REVEGETATION LESSONS FROM A RIPARIAN SUPERFUND SITE IN SOUTHWEST MONTANA[1]

Richard A. Prodgers[2]

Abstract: Remediating 34.8 km (21.6 miles) of Silver Bow Creek and associated floodplain in southwest Montana entails removing 3.2 x 10^6 m^3 (4.2 x 10^6 yd^3) of tailings/mine waste, reconstructing the stream so that it effectively transports sediment, rebuilding the floodplain using an effective growth medium, and revegetating it. Approximately half of the 610-ha (1,510-acre) project has been remediated as of June 2006. Revegetation objectives include protecting other elements of the remedy and returning remediated areas to a permanent, productive condition; protecting the streambank and adjacent floodplain from accelerated erosion; and promoting soil genesis to sustain vegetation. Revegetation must be self-sustaining and self-repairing, although weed control measures are necessary. Restoration further creates an approximation of preimpact vegetation and soils while creating wildlife habitat for a variety of animals and providing aesthetically pleasing landscape components. Specific challenges are:

- Finding suitable fill to replace removed tailings.
- Capillary rise of coversoil salts, including formation of surface crusts.
- Very coarse, in situ soils of upland hydrology.
- Residual contamination.
- Controlling noxious weeds.
- A sequence of six years with annual precipitation between 25 and 29 cm (10.0 and 11.4 inches) in an area where average annual precipitation is 32 cm (12.6 inches).
- One early spring snowmelt flood.
- Using contract revegetation services.

Solutions and partial solutions include innovative seeding and transplanting techniques, compost soil amendments, adapted species, and aggressively interseeding areas where initial seedling density is unsatisfactory. Seeding has fared better and been more cost-effective than transplanting. Simultaneously implementing remediation and restoration practices has been relatively easy.

Additional Key Words: remediation, restoration, suitable plant species, seeding, transplanting, saline soils, residual contamination, revegetation success criteria, weed control.

---

[1] Paper was presented at the 2006 Billings Land Reclamation Symposium, June 4-8, 2006, Billings MT and jointly published by BLRS and ASMR, R.I. Barnhisel (ed.) 3134 Montavesta Rd., Lexington, KY 40502.

[2] Richard A. Prodgers, Plant Ecologist, Bighorn Environmental Sciences, 610 Monroe Ave., Dillon, MT 59725 (406) 683-6529. bighornenv@msn.com

Proceedings America Society of Mining and Reclamation, 2006 pp 838-848
DOI: 10.21000/JASMR06010838

http://dx.doi.org/10.21000/JASMR06010838

Background

The Silver Bow Creek Superfund site, officially named the Streamside Tailings Operable Unit (SSTOU) of the Silver Bow Creek/Butte Area National Priority Listing Site, is a mostly riparian strip between lower Butte and the upper Warm Springs Pond, Montana. The SSTOU comprises the geographic area of contamination along and in Silver Bow Creek in this 35-km (22 mile) stretch. The SSTOU includes mine, milling, and smelting waste in Silver Bow Creek; fluvially deposited mining, milling and smelting wastes along the banks of Silver Bow Creek and throughout the floodplain; the adjacent railroad beds; and all areas in close proximity that are necessary to the implementation of the remedy, including borrow areas.

The principal contaminants of concern (COC) in the SSTOU are arsenic, cadmium, copper, lead, zinc, and mercury associated with mine tailings that were fluvially deposited along Silver Bow Creek and contaminated soils that are intermixed with or underlie those tailings. Surface water and alluvial aquifer groundwater also have been contaminated with or from mining wastes.

Remediation is being conducted by the Mine Waste Cleanup Bureau of the Montana Department of Environmental Quality. Remedial construction typically includes:

- Following sampling, most tailings/impacted soils and in-stream sediments are excavated and removed from designated portions of Silver Bow Creek and its floodplain. However, some contaminants remain. Acceptable or actual residual contaminants are specified in final design or final construction reports.
- Dewatering may be required.
- The stream channel and streambanks are reconstructed using sized rock and clean fill from designated borrow areas. An approximately two-meter width of the streambanks is seeded by the RA Contractor, and fabric is installed to contain and support the banks.
- To the extent practical, weeds are controlled in borrow areas, the floodplain, and along travel routes. The intent is to prevent introducing weed seed into clean substrates.
- After construction, surface substrates are either relatively clean in situ material or clean borrow material that has been transported to the site. Substrate characteristics vary by reach and even within reaches.
- The floodplain is brought to final grade according to the grading plan and left with a rough surface.
- Compost is applied to provide two to four percent dry organic matter (varies by reach) in the upper four inches of coversoil. Incorporation depth is typically four to six inches.
- Sediment basins are constructed to trap runoff from mine-waste embankments outside of the Operable Unit.
- Seeding is done at the first suitable opportunity, transplanting in mid-May. Remedial and restorative revegetation are executed seamlessly.
- The reconstructed floodplain accommodates construction of the Greenway trail base. Initially, the trail base was constructed prior to revegetation. Now it is done later to prevent weed infestations during construction delays measured in years.

Revegetation Planning

Revegetation planning is predicated foremost on matching plants to habitats. The primary habitat factor is hydrology; secondary is coversoil characteristics. The floodplain is a mosaic of hydrologic and edaphic zones. Relations among plant species are other important factors in revegetation planning.

Reclamation and revegetation are usually done by "reach," each typically about 1.2 linear miles of floodplain. Each reach has most or all of these hydrologic zones: streambanks, wetlands corresponding to the jurisdictional wetland definition, transition zone, subirrigated zone, and uplands. Often two soil/coversoil types are recognized based on texture, e.g., one for fill material and another for in situ material if the two differ significantly.

From prior experience, anticipated changes in coversoil properties may be considered during planning. For example, moderately saline coversoil (electrical conductivity 2.1 to 4 dS/m from saturated paste) may develop a strongly or very strongly saline surface zone (8 to >16 dS/m) through capillary rise and evaporation at the surface. Halophytes would be included in the seed mix.

Based upon the length of streambanks and area of suitable hydrology, woody transplants and wetland plugs are ordered more than one year ahead of planting to allow for growing and hardening. The bulk of transplants and compost is paid for with restoration funds provided by the Natural Resource Damage Program, Montana Department of Justice, whereas most seeding is funded by remediation.

Finding Suitable Fill for Coversoils

Usable areas of suitable borrow are limited. Fill used as coversoil must meet these criteria:

- Suitable physical and chemical properties.
- Reasonable proximity and access. Constructed haul roads must be used because hauling over public roads is dangerous and illegal.
- The landowner must be willing to sell at a reasonable price. Fill in place usually costs less than one dollar per bank cubic meter (currently about $.70/bank cubic yard).

Borrow typically comes from deposits of unweathered tertiary valley-fill. From a revegetation standpoint, the chief limitation is salinity. One borrow area was prematurely closed due to higher-than-anticipated salinity. Root-zone material is screened to prevent the use of borrow that is more than moderately saline (< four dS/m), but variations within the material combined with sampling limitations result in zones of more saline material within the root zone. More saline deeper fill also can influence root-zone salinity through capillary rise.

Unsaturated flow is the movement of water from moist to dry soil by capillary action in any direction, but upward movement is the revegetation concern. The adhesive and cohesive properties of water are responsible for capillarity. Adhesion is the attraction of water to soil particles, while cohesion is the attraction of water molecules to other water molecules. Capillary rise stops when gravity equals the combined force of adhesion and cohesion. For sustained capillary flow, a constant water supply must be present to keep water films thick. Without this source of water, water films thin out and become discontinuous, which causes unsaturated flow to slow dramatically while restricting it to very short distances, e.g., a few centimeters per day.

Capillary rise brings soluble salts to the surface even if the fill is very slightly saline (<2 dS/m). Of 23 near-surface coversoil samples with impaired revegetation, 18 (78%) would be expected to have impaired vegetation due to salinity, sodicity, or both. In extreme cases where a salt crust was present, conductivity in the upper five centimeters exceeded 20 dS/m and the sodium adsorption ratio exceeded 50. From an experiment using material from one of the SSTOU borrow areas, we learned that a light sandy loam (just 6% clay) with about 35% pea gravel can wick water up at least 1.3 meters if continuously saturated at the base. Where capillary rise reaches the surface for an appreciable time, transplant mortality has been high and species composition from seed limited to salt-adapted species.

Most Successful Plant Species

A variety of native and introduced species is used. The main introduced species are legumes. It is important to remember that biologically inert borrow amended with compost is not real soil, and nitrogen-fixation is important to supply nitrogen in the short term because mineral N from fertilization and compost is quickly immobilized by establishing plants. However, legumes cannot establish successfully in saline or acidic/metaliferous coversoils. All legume seed is purchased pre-inoculated. Native species are more prevalent than introduced ones in revegetation, although legumes can be more abundant locally.

A list of scientific and common names of plants concludes this paper.

Streambanks. If seeded effectively, streambank revegetation is relatively easy because banks are seeded before being wrapped with coir fabric and because Silver Bow Creek carries a heavy load of nitrogen and phosphorus, particularly near Butte. In the upper reaches, high banks and resulting subirrigated hydrology limited establishment of many typical wetland and streambank species. Banks are now constructed in two tiers, the lower of wetland or transition-zone hydrology and the upper subirrigated. The most successful streambank herbs have been tufted hairgrass, alkaligrass, Canada milkvetch, slender wheatgrass, red clover, tarragon, red fescue, mountain golden banner, and at the water's edge seep monkeyflower and American mannagrass. Greasewood, silver sagebrush, and golden currant are good shrub choices. Among transplants, narrowleaf and Booth willow and golden currant are suitable shrubs. Near the water's edge, panicled bulrush and Nebraska sedge are top herbaceous choices, with Baltic rush, silverweed cinquefoil, and Rocky Mountain Iris on higher banks of subirrigated or wetter hydrology.

Wetlands. Alkaligrass becomes prevalent where the ground surface is saline. Other prime candidates from seed are tufted hairgrass, birdfoot deervetch, and seaside arrowgrass when available. On the wettest sites, panicled bulrush and American mannagrass, while expensive, can be worth seeding. The best wetland plugs have been panicled bulrush, water sedge, Northwest Territory sedge, water smartweed, and silverweed cinquefoil. In seasonally saturated soils, Booth, Geyer, and narrowleaf willow can work. Salinity can limit willow survival. In seasonally inundated sites, diamondleaf willow is being tried; it reputedly tolerates conditions that might drown other willows.

Transition Zone: This hydrologic zone lacks true wetland hydrology but is often moist but not saturated to the surface. Again, alkaligrass is most successful in saline coversoils, and slender wheatgrass works if not strongly saline. Otherwise, good choices are tufted hairgrass, basin wildrye, Canada wildrye, common yarrow, white sagebrush, alkali sacaton, Canada bluegrass, medium red clover, and birdsfoot trefoil. Golden banner is a suitable native legume. Alfalfa and western wheatgrass can work very well in the drier portion. Rocky Mountain bee plant helps to suppress Mexican-fireweed; although fireweed does not persist more than a few years, it can impair perennial plant establishment. Good shrub choices from seed are greasewood, golden currant, and silver buffaloberry. Baltic rush is the top choice in wetland plugs, but Nebraska sedge and silverweed cinquefoil work in the moister areas. Narrowleaf and Booth willow survival is a little better than Geyer willow, but we plant all three. Narrowleaf willow is better adapted to saline soils than the others. Golden currant is an excellent transplant choice with survival that may exceed that of willows. Shrubby cinquefoil works in coversoils moderately saline at most. Quaking aspen usually survives a little better than black cottonwood and boxelder, but tree survival is usually 50% or less and growth can be slow. Tree mortality is higher in saline coversoils.

Sometimes a salt crust is assured, e.g., one formed before compost application and seedbed preparation. The best species to broadcast seed are alkaligrass and secondarily alkali sacaton and Canada bluegrass, but alkaligrass will dominate strongly. If conditions are favorable for planting heavy-seeded species, inland saltgrass, tall wheatgrass, slender wheatgrass, and greasewood can be seeded into the soil in contrast to broadcasting the lighter seed on the surface.

<u>Subirrigated Zone:</u> Most coversoils in this zone are not moist to the surface from capillary rise, so salinity is a lesser issue, and drought-adapted upland species survive dry periods best. However, plants surviving until their roots tap the capillary fringe can have at least a seasonal soil moisture supplement. Coversoil texture is more influential in the subirrigated and upland zones than in wetter ones. A broad array of species can work well. Good grass choices are Canada wildrye, thickspike wheatgrass, basin wildrye, streambank wheatgrass, big bluegrass, alkali sacaton, sheep fescue, and Canada bluegrass. Western and Tanseyleaf aster have done very well, but common yarrow, common gaillardia, and white sagebrush can perform satisfactorily too. The annual Rocky Mountain bee plant can suppress fireweed but does not seem to harm perennials; it is virtually absent the second year. The single best shrub to date has been rubber rabbitbrush and the best subshrub white sagebrush, but mountain big sagebrush can establish very well, although growth among grasses is slow and mortality is high with stiff competition. Fourwing saltbush sometimes makes a contribution, although not to the extent of those shrubs previously mentioned. We usually do not transplant into the subirrigated zone because shrubs can be established more economically from seed, but narrowleaf and Bebb willow can prosper at the transition-zone boundary.

<u>Uplands:</u> In coarse soils, the nod goes to Indian ricegrass, needle-and-thread, and thickspike wheatgrass. Yellow-flowered alfalfa should be seeded but droughty soils may limit establishment/survival in dry years. Rubber rabbitbrush is the best choice for a shrub, and somewhat surprisingly, white sagebrush is a suitable forb/subshrub. Very coarse substrates are better suited to shrubs and subshrubs than grasses. Grasses alone will not provide the plant abundance desired of effective revegetation.

On soils of at least sandy loam texture with about 10% or more clay, the best grasses are thickspike wheatgrass, western wheatgrass, green needlegrass, prairie Junegrass, streambank wheatgrass, and sheep fescue. Rubber rabbitbrush, mountain big sagebrush, and fourwing saltbush are prime shrub candidates, and white sagebrush establishes well. A rhizomatous variety of alfalfa or yellow-flowered alfalfa is always part of the mix.

Where diversity is not a goal and introduced species with weed-excluding characteristics are desirable, Russian wildrye and a lesser amount of a rhizomatous alfalfa or yellow-flowered alfalfa make an effective, inexpensive seed mix for uplands or the subirrigated zone.

Revegetation Practices

Flexibility is a must. Using contract seeders and planters is a special challenge due to their unfamiliarity with sites and project objectives and sometimes an aversion to using new techniques or a focus on finishing quickly. Even when instructions seem unambiguous, oversight requirements can exceed expectations. The goal is to work together to achieve good revegetation, whatever that entails, using the available equipment.

Seedbed conditions and seed characteristics should dictate seeding method using the equipment available. Wherever conditions allow, two-phase seeding is practiced to place seed on the soil surface or at optimal depth. First, the heavy seed (<300,000 seeds/pound) is drilled or broadcast and harrowed, depending upon seedbed conditions. Light seed (>300,000 seeds/pound) is then broadcast on the surface. Broadcasting may be done with a cyclonic broadcast seeder or a drill seeder with the drill removed so that seed falls from unconnected drop tubes. This works better in windy conditions than cyclonic seeding. Fertilizer is often used as a carrier with light seed that does not flow well.

Along with spring precipitation, the condition of the seedbed is a prime determinant of revegetation success. Revegetation on a large scale was initiated in 2001. From 1999-2004, average annual precipitation was 10.6 inches, 15% below normal; it was below average in each of those years. Excessively fluffy seedbeds in the subirrigated and upland zones provide a poor seedbed for drill seeding because even with depth regulators, drills often placed seed too deep. In fluffy and coarse seedbeds, we broadcast heavy seed followed by a light harrowing, then broadcast the light seed and compact the surface with a roller. This firms the seedbed to a useful degree and provides good seed/soil contact.

Another challenge is transition-zone covers that form an inhibitory saline or saline-sodic crust, especially on flat surfaces. These sites are furrowed as deeply as possible following compost application, and light and heavy seed are broadcast together. No further treatment is made. Most seed is buried in the troughs while salts accumulate mostly at the tops of the furrows. Plants establish in the bottoms. In just a few years, the furrows are unnoticeable.

Promptly interseeding initially unsatisfactory vegetation is an integral part of SSTOU revegetation. Delay just promotes weed establishment, assuming the substrate is nonlimiting. Seedling density and transplant survival surveys are conducted one year after permanent seeding. If the initial seedbed remains receptive, only light seed may be applied by broadcasting. Otherwise, a no-till drill may be used with heavy seed followed by broadcasting light seed.

The cost of transplants is high compared to seeding. Transplant survival has been dismal in most reaches. One major cause of mortality and die-back is frost. Most species are of local genetic origin to assure climatic adaptation. However, nursery-raised “hardened” plants are ill-prepared for Butte’s climate, where temperatures can fall well below zero before the formal arrival of winter. Spring transplants are better able to survive the cold than fall transplants. The other major cause of transplant mortality is saline root zones.

Along streambanks, a chief cause of transplant loss is predation. For security reasons, Canada geese prefer streambanks before the adjacent floodplain is well vegetated, and streambank transplanting is done at the first opportunity to minimize competition with herbaceous vegetation. While geese often feed elsewhere, they gobble streambank plants while watering and lounging. They also pull transplanted herbs from the banks even if they do not eat them. Geese also pluck willows for unknown reasons. Once the floodplain blooms with young plants, streambank predation diminishes. Transplanting in mid-May as the floodplain blooms minimizes predation. The same practice also lessens predation by muskrats, which often cut willow stems and leave them on the bank.

Tree protectors (plastic tubes that surround and overtop seedlings) and brush blankets (fabric stapled around the base of small woody seedlings to limit competition and partially direct water to the plant) have not provided benefits commensurate with costs.

In the transition zone, substrate quality plays a major role in woody transplant survival. The chief limiting factor is salinity. Unfortunately, saline sites cannot always be predicted beforehand. We are now creating areas of appropriate hydrology with minimal fill to minimize saline substrates in transplant areas. Another tactic has been a shift to plants with larger, deeper roots (e.g., 16" root length) as salinity is worst near the surface. Transplanting may be spread over two years to spread the risks. Poor substrates are more visible the second year, but competition from established revegetation on the best sites can conflict with second-year transplanting. "Prospecting" for the best open spots helps.

The extent of enhanced revegetation, such as transplants and seed mixes featuring expensive forbs and shrubs, depends on postremediation land uses as well as site features. In uplands, where landowners express the intent to introduce livestock at the first opportunity, enhanced revegetation is not implemented.

Residual Contamination

Even with 90% of the tailings volume removed, a significant amount of the excavated surface can have metal and pH levels that seriously impair revegetation or are phytotoxic. Continuous sampling to identify hot spots and requiring the general contractor to return for additional removal is generally impractical, although confirmation sampling has in some cases triggered additional removal. The degree of ensuing impairment depends also on the depth of coversoil.

After seeding and interseeding, sometimes twice, substrates that preclude effective revegetation become obvious. Contaminated areas are then mapped based on plant cover/barrenness, and additional removal is performed using relatively small, rubber-tired equipment. Borrow may then be applied, but the construction grade need not be restored, and depressions may be left. These areas are reseeded, often by hand, and may be transplanted depending upon the density of surviving nearby trees and shrubs.

Merely covering contaminated material with less than one foot of clean fill has not worked well. The small equipment used for repair work tends to mix contaminated and clean material rather than cover it uniformly. Revegetation then may start well but decline markedly within a few years. Removal is far more effective in establishing permanent vegetation and ultimately more cost-effective as well.

Weeds

Due to effective weed control, remediated areas become weed-free oases in the ocean of noxious weeds prevalent in Silver Bow and Deer Lodge Counties. The limitations of using deep borrow in place of real soil is to some extent compensated by having a weed-free substrate. Most in situ substrates quickly develop a thick crop of weeds from the seed bank or subterranean portions of rhizomatous weeds. Equipment and animals that traverse weedy areas also bring weed seed into reclamation.

In areas with rhizomatous, herbicide-resistant weeds such as whitetop, leafy spurge, and tall pepperweed, effective weed control in a single year may not be achievable, and permanent revegetation may be delayed. Herbicide is first applied in early spring followed by planting a cover crop, usually barley, to reduce erosion. Once the cover crop has grown enough to be somewhat herbicide resistant, herbicide is reapplied to weed concentration areas. Herbicides with strong residual effects are proscribed to prevent damage to susceptible revegetation.

Where easily killed weeds such as spotted knapweed predominate, the permanent seeding is executed at the first suitable opportunity. Due to the use of woody plants, legumes and other forbs, herbicide is applied on a plant-by-plant basis using backpack sprayers. This labor-intensive approach is uncommon among herbicide applicators, and interested contractors have been few. Two passes, one in early and one in late spring, are required each year. Payment is based upon inspection for effectiveness.

Floods

Due to the prevalence of droughty conditions, no major floods have occurred since remediation started. The last significant flooding resulted from a cloudburst in summer 1997. Before remediation is completed (anticipated in 2012), one or more significant floods are expected to raise havoc in freshly seeded or unseeded areas. Contingency funds have been allocated for repair.

A brief snowmelt March flood in 2003 washed away coversoil, seed, and compost from near-stream portions of B and C, with lesser areas of erosional loss and deposition in the subirrigated and upland zones. Many near-stream areas were scoured, leaving a raw, moist substrate. Based on visual estimate, at least 10% of the floodplain was affected. On 3/13/03 in the east end of Subarea 1, streamflow of 7.93 m^3/s (280 ft^3/s) was measured, about 10 times the base flow, but peak flow was higher.

Areas of scour and deposition were hand-broadcast seeded within weeks before germination from the previous fall seeding. This resulted in some of the best moist-site revegetation in Reaches B and C. The lesson was that raw, moist, coarse substrates are preferable to better-textured, amended ones with residual metals or substrates that accumulate surface salts.

Streambanks in Reaches B and C, where revegetation seemed hopelessly stalled due to the two-layer coir fabric that defied interseeding, were rescued. Most of the coir fabric was covered by a thin layer of fresh sediment from the flood. This provided a fine substrate for interseeding.

Evaluating Revegetation Success

Elsewhere, even in areas of rather uniform coversoil application and topography, and with no particular limiting factors other than weather, revegetation tends to be patchy both in plant abundance and species composition. Improper seeding implementation or a poor seedbed frequently result in suboptimal revegetation. Seasonal precipitation during the establishment phase exerts a major influence on stocking. Revegetation standards must incorporate these practicalities.

SSTOU revegetation standards are based upon plant cover, which is probably the best and most easily measured parameter indicating revegetation success. Standards vary by hydrologic zone (Table 1).

Table 1. Minimum stratified canopy coverage approximately 10 years after seeding in years of approximately normal seasonal precipitation.

HYDROLOGIC ZONE	AVERAGE CANOPY COVERAGE[1]
Uplands, Subirrigated	60%
Streambanks, Transition Zone	80%
Wetlands (not open water)	100%

[1] Daubenmire 1959

Following remediation, revegetation substrates may be suboptimal for some combination of these factors, which vary by area:

- Soil texture constraints. Excessively coarse in situ substrates are the most common challenge, but some Reach E coversoils had textures of clay loam, silty clay, or silty clay loam, which present different revegetation challenges.
- Salinity and sodicity problems. Surficial salt accumulations prevent seed germination, whereas salinity in the root zone makes it difficult for plants to extract water. Sodicity limits water infiltration and percolation. Both can contribute to transplant mortality.
- Drought conditions and related drops in groundwater elevation. Subnormal first-year precipitation prevailed throughout all the seeding and transplanting in Subarea 1 and upper Subarea 2.
- Residual contamination may become evident soon after remediation or not until several years later.

Since these limitations are inherently present to some degree following remediation and restoration, we adopted a threshold percentage of samples that must meet performance standards for a reach to be deemed satisfactorily vegetated. Revegetation is satisfactory if two-thirds of remediated areas meet the revegetation standards in Table 1 in years of approximately normal precipitation 10 years following seeding/planting. Unless disturbances require modification, monitoring measurements are taken three, six, and 10 years following planting. Vegetation monitoring may be discontinued if a reach meets the plant cover standard in the sixth year.

Literature Cited

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Sci. 33(1): 43-64.

Common and Scientific Names of Plants (Nomenclature: NRCS online database)

Alfalfa	*Medicago sativa*	Needle-and-thread	*Hesperostipa comata*
Alkaligrass	*Puccinellia nuttalliana*	Northwest Territory sedge	*Carex utriculata*
Alkali sacaton	*Sporobolus airoides*	Panicled bulrush	*Scirpus microcarpus*
American mannagrass	*Glyceria grandis*	Prairie Junegrass	*Koeleria macrantha*
Baltic rush	*Juncus balticus*	Prairie sagewort	*Artemisia frigida*
Basin wildrye	*Leymus cinereus*	Quaking aspen	*Populus tremuloides*
Bebb willow	*Salix bebbiana*	Red clover	*Trifolium pratense*
Big bluegrass	*Poa secunda*	Red fescue	*Festuca rubra*
Birdfoot deervetch	*Lotus corniculatus*	Rocky Mountain bee plant	*Cleome serrulata*
Black cottonwood	*Populus balsamifera*	Rocky Mountain Iris	*Iris missouriensis*
Booth willow	*Salix boothii*	Rubber rabbitbrush	*Eriameria nauseosa*
Boxelder	*Acer negundo*	Russian wildrye	*Psathyrostachys juncea*
Canada bluegrass	*Poa compressa*	Seaside arrowgrass	*Triglochin maritimum*
Canada milkvetch	*Astragalus canadensis*	Seep monkeyflower	*Mimulus guttatus*
Canada wildrye	*Elymus canadensis*	Sheep fescue	*Festuca ovina*
Common gaillardia	*Gaillardia aristata*	Shrubby cinquefoil	*Dasiphora floribunda*
Common yarrow	*Achillea millefolium*	Silver buffaloberry	*Shephardia argentea*
Diamondleaf willow	*Salix planifolia*	Silver sagebrush	*Artemisia cana*
Fourwing saltbush	*Atriplex canescens*	Silverweed cinquefoil	*Argentina anserina*
Geyer willow	*Salix geyeriana*	Slender wheatgrass	*Elymus trachycaulus*
Golden currant	*Ribes aureum*	Streambank wheatgrass	*Elymus lanceolatus*
Greasewood	*Sarcobatus vermiculatus*	Tall wheatgrass	*Thinopyrum ponticum*
Green needlegrass	*Nassella viridula*	Tansyleaf aster	*Machaeranthera tanacetifolia*
Indian ricegrass	*Achnatherum hymenoides*	Tarragon	*Artemisia dracunculus*
Inland saltgrass	*Distichlis spicata*	Thickspike wheatgrass	*Elymus macrourus*
Mexican-fireweed	*Kochia scoparia*	Tufted hairgrass	*Deschampsia caespitosa*
Mountain big sagebrush	*Artemisia tridentata ssp. vaseyana*	Water sedge	*Carex aquatilis*
		Water smartweed	*Polygonum amphibium*
Mountain golden banner	*Thermopsis montana*	Western aster	*Symphyotrichum ascendens*
Narrowleaf willow	*Salix exigua*	Western wheatgrass	*Pascopyrum smithii*
Nebraska sedge	*Carex nebrascensis*	White sagebrush	*Artemisia ludoviciana*
		Yellow-flowered alfalfa	*Medicago sativa* var. *falcate*