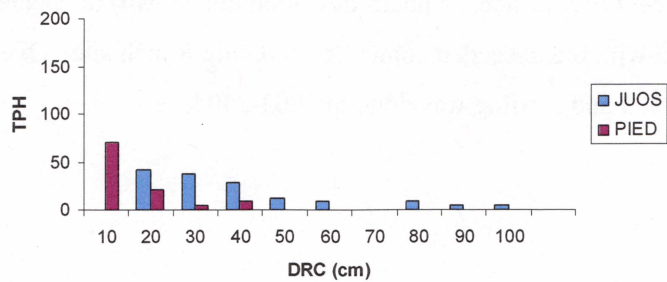
CR 2004



GP 2002

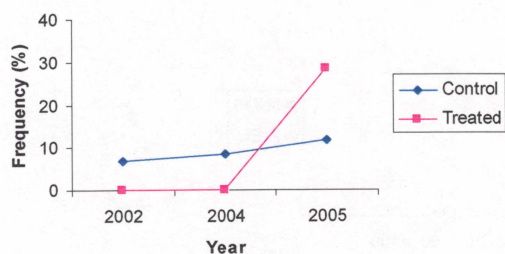


GP 2004

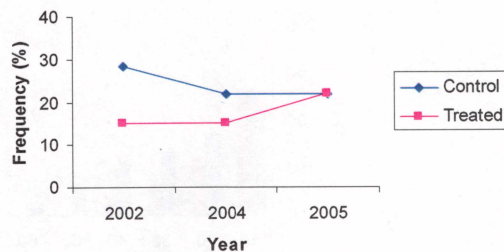


Diameter (DRC) distributions for treated units at Craig Ranch (CR) and Goose Pond (GP) sites on Grand Canyon-Parashant National Monument in 2002 (pretreatment) and 2004 (post-treatment).

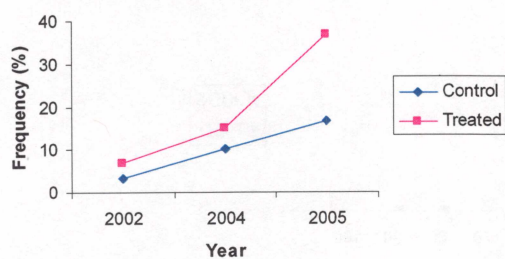
Bouteloua curtipendula



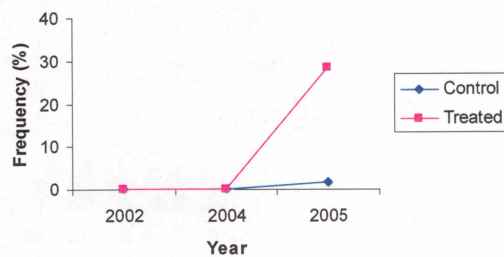
Bouteloua gracilis



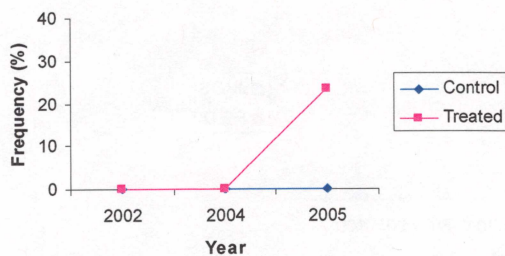
Elymus elymoides



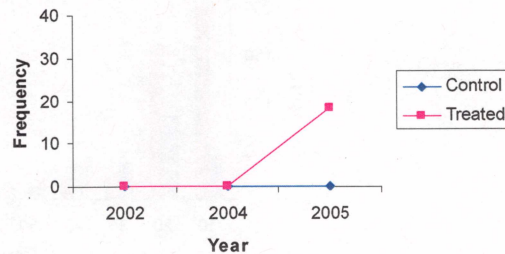
Sporobolus cryptandrus



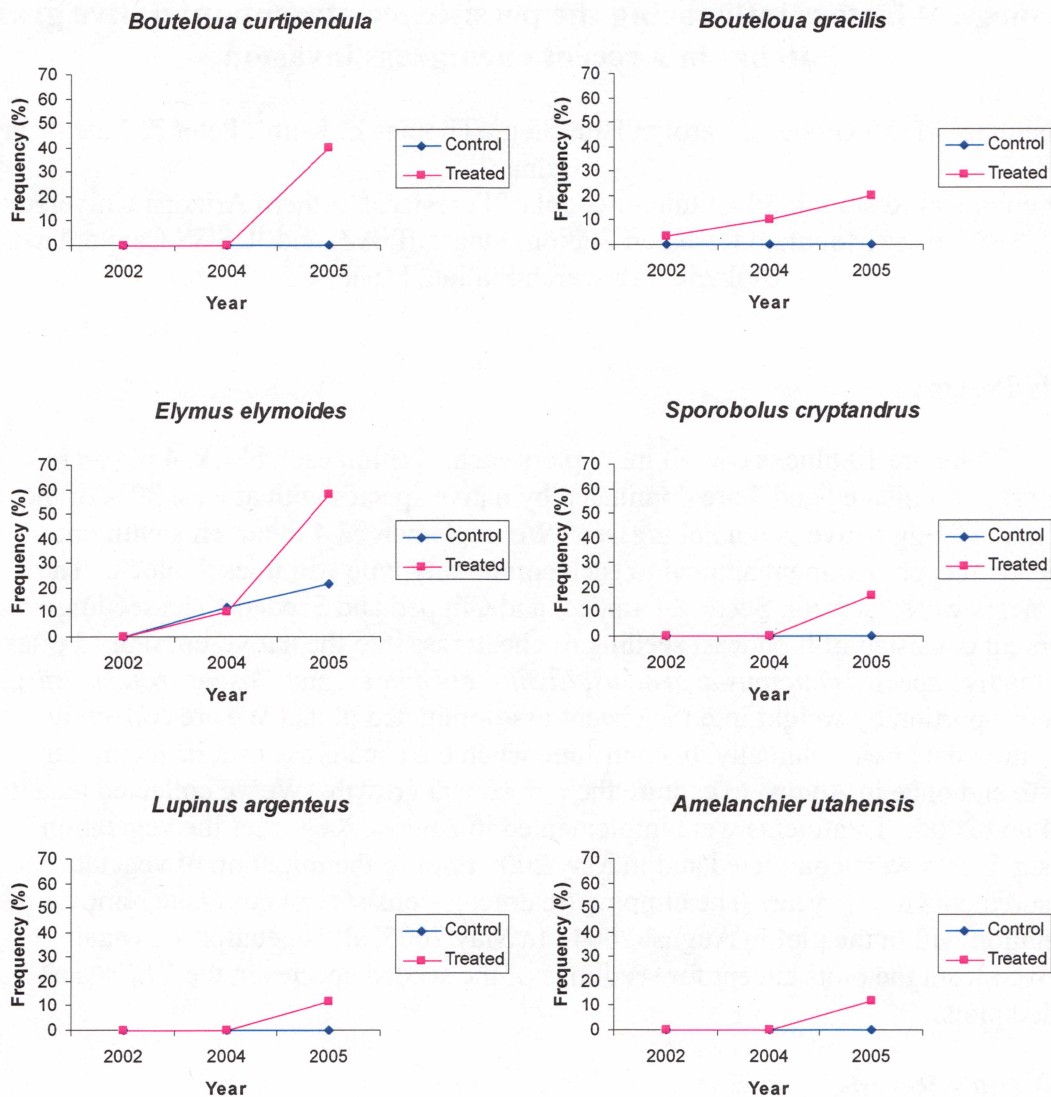
Lupinus argenteus



Rhus trilobata



Mean frequency (percent occurrence; standard deviation not shown) of species seeded in the treated unit compared with the unseeded control at the Craig Ranch site. Overstory of the treated unit was thinned in 2003 and seeding was done in 2003-2004.



Mean frequency (percent occurrence; standard deviation not shown) of species seeded in the treated unit compared with the unseeded control at the Goose Ponds site. Overstory of the treated unit was thinned in 2003 and seeding was done in 2003-2004.

Ecological factors influencing the persistence of remnant native grass patches in a recent cheatgrass invasion

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Study Design:

There are 10 blocks containing 8 plots each. Within each block, 4 plots are cheatgrass-dominated and 4 are dominated by native species with at least 30% of the vegetation being native perennial grasses. We implemented 4 treatments with one replicate of each treatment applied to each community type within each block. The treatments were: Control, Seeded, Clipped, and Clipped and Seeded. The seeding treatment consisted of broadcast seeding of cheatgrass into the native-dominated plots and 3 native species (*Lupinus argenteus*, *Elymus elymoides*, and *Pascopyron smithii*) in equal proportion by weight into the cheatgrass-dominated plots. We are collecting vegetation data twice annually, once in June when the cheatgrass is at its maximum growth and once in August to capture the monsoonal growth. We've collected data in 2004 and 2005. Treatments were implemented in August 2004 after the vegetation measurements were completed and in May 2005 prior to the initiation of vegetation measurements in that year. The clipping treatments consisted of complete removal of all vegetation within the plot in August 2004. In May 2005, all vegetation was again removed from the plots except for seedlings of the seeded species in the Clipped and Seeded plots.

Field Study Results:

The first 2 pages of graphs show the preliminary results of our field data collection. The data were blocked before averaging, so n=10. We looked at 4 variables in each treatment. The 3 dominant species in the area: *Bromus tectorum* (BROTEC), *Elymus elymoides* (ELYELY), and *Lupinus argenteus* (LUPARG), as well as the average total cover per plot. Page 4 shows the results in the cheatgrass-dominated plots and page 5, the native-dominated.

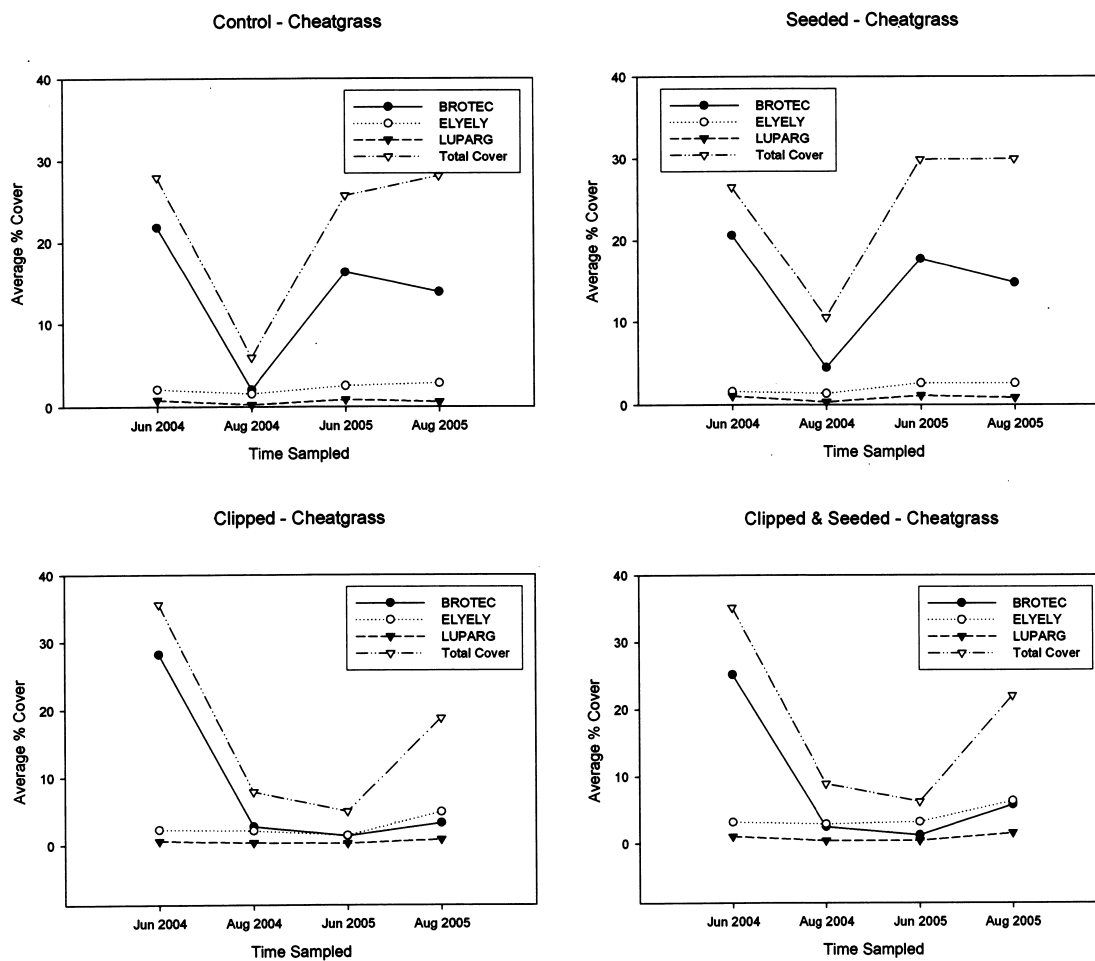
Cheatgrass-dominated plots:

These plots initially had higher overall cover than the native-dominated plots. In 2004, the plots were heavily dominated by cheatgrass. By 2005, the unclipped plots were only about 50% cheatgrass. The remainder was predominantly comprised of annual forbs, both native and nonnative. Cheatgrass did not recover well in the clipped plots and by August 2005, these plots were dominated by annual forbs. There was a slight increase in ELYELY in the seeded plots, particularly in the ones that were also clipped.

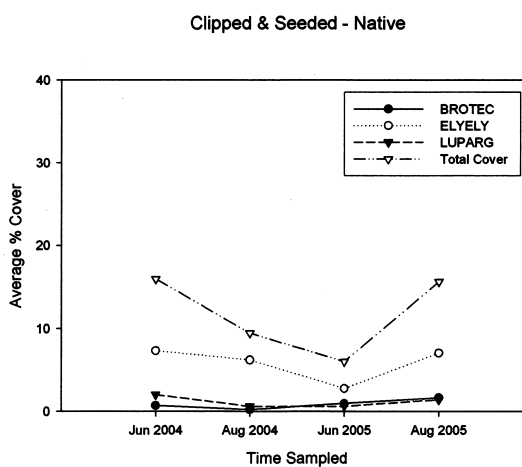
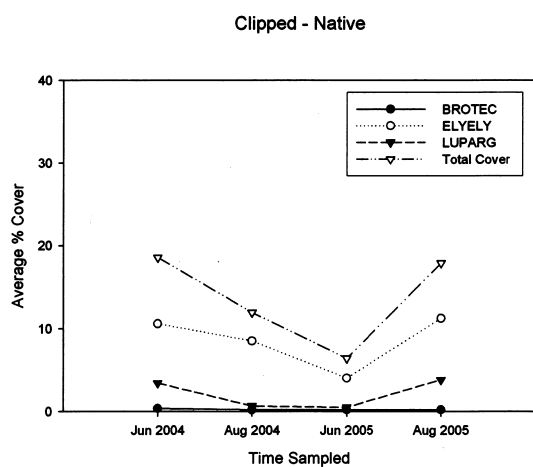
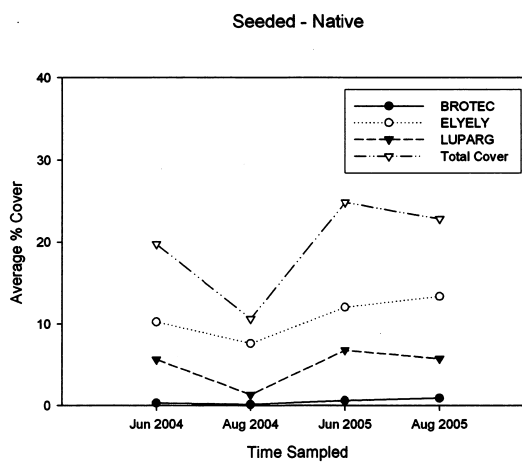
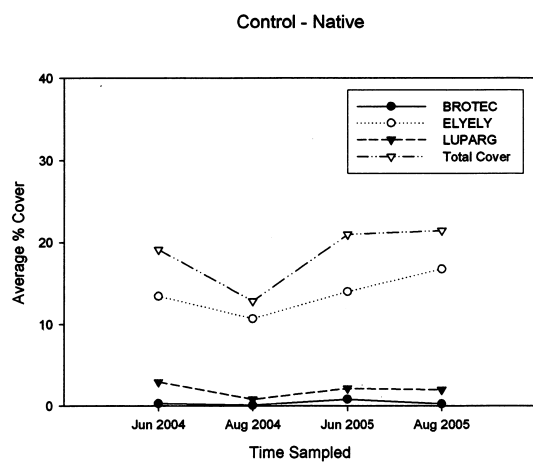
LUPARG showed little response to seeding. The higher cover of cheatgrass in the unclipped plots in August 2005 as compared to August 2004 was due to a large pulse of seedlings that year. The lack of such a pulse in the clipped plots suggests that the cheatgrass seedbank was highly depleted by the clipping in 2004. It's possible that cheatgrass is very dependent on annual replenishment of the seedbank to maintain dominance in the system. Both annual seedbank depletion and repeated removal of cheatgrass are (hopefully) going to be future senior thesis projects for ERI undergraduates.

Native-dominated plots:

These plots had consistently lower total cover than the cheatgrass plots. Cheatgrass did increase slightly in the seeded plots, but cover was still very low. By August 2005, ELYELY and LUPARG had recovered to pretreatment levels in the clipped plots. There was a large annual species component only in the Clipped and Seeded plots. In all other treatments, annual forbs remained at fairly low levels (data not shown).



Vegetation response to treatments on the cheatgrass-dominated plots. Treatment was implemented between the August 2004 and June 2005 measurements. BROTEC = cheatgrass; ELYELY = squirreltail; LUPARG = silver-leaf lupine.



Vegetation response to treatments on the native-dominated plots. Treatment was implemented between the August 2004 and June 2005 measurements. BROTEC = cheatgrass; ELYELY = squirreltail; LUPARG = silver-leaf lupine.

Seeding study – Nixon North and Corner units

Methods, a few very preliminary results and future research

Judy Springer and Christopher M. McGlone, Ecological Restoration Institute

Aboveground herbaceous vegetation

Ten plots were installed in each unit in late June, 2005, for a total of twenty. Plots were also split in half into a treatment (seeded) and a control (unseeded). Pre-treatment data were collected for each plot (presence/absence for each plant species) at the time of plot installation. We will re-sample these plots in June 2006.

Soil Seed Bank Study

In early September, we collected pre-burn seed bank samples from both Nixon and Corner (20 samples from each plot – ten from the seeded and ten from the unseeded halves of the plot). Samples were placed in cold storage. In late September, we collected additional seed bank samples from the Corner Unit, preceding and immediately after the prescribed burn (9/26 and 9/28). These samples were also placed in cold storage, and all samples were then moved to the NAU greenhouse in the winter, where samples were “grown out” using the seed emergence method. This method determines the viable seed bank based on germination of seeds in the soil. The study is still ongoing as we wait for the perennial grasses to flower for identification purposes, but preliminary results suggest that many cheatgrass seeds still remain in the soil seedbank even following prescribed burning. Results will also give us an idea of the viable seeds per acre of grass species that were seeded in the seed mix.

Seeding Rates

Ken Moore and Aaron Wilkerson inquired about the rate of seed per acre that actually falls on the ground when seed hoppers are used. A group of six NAU researchers was recruited to compare broadcast hand seeding rates to seeding rates from full and partially full hoppers. Seeding rates per acre for the three methods are shown below. Hand seeding, by far, leaves many more seeds on the ground. In addition, partially full hoppers release more seeds than full hoppers.

	Ricegrass	Globemallow	Blue grama	Lupine	Western wheat	Unknown	Total
Full	43560	20328	1690140	5808	728909	229417	2,718,165
Partial	65340	10890	5452301	3630	1404820	156091	7,093,074
Hand	191665	75504	7355887	2904	5270800	249745	13,146,507

Field Research Projects on Mt. Trumbull for 2006

- Evaluating Tree Mortality in the Mt. Logan and Mt. Trumbull Wilderness Areas
- Reassessing Tree Mortality across the Mt. Trumbull Landscape
- Remeasurement on Pinyon-Juniper Demo Plots
- Second Post-treatment Measurements on Cheatgrass Plots
- First Post-treatment Measurements on Seeding Study Plots
- Second Measurements on Short-term Grazing Exclusion Plots
- Establishment and Pretreatment Measurements on Season-of-burn Pilot Study