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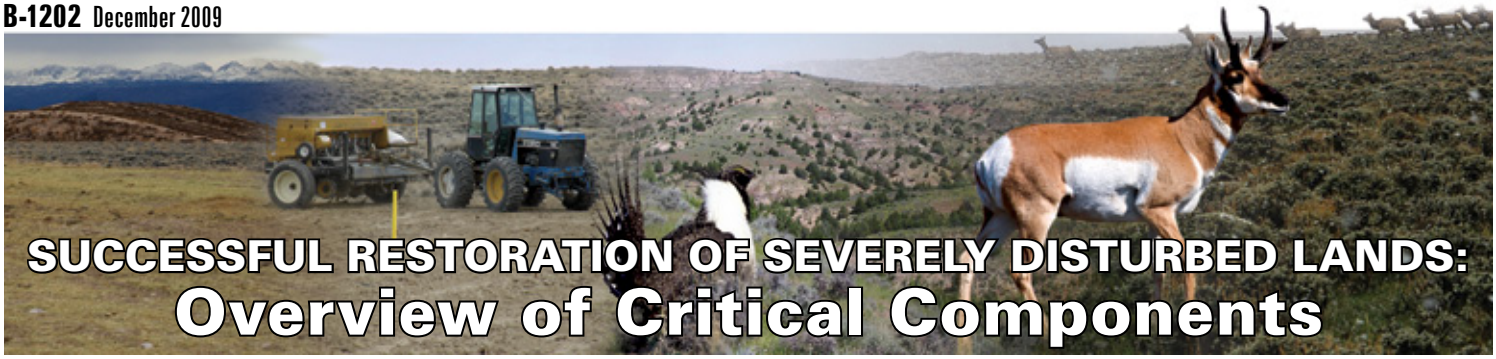

SUCCESSFUL RESTORATION OF SEVERELY DISTURBED LANDS: Overview of Critical Components

This bulletin provides general information appropriate for all Wyoming ecological sites.

First in a series by the University of Wyoming Cooperative Extension Service Reclamation Issue Team and the Wyoming Reclamation and Restoration Center that describes specific strategies for restoring ecological functions to disturbed Wyoming lands.

For this series, reclamation means restoration of components that support desired ecological functions, such as livestock grazing, wildlife forage and cover, water quality protection, and aesthetic values.

Introduction

This bulletin describes activities at the core of successful reclamation of Wyoming lands following severe disturbances, such as topsoil removal and replacement during energy development, mining activities, pipeline and road construction, residential development, and other activities. Our goal is to introduce the critical components of successful reclamation and to provide sources for more information. Future bulletins in this series will cover each of these components (I-VII) in more detail.

I. Determine reclamation objectives

The goal for any reclamation project is to restore important pre-disturbance ecological functions of a site disturbed by construction or mining operations. Important functions include wildlife habitat, forage for livestock and wildlife, watershed and water quality protection, and others. A thorough pre-disturbance inventory provides the basis for describing important functions and setting reclamation objectives.

Summary of components of successful reclamation. See text for more information.

Activity	Critical Components
I. Determine objectives	• Describe pre-disturbance functions that must be restored following disturbance.
II. Predisturbance/ baseline inventory	• Note all geomorphic features, roads, and structures by taking pre-disturbance photos of the land to be disturbed; • Analyze and tabulate the vegetation by, at a minimum, visual estimation of percent cover and species composition including dominant species; • Investigate the depth and quality of suitable soil for plant growth.
III. Salvage and separate suitable soil	• Salvage and separate all available and suitable soil (darker material) from underlying, less productive material (lighter material mixed with rocks or higher concentration of calcium carbonates); • Do not mix suitable soil with underlying material; store them separately.
IV. Backfill, grade, compact, and contour disturbed area	• Backfill, grade, compact, and contour all disturbed area to the pre-disturbance functionality; • Slopes of the disturbed areas should be reduced to at least three horizontal to one vertical unit (33-percent slope) to prevent erosion and increase stability.
V. Reapply soil and prepare seedbed	• Apply all salvaged soil to an average and uniform depth, unless there are significant variable geomorphic features, then apply variable soil according to the pre-disturbance inventory; • Prepare a firm, clod-free seedbed.
VI. Plant appropriate native/required species	• Plant a mixture of native/required species in the fall after October 15 but before the ground freezes, or in the spring before April 15; • Drill seeding at rate that applies at least 20 pure live seeds per square foot is preferred, with double that for steep slopes (see Wyoming Reclamation and Restoration Center Web site http://uwyo.edu/WRRC/ under "Reclamation Information" for seeding worksheet); • Broadcasting at double the drill rate is acceptable; • Mulching with weed-free straw should be considered. Crimping, or "punching" the straw into the soil surface with hand implements or a straight disk resulting in vertical stems, will also help to stabilize it and maintain moisture.
VII. Monitor for restored functionality	• Monitor often for weeds and erosion until native species become well established. Control erosion and weeds with best available technology.

II. Pre-disturbance/baseline inventory

A pre-disturbance or baseline inventory provides information on ecological values and functions of a site, such as wildlife habitat, forage production, water quality protection, aesthetics, or others, as well as the characteristics that underlie those values and functions – the plant, soil, and landscape features that need to be maintained or restored for successful reclamation. Photographs of the site are a valuable part of baseline inventory. The inventory should establish a framework for post-reclamation monitoring and evaluation. The baseline inventory includes two steps: 1) gathering existing site-specific information and 2) on-site evaluation of ecosystem functions that need to be maintained or restored.

Important components for which both existing and on-site information need to be gathered include (see the Wyoming Reclamation and Restoration System Web site http://uwyo.edu/wrrc under "Reclamation Information" or the resources at the end of this bulletin for additional information):

1. Topsoil depth based on texture, pH, salinity, and other properties that affect suitability for plant growth. The topsoil stripping depth should be marked in the field with labeled stakes indicating the required depth;
2. Properties of subsoil and underlying materials that affect drainage and water-holding capacity;
3. Vegetation types (including threatened or endangered plant species) and their cover, productivity, species diversity, and species composition;
4. Topography, landforms, and surface water hydrology as they affect post-disturbance functions to be restored;
5. Wildlife habitat and use, including threatened or endangered species, as indicated by site features and signs of use like fecal pellets, ungulate tracks, small mammal burrows, and bird nests. Consult Wyoming Game and Fish Department and federal land management agencies to identify species and critical habitats within a given area. Also, pre-project clearances must be made with these agencies prior to disturbance activities;
6. Archaeological and historical resources: The Wyoming State Historical Preservation Office.

III. Salvage and separate suitable soil

Stripping: Topsoil stripping should carefully follow the pre-disturbance plan, and operators should avoid stripping too deeply, which mixes topsoil with subsoil or underlying material and reduces the reclamation potential of the topsoil. Stripping depth should vary with the depth of the soil across a site because the thickness of the topsoil typically varies, especially on sites with sloping or undulating topography. This requires a skilled equipment operator trained to visually recognize when the correct depth is being stripped. The topsoil stripping depth should be marked with labeled stakes indicating the depth. Operators should keep in mind that lower slopes and swales usually have deeper soils while upper slopes, knolls, and ridge tops have shallower soils. Eroded sites may have no topsoil at all.

Stockpiling: Topsoil is a living entity where rapid cycling of plant material through microbial decomposition provides nutrients for plants and organic materials that improve soil quality. But sustained soil quality and plant growth depends on annual inputs of plant residues that do not occur in stockpiles. Decomposition continues – or even accelerates because of mixing and exposure of microbes to air – but plant inputs cease. If topsoils will be stockpiled for more than a month, stockpiles should be shallow and ridged to maximize surface area and planted to fast-growing sterile annual grains or early-succession natives like bee plant or slender wheatgrass to compete with weeds, prevent erosion, and contribute organic materials. Topsoil, subsoil, and underlying materials should be stored in separate piles and clearly labeled. They should be stockpiled on stable areas protected from wind and water erosion and from unnecessary compaction. Stockpiles should be seeded and protected from erosion by building berms or ditches around them as soon as possible.

IV. Backfill, grade, compact, and contour disturbed areas

Backfilling subsoils and underlying materials and grading to the original topography, along with reestablishing drainage properties, set the stage for successful reclamation. Where subsoils and underlying materials have been stripped in hillslope cuts, the original hydraulic conductivity should be recovered by careful compaction or ripping. Keeping slopes less than 3:1, or 33-percent gradient, minimizes erosion after reclamation. The original topography of the site should be recovered to a surface configuration consistent with post-disturbance land use and that blends with adjacent topography. Surface drainage patterns should be rebuilt to reestablish essential hydrologic functions. On sites with very deep disturbances, such as surface mines, hydrologic restoration should include aquifer reconstruction/restoration.

Segregated topsoil (left) and underlying materials (right) near natural gas drilling pads on the Jonah Field.

V. Reapply soil and prepare seedbed

Spreading and amending topsoil: Before topsoil is respread on the graded surface, sites should be cultivated to reduce compaction of the subsoil/underlying material to appropriate rooting depth (at least 8 to 12 inches deep). Cultivating soils allows for greater water infiltration as well as greater aeration of the soil.

Topsoil has been respread, packed, and seeded on a natural gas drilling pad near Wamsutter.

The most common primary tillage practices prior to spreading topsoil are deep ripping, deep chisel plowing, deep disking, and scarifying on the contour to control erosion.

After cultivating the graded area, topsoil should be respread consistent with the original depths. Topsoil should be scarified, disked, or harrowed on the contour to control erosion and prepare a proper seedbed prior to seeding. Respread topsoil should be inspected for potential hydrological issues, such as ponding or gullying.

Stockpiled topsoil may lose significant amounts of nutrients. Retesting stockpiled soils at the time of spreading and comparing to levels from the baseline inventory indicates types and quantities of amendments, like organic materials or fertilizers, that may be beneficial. The goal of amending the soil is not to change the potential productivity of the site but to restore it to predisturbance levels. If results of predisturbance soil analyses are not available, test soils after spreading and use the typical productivity from the ecological site description, or estimated from clipping some plots on the site, as the yield goal. This prevents over-fertilization, which promotes robust growth of weeds.

VI. Plant appropriate native/required species

Seedbed preparation for optimal seed-soil contact requires firming the respread topsoil prior to planting with a roller or cultipacker enough so an adult footprint makes an impression about one-half inch deep. Seeding technique and equipment depends on seed size, which determines the proper depth of seeding and the seeding rate for each. Most grasses and some forbs have relatively large seeds, meaning higher seeding rates (relatively few seeds per pound) and deeper depths, while many shrubs and forbs have very small seeds. Bluebunch wheatgrass, for instance, has about 126,000 seeds per pound and should be planted one-quarter to one-half inch deep, while Wyoming big sagebrush has about 2,500,000 seeds per pound and should be planted less than one-eighth inch deep. When seeding grasses with a seed drill, 20 seeds per square foot is a sufficient rate; however, when the mix contains grasses, shrubs, and forbs, a better rate is 50-100 seeds per square foot (usually 10-16 pounds per acre). But large-seeded species are typically planted with a grass-seed drill while small-seeded species should be planted with a broadcast seeder. The Natural Resources Conservation Service (NRCS) recommends higher rates for broadcast seedings. Ideally, one mix should be designed for drilling and another for broadcasting.

The ecological site descriptions, together with the seeding worksheet developed for Wyoming by the NRCS, are excellent tools for planning site-specific seed mixes (find links to these tools on the WRRC Web site under Reclamation Information).

Seeding time is crucial and, for Wyoming, reclamation seed mixes should be seeded in the fall after October 15 but before ground freezes or in the spring prior to April 15. Seeding in July and August should be avoided.

VII. Monitor for restored functionality

Developing and following a long-term monitoring plan is crucial so problems can be identified and controlled early, before they threaten the success of the reclamation project. Close attention should be paid to seeding success, noxious weeds, and erosion. Planted seedlings should start to show in the first season, but a proliferation of annual weeds is not unusual. By the second season, seeded plants should occur throughout the site but may be small compared to annual weeds and require a close look to find and identify them. A step-toe transect is a good, quick way to look for seedlings across a site: simply walk in a line across the seeded area and look at the square foot in front of your toes on each step. Record the number of seedlings seen. It's best to repeat step-toe transects through each part of a seeded area. In Wyoming, it often takes three years to establish a seeded plant community.

While annual broadleaf weeds like Russian thistle, lambsquarters, mustards, and others are not unusual in new seedings and usually disappear as seeded species take over, noxious weeds (by law) must be controlled by pulling or spraying before they spread or produce seed.

While monitoring vegetation, any instability or erosion issues should be noted. Uncontrolled erosion can rapidly degrade a reclaimed site and pollute land and water down slope. Carefully look for gully erosion and for sediment deposition, especially after rainstorms. If substantial erosion is noted and appears to be getting worse, control measures that slow and divert runoff flow must be implemented. These include installation of erosion control best management practices and sediment runoff control measures (e.g., rock check dams, wattles, silt fences, straw bales, trenches, etc.).

Seeded fourwing saltbush at a reclaimed site on the Pinedale Anticline.

More information

Wyoming topographic maps: Wyoming State Geological Survey at (307) 766-2286 or http://www.wsgs.uwyo.edu/.

Wyoming soil maps and information: Wyoming Soil Survey Office at (307) 233-6774 or http://websoilsurvey.nrcs.usda.gov/app.

Wyoming ecological sites and seeding information: NRCS state range specialist at (307) 233-6766 or http://esis.sc.egov.usda.gov.

Existing baseline inventory information from state-permitted sites: Wyoming Land Quality Division at (307) 777-7756 or http://deq.state.wy.us/lqd/.

Archaeological and historical information: Wyoming State Historic Preservation Office at (307) 777-7697 or http://wyoshpo.state.wy.us.

Critical wildlife habitat and migration corridors: Wyoming Game and Fish Department at (307) 772-2374 or http://gf.state.wy.us.

Noxious weeds: Wyoming Weed and Pest Council at (307) 777-6585 or http://www.wyoweed.org; http://ces.uwyo.edu/wyoweed/wyoweed.htm; http://plants.usda.gov/java/noxious?rptType=State&statefips=56.

Further Reading

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Authors

Jay Norton, Soil Fertility Specialist, University of Wyoming
Ania Krzyszowska-Waitkus, Consulting Soil Scientist
Todd Loubsky, Former Research Associate, Wyoming Reclamation and Restoration Center

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