

suggest that many natural resource programs are still encumbered by the agency's long-standing patterns of separating development and construction projects from their program objectives. We urge resource managers to heed Miller's advice about working with facility managers to design projects (Miller 1996).

In the 1980s, the NPS sponsored a series of training programs for natural resource specialists. The senior author, who was a graduate of the second such class, perceived during the intensive professional development program that revegetation and disturbed-site restoration lacked "ownership" and were not clearly aligned with natural resource programs at national, regional, or park levels. We hope this is changing as more parks express a program need, establish professional resource management positions, and obtain added expertise. Professional organizations such as the Society for Restoration Ecology can offer educational assistance and training to park personnel in any division. Also, NPS's geologic resources division (GRD) can provide parks with technical assistance and, since 1998, some project funding from its abandoned mining lands program, in addition to fee demonstration monies. As part of the NPS director's natural resource initiative, the GRD has asked for an increased budget of \$1 million annually, which would be awarded competitively beginning in fiscal year 2000 for disturbed-site reclamation projects (D. Steensen, NPS GRD, personal communication). This proposal, if approved, will substantially improve the organization and funding support available for addressing a backlog of site restoration needs in Yellowstone and across the National Park System.

Still, the task is daunting. Yellowstone staff have identified more than 150 sites in the park that need reclamation. Yet, by strengthening our interdisciplinary efforts to plan, fund, and execute many more "undevelopment" projects, Yellowstone hopes to restore more acres of wetlands, natural contours, vegetation, and plant and animal habitats; to improve aesthetics; and to remove safety hazards to humans and wildlife in America's oldest national park.

References

- Consolo-Murphy, S., and B. Kaeding. 1998. Fishing Bridge: 25 years of controversy regarding grizzly bear management in Yellowstone National Park. *Ursus* 10, 385-393.
- Eberhardt, L. L., B. M. Blanchard, and R. R. Knight. 1994. Population trend of the Yellowstone grizzly bear as estimated from reproductive and survival rates. *Canadian Journal of Zoology* 72, 147-150.
- Mattson, D. J., R. R. Knight, and B. M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. *International Conference on Bear Research and Management (Ursus)* 7, 259-273.
- Miller, A. 1996. Construction projects and natural resources. *Park Science* 16(4), 19-21, 30.
- Knight, R. R., and L. L. Eberhardt. 1984. Projected future abundance of the Yellowstone grizzly bear. *Journal of Wildlife Management* 48(4), 1434-1438.
- NPS [National Park Service]. 1973. *Master Plan, Yellowstone National Park*. Denver: National Park Service.
- . 1984. *Fishing Bridge and the Yellowstone Ecosystem: A Report to the Director*. Yellowstone National Park, Wyo.: National Park Service.
- . 1988. *Final Environmental Impact Statement/Development Concept Plan, Fishing Bridge Developed Area, Yellowstone National Park*. Denver: National Park Service.
- . 1994. *Draft Environmental Impact Statement, Fishing Bridge Campsite Replacement*. Yellowstone National Park, Wyo.: National Park Service.
- U.S. Fish and Wildlife Service. 1993. *Grizzly Bear Recovery Plan*. Missoula, Mont.: U.S. Fish and Wildlife Service.

Ecological Restoration of a Wilderness and Cultural Landscape, Bandelier National Monument, New Mexico

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Summary

In 1990, a program was conceived to actively restore the wilderness and cultural landscape of Bandelier National Monument, located in north-central New Mexico. Initial efforts were directed at documentation of baseline conditions, including vegetative cover and soil erosion rates in degraded piñon and one-seed juniper woodlands. Development and testing of restoration methodologies began with small-scale evaluations of overstory thinning, slash mulching, and supplemental seeding techniques. Encouraging results from small-scale trials led to testing of overstory thinning and slash mulching techniques at a functional (100-acre) watershed scale. With validation of restoration methodologies at multiple scales, the park successfully obtained funding to implement large-scale restoration efforts. Implementation is being delayed however, pending environmental impact statement (EIS) review of the proposed restoration actions on wilderness, cultural, and natural values.

Program Review

In 1916, Bandelier National Monument was established to protect the "relics of a vanished people" whose cultural remains—i.e., "certain prehistoric aboriginal ruins"—were considered to be "of unusual ethnologic, scientific, and educational interest." Subsequently, in 1976, a large portion of the park was designated as wilderness owing to the rugged and remote nature of its backcountry. Therein was sown a unique management dilemma: the tools for cultural resource protection now had to be compatible with a wilderness philosophy. Moreover, even a management founded on ecological considerations could sometimes find itself at odds with a nature defined more by aesthetics than by process.

Piñon (*Pinus edulis* Engelm.) and one-seed juniper (*Juniperus monosperma* (Engelm.) Sarg.) woodlands occupy some 10,000 acres within Bandelier National Monument. Domestic livestock grazing, beginning in the late 1600s and intensifying with the arrival of the railroad in 1880, transformed fire-dependent grassland and savanna communities into woodlands choked with young tree growth. Overgrazing reduced standing herbaceous biomass and continuity of fine-grass fuels, effectively preventing fire from propagating in these systems (Gottfried et al. 1995). As the soil-stabilizing, grassy ground cover was supplanted by increasing densities of trees, highly erodible soils were exposed to physical processes. Bandelier, a mountain wilderness and cultural landscape of abandoned pre-historic settlements, was established to preserve the unique ancestral remains of Puebloan Indian peoples. The largest proportion of archeological sites in the monument occur within piñon-juniper communities, and of these, over 80% have sustained erosional damage. Rapid soil loss in degraded piñon-juniper communities is unsustainable and threatens the integrity of thousands of pre-historic cultural sites. On the basis of soil erosion bridge and sediment catchment data, soil loss within degraded piñon-juniper communities at Bandelier is conservatively estimated at 2.5 cm per decade; an unsustainable rate given shallow soils with average depths of 1.0 to 12.0 cm (Davenport 1997; Davenport et al. 1996; Wilcox and Breshears 1995).

Without prompt management action to stabilize soils, we predict wholesale loss of soils and cultural resources within the next 100 years. Approximately 8,000 acres of woodland at Bandelier are in critical condition, relative to soil loss and threats to cultural resources, and could benefit from proposed management restoration actions.

Beginning in 1990, Bandelier began to document baseline conditions within

woodland communities in an attempt to quantify the erosion issue. At the same time, an evaluation of locally native plant materials with potential for use in soil stabilization efforts was initiated in cooperation with the Soil Conservation Service. A two-year revegetation study, designed to evaluate techniques for establishment of grass from seed in degraded woodland areas, was started in 1992 (Chong 1993; 1994). In 1993, instruments were installed in a 1-ha experimental watershed, yielding high-resolution measurements of precipitation, runoff, and sediment transport that could be used to model the hydrologic dynamics of degraded woodland systems (Wilcox, Newman, et al. 1996; Wilcox, Pidick et al. 1996). In 1994, development and testing of restoration methodologies that altered woodland structure were begun, with evaluations of overstory thinning, slash mulching, and supplemental seeding techniques (Jacobs and Gatewood 1998; Loftin 1998). By 1996, the measured herbaceous response to structural restoration treatment was encouraging enough to prompt evaluation of the overstory thinning and slash mulching method at a functional 100-acre watershed scale. Results from these large-scale studies, at two years post-treatment, continue to validate the herbaceous response of small-scale tests across greater a heterogeneity of pre-treatment conditions. By 1998, confident a feasible restoration approach had been identified and anxious to stem additional losses of soil and cultural materials, the park obtained agency funding to begin implementation of restoration efforts covering thousands of acres. Subsequently, heightened concerns about the potential impacts of large-scale restoration on wilderness values prompted National Park Service management to postpone the project until a wilderness plan and associated EIS could be completed. Preparation of a wilderness plan and EIS which clearly articulates the role of research and management, and defines an acceptable balance between wilderness values and ecosystem processes, is in progress.

References

- Breshears, D. D., O. B. Myers, S. R. Johnson, C. W. Meyer, and S. N. Martens. 1997. Differential use of spatially heterogeneous soil moisture by two semiarid woody species: *Pinus edulis* and *Juniperus monosperma*. *Journal of Ecology* 85, 289-299.
- Chong, G. W. 1993. Revegetation of pinyon-juniper woodlands with native grasses. In *Managing Pinon-Juniper Ecosystems for Sustainability and Social Needs*. E. F. Aldon and D. W. Shaw, eds. General Technical Report RM-236. N.p.: USDA Forest Service.
- . 1994. Recommendations to improve revegetation success in a pinyon-juniper woodland in New Mexico: a hierarchical approach. M.S. thesis, University of New Mexico, Albuquerque.
- Davenport, D. W. 1997. Soil survey of three watersheds on South Mesa. Unpublished report, Bandelier National Monument, Los Alamos, N.M.
- Davenport, D. W., B. P. Wilcox, and D. D. Breshears. 1996. Soil morphology of canopy and intercanopy sites in a piñon-juniper woodland. *Soil Science Society Journal* 60, 1881-1887.
- Gottfried, G. J., T. J. Swetnam, C. D. Allen, J. L. Betancourt, and A. L. Chung-MacCoubrey. 1995. Pinyon-juniper woodlands. In *Ecology, Diversity and Sustainability of the Middle Rio Grande Basin*. D. M. Finch and J. A. Tainter, eds. General Technical Report RM-268. N.p.: USDA Forest Service.
- Jacobs, B. F., and R. G. Gatewood. 1998. Restoration studies in degraded piñon-juniper woodlands of north-central New Mexico. In *Proceedings: Ecology and Management of Pinyon-Juniper Communities within the Interior West*. (15-18 September 1997, Provo, Utah.) S. B. Monsen, R. Stevens, R. J. Tausch, R. Miller, and S. Goodrich, eds. General Technical Report INT-000. Ogden, Utah: USDA Forest Service, Intermountain Research Station.
- Loftin, S. R. 1998. Initial response of soil and understory vegetation to a simulated fuelwood cut of a pinyon-juniper woodland in the Santa Fe National Forest. In

Proceedings: Ecology and Management of Pinyon-Juniper Communities within the Interior West. (15-18 September 1997, Provo, Utah.) S. B. Monsen, R. Stevens, R. J. Tausch, R. Miller, and S. Goodrich, eds. General Technical Report INT-000. Ogden, Utah: USDA Forest Service, Intermountain Research Station.

- Wilcox, B. P., and D. D. Breshears. 1995. Hydrology and ecology of pinyon-juniper woodlands: conceptual framework and field studies. In *Desired Future Conditions for Piñon-Juniper Ecosystems*. (8-12 August 1994, Flagstaff, Arizona.) General Technical Report RM-258. Ft. Collins, Colo.: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Wilcox, B. P., B. D. Newman, C. D. Allen, K. D. Reid, D. Brandes, J. Pidick, and D. W. Davenport. 1996. Runoff and erosion on the Pajarito Plateau: Observations from the field. New Mexico Geological Society Guidebook, 47th Field Conference, Jemez Mountain Region, Los Alamos, N.M.
- Wilcox, B. P., J. Pidick, J., C. D. Allen, and D. W. Davenport. 1996. Runoff and erosion from a rapidly eroding pinyon-juniper hillslope. In *Advances in Hillslope Processes*, Vol. 1. M. G. Anderson and S. M. Brooks, eds. New York: John Wiley & Sons.