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Restoring High-Elevation Mine Spoils

A growing demand for natural resources throughout the western United States is placing pressure on public land managers to find ways to restore severely disturbed sites. Disturbances to the land often alter the integrity of natural resources resulting in either their complete loss or a degraded condition that affects their availability and quality. The relatively recent advent of large-scale high-intensity and high-frequency disturbances created by human activity often falls outside of the evolutionary capability of ecosystems to recover. Such human-caused disturbances include: road and highway construction, mining and some types of mineral exploration, pipeline and power line construction, recreational development and facilities, and town site development and expansion.

When wildland areas become severely disturbed, especially by human activities, various natural ecosystem processes are often destroyed or greatly altered, thus leading to degradation in natural resource quality and quantity. Mounting evidence shows that many severe human-caused disturbances lead to major alterations in ecosystems by greatly simplifying their structure and function. If left untreated, they often result in accelerated rates of erosion by water and wind, sediment transport, and the contamination of natural streams, rivers and riparian ecosystems.

Some disturbances are so severe that natural recovery processes have become deflected, suspended or terminated altogether. Areas often left to recover by natural processes include abandoned mines on public lands, which are particularly common in mountainous regions as well as in arid areas throughout the West. In many cases, waste rock and debris containing toxic chemicals have been exposed, resulting in residual material bearing little resemblance to natural soil. Erosion from these disturbances, especially where pyretic materials and other chemicals are exposed, results in sediment transport leading to acid, metal or other

Restoring these native wildland communities is a critical challenge for land managers who must reinitiate natural succession and other recovery processes to reverse the effects of severe disturbances and repair natural resource integrity. To accomplish this on wildland areas, natural succession is reinitiated on the disturbance to serve as the primary "driver" for developing and reestablishing natural processes required to sustain the system consistent with current climatic and other environmental conditions.

Land management practices such as revegetation and reclamation can be used as tools to reinitiate and accelerate succession, to enhance other natural

McLaren Mine Demonstration

In a new research paper, published by the Rocky Mountain Research Station, Station scientists present evidence that the practices of revegetation and reclamation can be utilized to initiate succession. Findings are based on data and experiences gathered from a high-elevation mine site in the New World Mining District of southern Montana. They note that the principles discussed are equally applicable to a broad range of sites and conditions throughout the West where severe disturbances have suspended or arrested succession. This research is the result of a long-term study extending from 1976 through 1998 conducted in a set of demonstration area plots

According to Michael Amacher, Soil Scientist with the Station's Forestry Sciences Laboratory in Logan, Utah, numerous small adits (horizontal mine entrances) and open pit mines were operated in the New World District between 1869 and the mid 1960's; the largest of these included the McLaren Mine, which operated from about 1938 to 1952. "There were no formal legal requirements for reclamation of hardrock mining operations in the 1960's, hence the abandoned mines had not been reclaimed or treated to mediate acidic or other limiting soil conditions when mining was discontinued," says Amacher.

The principle objective of the McLaren Mine demonstration was to determine the effectiveness of spoil treatments (liming, organic matter, fertilizer, and mulching) and planting techniques (seeding vs. transplanting vs. natural "seed rain") on long-term plant community development over a large and variably diverse area. An additional objective was to determine the relative effects of

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Findings

"The seeded area and adjacent reference areas were assessed during or immediately following the period of peak growth and production," said Amacher. "We analyzed biomass and live cover, number of plant species, life-form comparisons, species frequency comparisons, effects of refertilization, soil properties, soil genesis, and erosion and surface stability. On the transplant and natural seed-rain areas, located immediately upslope of the seeded area, we observed plant survival, biomass and live cover," he says.

Their research suggests that the ultimate solution to the problem of site degradation at New World, and elsewhere in the West, will not be achieved with structural or engineering manipulations of mine spoil, waterflow, or adit closures alone. Nor is revegetation alone sufficient. They conclude that returning the New World site to a natural self-sustaining, diverse and resilient condition requires a long-term commitment to a restoration program involving physical, chemical and biological intervention by managers that ameliorates limiting conditions and initiates plant establishment.

Station scientists and cooperators have identified 10 principles of ecological restoration, based

1) **Save and redistribute natural soil on disturbances, where possible, prior to revegetation and restoration.** Unfortunately, few if any older disturbances have native soil available for reapplication. However, at New World and similar sites where topsoil must be imported, scientists do not advocate the use of soil caps to cover spoil materials. Data, combined with experience, show that the raw mine spoils at New World can successfully be treated with readily available amendments at rates sufficient to ameliorate any conditions limiting establishment and growth of native seral plant species adapted to the area.

2) **Shape and contour disturbed areas to approximate the original slope and topographic conditions.** Concerns about drainage and ponding of accumulated water can be managed during this step. Attempts should be made to provide topographic diversity that mimics natural slope features of exposure and slop angle and that provide conditions for amendment application

3) **Analyze the soil/spoil properties of substrate materials near the surface.** In the New World District, the general properties of greatest concern include soil pH, availability of macronutrients such as N (nitrogen)-P (phosphorus)-K (potassium), and concentrations of toxic chemicals. The weakest link in using such data appears to be in translating the quantitative limits of these soils into needed amendments to meet plant physiological tolerances. Consultation with Rocky Mountain Research Station scientists is recommended.

4) **Apply soil amendments specifically designed to ameliorate the limiting factors identified by the soil analyses.** Apply lime to spoils with pH values lower than about 4.5 to 5.0; incorporate the lime into at least the upper 6 to 12 inches of spoils (24 inches is better). Rates of lime application will vary with local site conditions, but experiences suggest rates from 2 to 4 tons per acre on the least acidic materials, ranging up to 10 or more tons per acre on the more acidic areas. Incorporate organic matter to the same depth as lime. Use sterilized manure, straw, peat or other organic products to enhance nutrient retention and water holding capabilities, immobilize free metals, minimize compaction, and improve aeration. Apply and incorporate fertilizer to a depth of approximately 6 inches to increase the availability of the primary nutrients that may limit plant growth. Commercial fertilizers with N-P-K ratios such as 16-16-16, 21-8-8, 16-41-5 and 31-4-4 appear useful. Application rates that provide 100 lb N per acre and 200 lb P per acre are recommended during the initial fertilization. Refertilization treatments should be

5) **Observe natural succession on old disturbances in the area such as road cuts and fills, and old mine piles, and compare the abundance of different volunteer plant species to use as a guide to species selection.**

6) **Select native plant species based on the observations from old, natural succession areas.** Research strongly supports recommendations that introduced species should be avoided. No known scientific evidence exists to support the use of either exotics or "naturalized" nonnatives from habitats outside of the area. Scientists recommend the early initiation of a program to collect supplies of seed of local species for use in reclamation and restoration.

7) **Perform revegetation-restoration activities in the fall of the year.** Fall coincides with the period when native plant species mature and disperse their seeds, and ensures that seed will be in place during the winter to coincide with potential dormancy requirements. In addition, seeds will be in place during spring snowmelt when conditions are ideal for germination and seedling emergence

8) **Apply seed by broadcasting rather than by drilling or other mechanical means.** Native seeds are highly variable in size, shape, mass and surface characteristics, and are therefore not well suited to mechanical devises developed for more uniform agricultural crop plants. Seed should be lightly raked to cover them with soil, and the soil packed firmly. Application of seed by hydromulching and hydroseeding is not recommended in high elevation environments. Mixtures of at least several different species are generally more successful than a single species alone.

9) **Apply surface mulch, such as erosion blankets, following seeding and planting.** This material protects and stabilizes the surface, and promotes restoration. Light to moderate application rates are better than heavier applications.

10) **Assess the site yearly for several years to determine relative success or failure and reapply amendments or seed in places when necessary.** Refertilization will almost certainly be required to further accelerate successional development of restored areas and to enhance survival and establishment of invading outside species. Periodic soil sampling and analyses are recommended to assess nutrient deficiencies, requirements for additional liming, and other amendments. In addition, domestic livestock should be excluded from these areas, at least until the vegetation

This 25-year demonstration study at the New World site shows what land managers can do to "reset" the successional clock that was terminated, deflected, or suspended when highly mineralized alpine areas are disturbed by mining or other human influences. You can learn more about this study, research results and management suggestions in *Reestablishing Natural Succession on Acidic Mine Spoils at High Elevation: Long-Term Ecological Restoration*, Research Paper RMRS-RP-41, available from the Rocky Mountain Research Station. This publication is also available on-line at http://www.fs.fed.us/rm/pubs/rmrs_rp041.html.

Publication Reviews

Reestablishing Natural Succession on Acidic Mine Spoils at High Elevations

Methods for restoring native plant communities on acidic mine spoils at high elevations were evaluated in a "demonstration area" in the New World Mining District of southern Montana. Research plots installed in 1976 were assessed for 22 years and compared with adjacent native reference plant communities. A 1.5-acre area of mine spoils was shaped and treated with hydrated lime, organic matter, and fertilizer. The area was then seeded heavily with five native grasses collected from adjacent native plant communities. Natural seed rain, transplanting, refertlilization, and use of introduced species were also studied. Research Paper RMRS-RP-41 is available online at http://www.fs.fed.us/rm/pubs/rmrs_rp041.html.

Economic, Social and Cultural Aspects of Livestock Ranching on the Espanola and Canjilon Ranger Districts of the Santa Fe and Carson National Forests: A Pilot Study

(RMRS-GTR-113)

The ranches of northern New Mexico, composed of land and livestock, are integral components of family and community life. This pilot study examines current economic, social, and cultural aspects of livestock operations owned by ranchers with federal grazing permits (permittees) on the Canjilon and Espanola Ranger Districts of the Santa Fe and Carson National Forests. The research develops preliminary results and tests survey methods that will be used in a planned larger study. Information gathered is intended to help agency managers administer forest lands with increased effectiveness by promoting greater cultural understanding. General Technical Report RMRS-GTR-113 is available online at http://www.fs.fed.us/rm/pubs/rmrs_gtr113.html.

RMRScience is a quarterly report from the USDA Forest Service's Rocky Mountain Research Station. Each issue highlights on-going or recently completed research, and features findings useful to land managers and other natural resource specialists. To be added to the mailing list, free-of-charge, write *RMRScience*, Rocky Mountain Research Station, 2150 Centre Ave., Bldg. A, Fort Collins, CO 80526; or e-mail rfletcher@fs.fed.us; or fax (970) 295-5927. Comments and suggestions are always welcome.

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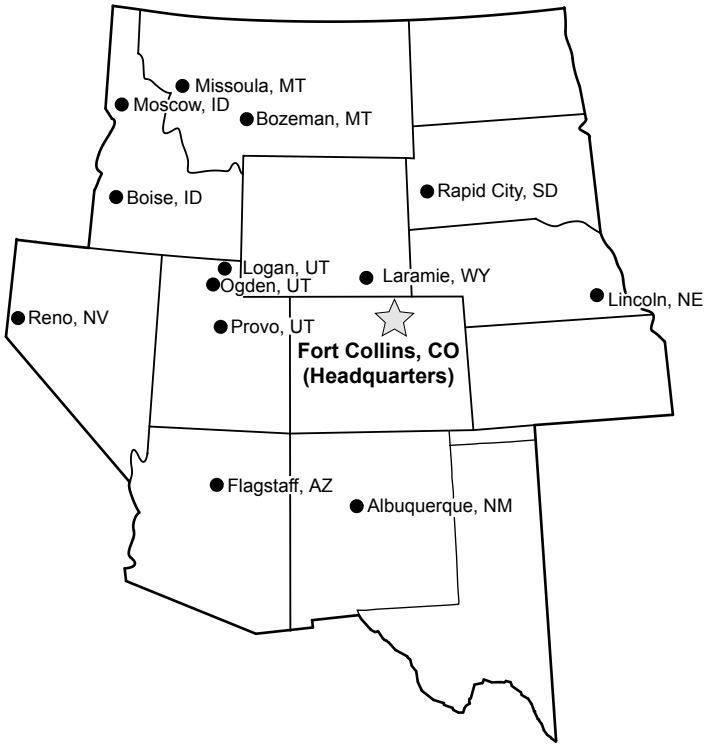

The USDA Forest Service's Rocky Mountain Research Station is one of seven units nationwide that make up the most extensive natural resource research organization in the world. Headquartered at the foot of the Rockies in Fort Collins, CO, the Station maintains 14 field laboratories within a 14 state territory (see map). Scientists conduct studies nationwide, with emphasis on the Rocky Mountains, Great Basin, Great Plains, and Southwest. Research serves the Forest Service, as well as other federal agencies, international organizations, private groups, and individuals. For more information, visit our website at http://

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