treatment effects at the 0.05 level of significance ($F_{5, 383} = 2.01$, $p < 0.076$). However, our observations of relatively low gallberry densities in burn-only plots, and higher densities in plots that were chopped, may still be biologically significant and meaningful to restoration efforts in which reducing this shrub is an important management objective. Similarly, we did not find statistically significant effects among the treatment plots in densities of rusty lyonia and fetterbush (*Lyonia* spp.; $F_{5, 383} = 1.89$, $p < 0.095$). Later tests showed that higher densities of lyonia and fetterbush occurred in plots that were chopped and burned during winter, or that were burned in either summer or winter.

Clearly, successful restoration of dry prairies cannot be measured by considering only a small group of species. We present data for these species not to encourage such a narrow focus, but because we realize that many management and restoration efforts justifiably monitor these important ecosystem components, which provide structure, wildlife habitat, and/or promote ecological processes such as the movement of fire.

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SER/ESA 2002

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FROM: Abstracts of the 16th Annual Meeting of the Society for Conservation Biology

145.1

Use of Salvaged Plant Materials to Restore Native Communities in Southern California. Ervin, M. and T. Smith, The Nature Conservancy, 2833 Irvine Blvd., Irvine, CA 92602, mervin@tnc.org.

The Nature Conservancy and the Irvine Company, a land developer, worked together to salvage plants and topsoil for stands of coastal sage scrub and native grassland slated for development and move them to degraded habitat areas in the Nature Reserve of Orange County, California. Workers moved approximately 17,500 plants and ten acres of high-quality grassland topsoil. To date, the survival rate for two of the most dominant shrub species is about 85 percent.

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Chemical Amelioration of High Phosphorus Availability in Soil to Aid the Restoration of Species-Rich Grassland. 2003. Gilbert, J.C., Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire, SG19 2DL, United Kingdom, +44-1767-680551, Fax: +44-1767-689836, jo.gilbert@rspb.org.uk; D.J.G. Gowing and P. Loveland. **Ecological Engineering** 19(5):297-304.

The authors investigated using chemical amelioration to reduce phosphorus (P) availability in grasslands. They treated blocks at two sites (in Beldforshire and London) with aluminum sulfate, elemental sulfur, or calcium carbonate and transplanted five wet grassland plant species. Aluminum sulfate decreased P availability at both sites. Sulfur-treated blocks showed either an increase in P availability or no significant effect. Calcium carbonate did not affect P availability. No treatment increased species diversity. The aluminum sulfate treatment initially decreased diversity, likely because of the associated lowering of pH. The authors conclude that the presence of aluminum ions is important to reduce P availability and suggest further research to determine if other aluminum compounds that will not decrease pH can reduce the dominance of individual species. They note that for large-scale restoration, researchers need to determine whether the compounds will adversely affect soil fauna or leach into nearby watercourses.

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Rainfall Variability, Carbon Cycling, and Plant Species Diversity in a Mesic Grassland. 2002. Knapp, A.K., Division of Biology, Kansas State University, Manhattan, KS 66506, aknapp@ksu.edu; P.A. Fay, J.M. Blair, S.L. Collins, M.D. Smith, J.D. Carlisle, C.W. Harper, B.T. Danner, M.S. Lett and J.K. McCarron. **Science** 298(5601):2202-2205.

During a four-year experiment, these researchers manipulated rainfall patterns in a native grassland in northeast Kansas by extending the periods between natural rain events and increasing the amount of rainfall per event. They found that more extreme rainfall patterns increased temporal variability in soil moisture and plant species diversity. They also saw a reduction in carbon cycling processes, including the carbon dioxide uptake by the dominant grasses and a decrease in aboveground net primary productivity (ANPP). They conclude that increases in rainfall variability, a predicted result of anthropogenic climate change, can rapidly change key carbon cycling processes and plant community composition, independent of changes in total precipitation.

WOODLANDS

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Vegetation Trends at Auwahi Dryland Forest After Five Years of Restoration (Hawaii)

Arthur C. Medeiros, Tracy L. Erwin, Chuck G. Chimera and Lloyd L. Loope, U.S. Geological Survey, Haleakala Field Station, P.O. Box 369, Makawao, Hawai'i 96768, 808/572-4472, acm@aloha.net

Dryland forests are among the most diverse and endangered native Hawaiian plant communities. The botanist Joseph Rock (1913) described the dryland forest at Auwahi on the island of Maui as one of the richest botanical regions in the islands. Since then, fires, grazing, and invasion by non-native plant species—especially, kikuyu grass (*Pennisetum clandestinum*)—have prevented natural reproduction for most of the 49 native tree species at Auwahi. As a result, many of these trees have been reduced to near extirpation (Medeiros and others 1986).

This note describes our ongoing efforts to restore highly modified dryland forest within a 10-acre (4-ha) exclosure at Pu'u-ouli, as a prototype for future restoration in Auwahi and neighboring districts. Within this exclosure, we have excluded ungulates (domestic cattle and feral pigs), killed kikuyu grass mats with 1 percent glyphosate application, and initiated a program to outplant numerous native plant species with assistance from the local community. We are now beginning to see the establishment of seedlings and saplings of native shrub-tree species, such as ʻaʻaliʻi (*Dodonaea viscosa*), ʻulei (*Osteomeles anthyllidifolia*), and pilo (*Coprosma foliosa*). The increasing cover of these native shrub-tree species will likely make the site less susceptible to invasion by non-native plant species and promote the continued recruitment of native forest species.

In October 1997, we established 97 permanently marked 100-m^2 plots within the exclosure. In November 2002, we randomly selected and resurveyed a subsample of plots from those located in the highly modified southern part of the exclosure. We report here the comparison of cover estimates for ten plots and counts of woody species for six plots between 1997 and 2002.

Of all species, kikuyu grass declined most dramatically (Table 1). The large-scale decline of this species without evident seedling recruitment after a single herbicide application provides strong circumstantial confirmation that kikuyu grass does not produce seed here, as local ranchers believe. Following the decline of kikuyu grass, cover and abundance of the non-native herb, balloonplant (*Asclepias physocarpa*), increased to alarming levels (about 50-75 percent cover). It subsequently decreased (Table 1), perhaps facilitated by our hand-weeding control efforts, copious seed predation by non-native rodents, and seedling herbivory by non-native game birds.

From 1997-2002, native shrub-tree species increased significantly throughout the exclosure, with ʻaʻaliʻi having the largest increase in cover (Table 1). More than half (57 percent) of this increase was due to natural reproduction and growth of existing individuals, and the remainder from outplanted seedlings that were transplanted when about 8-12 inches (20-30 cm) tall and nine months old. From 2000-2002, community volunteers planted about 3,000 ʻaʻaliʻi seedlings throughout the exclosure.

We also recorded the natural establishment of native shrub-tree species in the plots over the five-year period. Between 1997 and 2002, the mean number of ʻaʻaliʻi seedlings and saplings (less than 50 mm basal diameter) increased from 2.0±1.8 plants/plot to 14.2±7.3 plants/plot, ʻulei from 0.7±0.3 plants/plot to 7.3±14.7 plants/plot, and pilo from 3.0±6.0 plants/plot to 3.8±7.5 plants/plot. These results are not statistically significant due to low sample size and high variability. However, when native shrub-trees are pooled and plots lacking these species at both sampling dates are eliminated, the results are significant (two-sample t-test, $p = 0.040$), increasing from 1.5±1.5 native woody shrub-trees/plot in 1997 to 9.5±14.2 native woody shrub-trees/plot in 2002.

One threat to the long-term conservation of Auwahi and similar forests is the spread of aggressive non-native tree species, especially bocconia (*Bocconia frutescens*). Although we eliminated large bocconia trees from the exclosure in the late 1990s using Garlon™ 4 and maintain manual control efforts, bocconia seedlings continue to become established. In 2002, we recorded bocconia in every sampled plot (compared to four out of ten plots in 1997), presumably from a persistent seed bank or avian seed dispersal. Without chemical and manual control, bocconia would likely be the species with the greatest cover values.

We predict that native shrubs and trees will increasingly dominate the exclosure over the next decade, recreating shaded understory sites probably similar to those of the original forest stands. Only time will tell whether the return of favorable microsites will spur the spontaneous reproduction of a broader spectrum of native dryland forest tree species, many of which have failed to reproduce naturally for decades, or whether some other perturbation will interfere.

Acknowledgments

We thank the Erdman family and ʻUlupalakua Ranch for the opportunity to explore strategies for restoration in Auwahi forest, and Paul and Stephanie Krushelnycky and Forest and Kim Starr for their assistance with fieldwork.

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Table 1. Mean cover estimates of native and non-native plant species five years after restoration at Auwahi Dryland Forest in Maui. T-test p-values: * = ≤ 0.05, ** = ≤ 0.01, * = ≤ 0.001.**

Cover Category	1997 Percent Cover	2002 Percent Cover	Two-sample t-test p-values
All non-native species (n = 23)	86.9 ± 29.8	7.7 ± 4.6	0.000***
All native species (n = 28)	25.3 ± 21.9	36.7 ± 22.6	0.266
Bare ground and rock	25.8 ± 21.6	50.7 ± 24.7	0.028*
Non-native *Pennisetum clandestinum*	64.1 ± 24.2	1.8 ± 1.3	0.000***
Non-native *Asclepias physocarpa*	17.3 ± 20.4	0.3 ± 0.5	0.027*
Non-native *Bocconia frutescens*	0.5 ± 0.7	1.1 ± 1.1	0.134
Native *Dodonaea viscosa*	0.6 ± 0.7	5.8 ± 6.0	0.014**
Native *Osteomeles anthyllidifolia*	1.2 ± 1.3	5.3 ± 8.3	0.164
Native *Coprosma foliosa*	2.8 ± 5.1	4.5 ± 7.1	0.547
All native shrub and tree species	1.5 ± 3.1	7.0 ± 7.6	0.001***

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Understory Plant Community Restoration in the Uinkaret Mountains, Arizona. N.d. Anon., Ecological Restoration Institute, Northern Arizona University, P.O. Box 15017, Flagstaff, AZ 86011-5017. **Working Papers in Southwestern Ponderosa Pine Forest Restoration,** www.eri.nau.edu/new/library/pdf/ERI_Booklet2.pdf.

This paper discusses plans by the Ecological Restoration Institute (ERI) to restore the understory of ponderosa pine (*Pinus ponderosa*) forests in the Uinkaret Mountains and other sites in northern Arizona. Goals include reestablishing 1) native species richness and community composition, 2) historic understory plant cover, 3) the ability to carry surface fire, and 4) a shrub component. Based on preliminary monitoring of restoration plots, the ERI recommends the following: 1) include native perennial grasses in seed mixes to help carry low-intensity fire, 2) include native forb seeds that colonize quickly or add nitrogen to the soil, 3) collect seed from local seed sources, 4) cover seed to improve germination rates, 5) limit livestock grazing, 6) limit spread of invasive species, such as cheatgrass (*Bromus tectorum*), and 7) monitor successional change.

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Comparing Ecological Restoration Alternatives: Grand Canyon, Arizona. 2002. Fulé, P.Z., Ecological Restoration Institute, P.O. Box 15018, Flagstaff, AZ 86011, 520/523-1463, Fax: 520/523-1080, pete.fule@nau.edu; W.W. Covington, H.B. Smith, J.D. Springer, T.A. Heinlein, K.D. Huisinga and M.M. Moore. **Forest Ecology and Management** 170(1-3):19-41.

The authors compared three restoration treatments on 30-acre (12-ha) units of ponderosa pine (*Pinus ponderosa*) forest in the Kaibab National Forest along the Grand Canyon's South Rim: 1) full restoration, including prescribed burning, forest floor fuel treatment, and thinning trees to emulate stand structure circa 1887; 2) minimal thinning, including burning, fuel treatment, and removing young trees only around old-growth trees; and 3) burn only, the forest's current management policy. After one year, the full treatment, minimal thinning, and burn-only treatment caused a tree-density reduction to 11, 23, and 37 percent of pretreatment levels, respectively. In a computer fire simulation, full treatment caused the greatest reduction in susceptibility to crown fire, minimal thinning caused an intermediate reduction, and the burn-only treatment caused the least.

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Planting Frozen Conifer Seedlings: Warming Trends and Effects on Seedling Performance. 2002. Kooistra, C.M., British Columbia Ministry of Forests, Nursery Services Interior, Forest Enterprises Branch, 2501 14th Ave., V1T 8Z1, Vernon, Canada, Clare.Kooistra@gems6.gov.bc.ca; and J.D. Bakker. **New Forests** 23(3):225-237.

The authors tested the hypothesis that thawing seedlings that have been held in frozen storage prior to outplanting may be unnecessary. They examined the seedlings of three conifer species—lodgepole pine (*Pinus contorta* var. *latifolia*), western larch (*Larix occidentalis*), and interior spruce (*Picea glauca* x *engelmannii*)—under irregular and regular watering regimes. Although bud break was faster for thawed compared with frozen western larch seedlings, the other species showed no differences. Overall, there were few significant differences between thawed and frozen seedlings under either watering treatment in field tests. The authors conclude that planting seedlings with frozen root plugs did not hamper field performance over one growing season under either watering treatment.

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Long-Term Fire Regime Estimated from Soil Charcoal in Coastal Temperate Rainforests. 2002. Lertzman, K., Simon Fraser University; D. Gavin, D. Hallett, L. Brubaker, D. Lepofsky and R. Mathewes. **Conservation Ecology** 6(2):5, www.consecol.org/vol6/iss2/art5.

The authors studied the distribution and age of charcoal buried in soil in two temperate rainforests on British Columbia's south coast to determine the dates of past fires. They discovered that both forests contained areas that had experienced either no fire or only one or two fires during the past 6,000 years. This contrasts with other, drier conifer forests where fires are of major ecological importance. In these coastal temperate rainforests, fine-scale processes of disturbance and recovery dominate the forest history and maintain a ubiquitous late-successional character over the landscape. The authors suggest that this information has important implications for ecosystem-based forest management.

WETLANDS

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FROM: Abstracts of the Society of Wetland Scientists 23rd Annual Conference

153.1

Soil Properties and Processes in Natural and Mitigation Nontidal Forested Wetlands in North Carolina. Bruland, G. and C.J. Richardson, Duke University Wetland Center, Duke University, Durham, NC 27708-0333, glb5@duke.edu.

The authors sampled eight nontidal forested mitigation wetlands (MIWs) and adjacent natural reference wetlands (NRWs) in North Carolina to determine 1) any differences in soil properties; and 2) how differences in soil properties affect biogeochemical properties, such as phosphorus sorption and denitrification. They found that the soils of forested MIWs generally had higher bulk density, sand content, and pH, and lower clay content, moisture, organic matter, and microbial biomass than the NRWs. These properties would lead MIWs to have lower phosphorus sorption and denitrification rates. The authors conclude that although forested MIWs may meet Army Corps of Engineers criteria for hydrologic and vegetative success, their soils may not be functionally equivalent to NRW soil.

153.2

Feasibility of Restoring Northern White Cedar (*Thuja occidentalis* L.) Wetlands. Hoefferle, A.M. and C.L. Wolverton, Northern Ecological Services, Inc., Reed City, MI 49677, hoefferle@northerneco.com.

Noting that there have been no documented successful northern white cedar wetland restorations to date, Hoefferle and Wolverton discuss the most critical factors for such restoration. Northern white cedar is slow growing and is a preferred winter food source for white-tailed deer (*Odocoileus virginianus boeralis*). Seedlings must be protected for an extended period because trees may take 20 to 40 years to reach a height where browsing no longer hinders development. In addition, northern white cedar cannot tolerate prolonged flooding. The restoration site must provide enough water to saturate the soil and prevent competing upland vegetation but not provide so much as to cause damage to tree roots. The authors recommend undertaking a demonstration project to evaluate various strategies.