

produced lower pine mortality, reduced the size of sub-canopy trees, and decreased the density of lichens. Shrubs declined the first year after both treatments, then increased to levels higher than in the control areas. Meanwhile, tree species recruitment was higher than the control in both treatment categories. Groundcover species did not respond to treatments. The authors recommend thinning part of the subcanopy and multiple prescribed burns as early restoration activities in areas that have a long history of fire suppression.

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Responses of Diversity and Invasibility to Burning in a Northern Oak Savanna. 2005. MacDougall, A.S., Dept. of Botany, University of British Columbia, Vancouver, British Columbia V6T 1Z4 Canada. *Ecology* 86(12):3354-3363.

MacDougall tested the diversity-stability model, which holds that greater species richness will increase the resistance of an ecosystem to invasion due to the fact that the positive effects of sudden disturbance on some species compensate for negative effects on other species. The study site was a fire-suppressed oak (*Quercus* spp.) in British Columbia with a diversity gradient ranging from cool-season, grass-dominated (*Poa* spp. and *Dactylis* spp.), low-diversity areas on deep, mesic soils to high-diversity, low-population, forb-dominated areas on shallow, drier soils was burned in the summer. MacDougall found that plants in the diverse areas were adapted to summer drought conditions and expanded after a burn, reducing available resources and inhibiting invasion. Fire negatively affected plants in the low-diversity areas, probably because they were drought stressed, allowing Scotch broom (*Cytisus scoparius*) and thistles (*Cirsium* spp.) to invade the openings. MacDougall concludes that support for the diversity-stability model depends on the species' evolutionary histories and disturbance severity.

CONTROL OF PEST SPECIES

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Integrating Weed Management and Restoration on Western Rangelands

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Cheatgrass (*Bromus tectorum*) dominates 3 million acres (1.2 million ha), has heavily infested 17 million acres (7 million ha), and threatens another 60 million acres (24 million ha) of rangelands in the Great Basin of western North America (Pellant and Hall 1994). An exotic annual, cheatgrass produces prolific seed, is highly competitive, and perpetuates large, frequent fires (Knapp 1998, Smith and others 2000). These characteristics

accelerate the loss of perennial species, increase cheatgrass dominance, and facilitate invasion of other rangeland weeds. The change from perennial to annual dominance and the altered fire cycle result in a "vegetation conversion" (Keeley 2006) that makes it difficult to restore native vegetation.

In 2003, we began experiments to control cheatgrass and restore native species on Great Basin rangelands with the intention of 1) controlling cheatgrass by reducing its seed production and competitive ability and 2) investigating whether "transitional communities" facilitate restoration of native plants. We established two common experiments at eight sites in Nevada, Oregon, Idaho and Utah, plus a third, large-scale experiment in Nevada. All sites were originally Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and native bunchgrass communities, but had converted to essentially cheatgrass monocultures. We repeated the first two experiments in 2003 and 2004, and established the third experiment in 2004.

Experiment 1 (Transition Species) tested establishment of 25 seed varieties (crested wheatgrass [*Agropyron cristatum* x *desertorum*] as a benchmark because it is an introduced grass commonly used to suppress cheatgrass, several native species, and sterile annual cover crops) with and without cheatgrass. We used a Truax Rough Rider range drill to seed each variety into 10-ft x 20-ft (3-m x 6-m) plots arranged in six blocks per site. Three blocks were treated with glyphosate (Roundup at 0.5 lb ai/acre or 0.7 kg/ha) to kill cheatgrass in the spring prior to seeding, and three blocks were not sprayed. Density of seeded varieties and density and biomass of cheatgrass and other species were monitored after seeding.

Experiment 2 (Functional Groups) used six native species with different growth forms to examine 1) how different growth forms reduce cheatgrass individually compared to a mix of species and 2) if decreased soil nitrogen (N) availability decreases cheatgrass competition. We seeded 4-ft x 8-ft (1.25-m x 2.5-m) plots by hand, and applied granulated sugar (3.9 oz/ft or 360 g/m) to stimulate microbial growth and immobilize soil N. On some sites, we also examined interactions with secondary weeds, such as medusahead (*Taeniatherum caput-medusae*) and rush skeleton weed (*Chondrilla juncea*).

Experiment 3 (Management Options) investigated prescribed fire and herbicide applied at a larger scale (12-acre or 5-ha plots) to reduce cheatgrass density and seed bank. In fall 2004, a "transition species" (a sterile annual hybrid) was planted on a subset of plots to immobilize soil N and provide additional fuel for a fall 2005 prescribed fire. We applied Roundup at 0.5 ai/acre in spring 2005 to a different subset of plots to reduce cheatgrass seed production. We compared the six best performers from Experiment 1 to the six-species mix from Experiment 2, and drill-seeded the mixtures in late fall 2005.

After two years, we have identified several promising plant materials comparable to crested wheatgrass, including native

sources of bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum smithii*) and Snake River wheatgrass (*Elymus wawawaiensis*), that might serve as transition communities for converting cheatgrass back to native vegetation. We also found that nitrogen limitation dramatically reduced cheatgrass seed output in the current year and density in the next year, although cheatgrass density rebounded the following year. In addition, personnel from the USDA-NRCS Aberdeen Plant Materials Center in Idaho, in cooperation with Mr. Jim Truax, modified the design of the Rough Rider drill to increase the flow of seed from the seed box to the ground, create a wider disc opening so more seed gets buried, and cause the press wheel to more accurately close soil around the seed.

We will continue to monitor our Transition Species and Functional Group experiments. We will also collect information on our third experiment to determine the effectiveness of site preparation and seeding treatments. In addition, we are using partnerships among governmental agencies, universities, and cooperative extension services to convey our findings to private and public land managers. Other partnerships with educators will help to increase public awareness of invasive species and native plant restoration issues. Finally, we are developing models of the economic and social effects of restoration in order to assess the net minimum costs to ranchers and to examine the degree of social acceptability among key stakeholders.

ACKNOWLEDGMENTS

This research was supported by a grant from the USDA IFAFS Program (CREES # 2001-52103-11322), with additional support from the Nevada Agricultural Experiment Station, Nevada Arid Rangeland Initiative, USDI Bureau of Land Management, USGS Forest and Rangeland Ecosystem Science Center, USDA Forest Service, USDA Natural Resources and Conservation Service, and USDA Agricultural Research Service.

REFERENCES

- Keeley, J.E. 2006. Fire management impacts on invasive plants in the Western United States. *Conservation Biology* 20:375-384.
- Knapp, P.A. 1998. Spatio-temporal patterns of large grassland fires in the Intermountain West, USA. *Global Ecology and Biogeography Letters* 7:259-272.
- Pellant, M. and C. Hall. 1994. Distribution of two exotic grasses on intermountain rangelands: Status in 1992. Pages 109-112 in S.B. Monsen and S.G. Kitchen (compilers), Proceedings—Ecology and management of annual rangelands. General Technical Report INT-GTR-313, Ogden, UT, USDA Forest Service, Intermountain Research Station.
- Smith, S.D., R.K. Monson and J.E. Anderson. 1997. *Physiological ecology of North American desert plants*. New York: Springer.

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Nitrogen Fixation by Kudzu: Impacts on Invaded Communities and Ecosystems

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Kudzu (*Pueraria montana*), a vine native to Asia, covers more than 7 million acres (3 million ha) in the United States and is expanding by more than 123,500 acres per year (50,000 ha/yr), mostly in the South (Forseth and Innis 2004). This legume packs a one-two punch with its impressive growth rates (up to 100 ft or 30 m in a single growing season) and its ability to fix nitrogen (Forseth and Innis 2004). We are exploring how these characteristics combine to alter community composition and disrupt ecosystem properties where it invades, particularly with respect to nitrogen cycling and accumulation. Various scientists (Vitousek and others 1997, Matson and others 2002) have noted that additions of nitrogen can lead to altered nitrogen accumulation and cycling in soils and streams, changes in plant and microbial community structure, increased invasion by exotic species, acidification of soils, acidification and eutrophication of downstream aquatic and marine systems, and increased emissions of trace gases that contribute to global warming and the production of tropospheric ozone.

In August and September 2005, we collected preliminary data to determine how kudzu is affecting the plant community and ecosystems at two sites in the Maryland Department of Natural Resources' McKee-Beshers Wildlife Management Area near Gaithersburg. Kudzu has formed dense carpets and thoroughly covers trees in several spots along the edge of the oak/hardwood forest typical of this region, where white and red oaks (*Quercus alba* and *Q. rubra*), box elder (*Acer negundo*), sassafras (*Sassafras albidum*), American elm (*Ulmus americana*), and hickory (*Carya* spp.) are common. We paired sites invaded by kudzu with nearby uninvaded sites that were similar in slope, aspect, topography and land-use history, and sampled three 1-m² plots within each site. By comparing community and ecosystem variables in the invaded sites to those in the uninvaded sites, we can detect the effects of kudzu invasion. At each site, we used standard quadrat methods to estimate species composition and cover, collected leaves from kudzu and the common tree species listed above to measure foliar nutrient concentrations, and took soil samples to measure the soil pools of carbon and nitrogen as well as the microbial processes responsible for nitrogen cycling in the soil (potential net nitrogen mineralization, potential net nitrification, and denitrification).

Preliminary results strongly support our hypothesis that kudzu invasion is altering community composition as well as nutrient pools and cycling. For example, we found only 20 percent as many juvenile trees in invaded sites as in uninvaded