Results of the Gardiner Basin Restoration Workshop April 19-21, 2005

GARDINER BASIN RESTORATION WORKSHOP
April 19–21, 2005
Comfort Inn, Gardiner, Montana

Gardiner, Montana 1888

Hosted by:
Yellowstone National Park
Gallatin National Forest
Center for Invasive Plant Management

Funded by:
Yellowstone Park Foundation
Rocky Mountains-Cooperative Ecosystem Studies Unit
Greater Yellowstone Coordinating Committee

Acknowledgements

The Gardiner Basin Restoration Workshop steering committee would like to thank the Yellowstone Park Foundation, The Rocky Mountains-Cooperative Ecosystem Studies Unit and the Great Yellowstone Coordinating Committee for funding the workshop.

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Executive Summary

On April 19-21, 2005, Yellowstone National Park, Gallatin National Forest, and the Center for Invasive Plant Management at Montana State University convened a group of 30 agency staff and invited guests to develop recommendations for a restoration plan for select federally-owned sites in the Gardiner Basin. (See Figure 1.) The sites were once tilled for agriculture, and those tilled areas now support several invasive non-native species and fewer native plants than desired. The physical and ecological conditions at these sites are deteriorated and challenging, and previous restoration efforts have not yielded the native plant associations land managers envisioned.

Prior to the workshop, the participants were sent a briefing binder with site descriptions and background history, allowing the group to quickly orient to the local issues. An electronic copy of the binder (Gardiner Basin Restoration Workshop Steering Committee, Briefing Binder, March 2005, Yellowstone National Park, Wyoming) is available on CD from the Yellowstone Center for Resources, Yellowstone National Park.

The participants visited the restoration sites, discussed degradation issues and developed recommended restoration strategies for each site, including alternative strategies for some sites. The key findings of the group were:

- While a range of conditions across the suite of sites exists, areas that had been tilled and irrigated generally have soils with altered physical and chemical properties.
- Across all sites, low annual precipitation, weeds, high winds and heavy use by native ungulates presents a challenge to restoring desired native plant associations.
- Seed availability of local ecotypes may be a constraint depending on site goals.
- Lack of comparable reference sites hampers restoration goal setting.
- Even with these constraints in place, the group believes that each of the sites visited can successfully be restored to functioning native plant associations.

The group identified guiding principles to oversee the restoration projects at all sites:

1. Begin each restoration project by developing a site characterization including soil analysis and a conceptual model.
2. Develop clear, specific goals with clearly defined objectives for the restoration project.
3. Determine degree of flexibility in species selection and seed sourcing.
4. Use the best science and technology to tackle these restoration projects.
5. Use a stepwise approach to move sites through stages of restoration. This stepwise approach includes:

- site characterization, goal setting and development of restoration alternatives
- soil stabilization
- site preparation
- seed selection and planting
- site maintenance
- monitoring and management

The group also discussed genetics and selection of plant materials, identified next steps, and made closing comments.

The following is a record of the workshop discussions that was prepared by the facilitator, Mr. Will Murray, of Conservation Impact, Denver, Colorado. The steering committee and workshop participants reviewed his report for errors and omissions, and the following (excluding Appendices B and C), is the final report of the workshop. Because it is a record of the actual discussions, knowledge of the site specific background information is often inferred. The background information upon which the discussions and recommendations were made is found in the briefing binder which was given to the participants prior to the workshop.

After the workshop, Gallatin National Forest and Yellowstone National Park staff began to implement the participants' "next steps" recommendations and to refine the recommendations into site specific implementation plans. Appendix B is a copy of Gallatin National Forest's March 2006 public scoping document for its proposal to restore a native plant community to the Cutler Meadow area. Appendix C is a brief summary of Yellowstone National Park's proposal for its restoration projects.

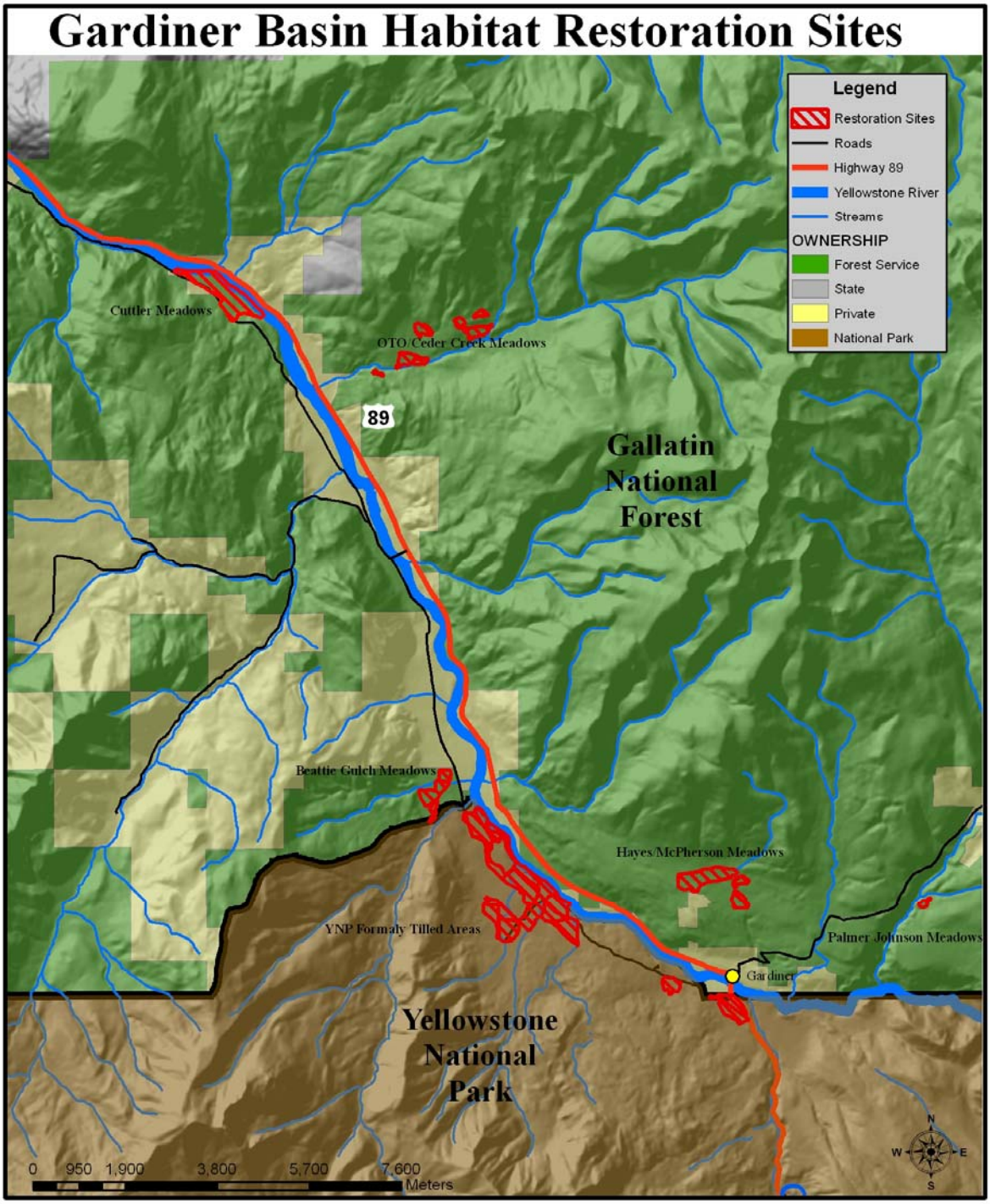


Figure 1. Proposed Gallatin National Forest and Yellowstone National Park Restoration Sites

Purpose of the Workshop

The purpose of this workshop was to develop recommendations for a restoration plan for selected federally-owned sites in the Gardiner Basin. Several sites in the basin were once tilled for agriculture, and those tilled areas now support several invasive non-native species and fewer native plants than desired. The physical and ecological conditions at these sites have deteriorated, and previous restoration efforts have not brought about the native plant associations that land managers envisioned. To improve the results of future restoration projects, Yellowstone National Park, Gallatin National Forest and the Center for Invasive Plant Management at Montana State University brought together 30 key people, including agency employees and outside experts, to make recommendations for a restoration plan. Participants' names and contact information are listed in Appendix A.

Key Findings

While the group found a range of conditions across the suite of restoration sites, areas that had been tilled and irrigated generally have soils with altered physical and chemical properties. These formerly intensively farmed areas support few native plants and a large number or concentration of invasive non-native species. Areas that had a less intense farming history have better soil conditions and more native vegetation, but still support undesirable non-native species. Heavily impacted soils will require remedial actions to enable native species to re-establish over time.

Across all sites, low annual precipitation, weeds, high winds and heavy use by native ungulates presents a challenge to restoring desired native plant associations. Restoration success will depend heavily upon site remediation and preparation; seed selection, placement, timing and protection; and adequate spring precipitation for seedling establishment. High winds desiccate the soil, which hampers germination and seedling survival and strips away topsoil. Both annual and perennial weeds present potential competition to seeded species. Heavy ungulate grazing during the establishment period can reduce seedling survival and long-term plant community sustainability.

Seed availability of local ecotypes may be a constraint, depending on site goals. In some cases, a few years of a cereal grain cover crop will be necessary to recover soil properties and provide weed competition, giving time to locate, collect, and propagate native seed stock. In other cases, local ecotypes may not be available in a timely manner.

Lack of comparable reference sites hampers restoration goal setting. It seems that no similar sites in the immediate area escaped cultivation in the past decades. Without reference sites in good ecological condition, the specific restoration goals become based on speculated past site conditions. Restoration goals then need to be inferred from the surrounding landscape, which is composed of different landforms and soil types and quite possibly different vegetation than that of the restoration sites themselves.

Even with these constraints in place, the group believes that each site visited can successfully be restored to a functioning native plant assemblage. Restoration success is highly likely given current technologies, appropriate remediation, and the four P's of arid lands restoration:

- Planning
- Patience
- Perseverance
- Precipitation

Guiding Principles

After the site visits and development of site prescriptions, the invited guests deduced a set of guiding principles for the overall restoration efforts.

1. Begin each restoration project by developing a site characterization including soil analysis and a conceptual model. The soil analysis should include soil chemistry analysis, characterization of soil physical structure, and soil water infiltration. All of these will help determine whether a plow pan is present and if soil chemical and physical properties need to be addressed (repaired) during the remediation implementation phase. The conceptual model depicts driving forces and the interactions between physical, chemical, and biological systems. It is a graphic representation of the working hypothesis underpinning the restoration project and will help guide the restoration process.

2. Develop clear, specific goals with clearly defined objectives for the restoration project. The goals and objectives should identify desired abiotic and primary processes and functions such as the ability for water and nutrients to be captured and incorporated into the soil. Goals and objectives should also specify the desired native plant association, including composition and structure, spatial patterns of vegetation where appropriate, function of the site including use as wildlife habitat, scenic values, aesthetic values, watershed values, and other important functions. Restoration objectives should be realistic in spatial and temporal scales. Performance goals/success criteria will help measure the success of restoration effects and/or guide adaptive management.

3. Determine degree of flexibility in species selection and seed sourcing. With the site characterization and conceptual models in hand, decide on the appropriate source of plant materials for restoration, along the continuum from locally collected native seed to developed cultivars and analogous species. Please see page 34 for more information on this topic.

4. Use the best science and technology to tackle these restoration projects. Use ecological principles to guide the restoration strategies. By addressing the ecology of the system and the causes of degradation, restoration techniques may develop sustainable, functional ecosystems that fit and blend into the landscape over a period of time. Use techniques, quipment and materials to address the basic causes of degradation. The intensity of the restoration remedy is often directly proportional to the intensity of the degradation, so be prepared to take strong measures when necessary, while keeping the ultimate goal of the functioning native plant association and associated land values in mind.

5. **Use a stepwise approach to move sites through stages of restoration.** At most sites, some basic ecological processes (nutrient, water, energy cycles, and succession) have been disrupted. Successful restoration will depend on repairing those basic functions such that the sites become self-sustaining. A succession staircase of several steps may be necessary to achieve the restoration goals, rather than a one-step approach from the present highly degraded condition to a fully functioning native plant association. The degree of plant establishment success will ultimately depend on being responsive to management on the micro scale, i.e. moisture, timing of planting, planting depth, grazing, etc.

Methods of the Workshop

John Varley (Director, Yellowstone Center for Resources, Yellowstone National Park) and Ken Britton (District Ranger, Gallatin National Forest) welcomed the group and highlighted the need for more effective solutions than those tried in the past. Lynn Burton (Rangeland Management Specialist, Gallatin National Forest), Roy Renkin (Vegetation Management Specialist, Yellowstone National Park) and Henry Shovic (Soil Scientist, Gallatin National Forest) oriented the group to the issues and the sites with presentations on the overall situation. (Prior to the workshop, the participants were sent a briefing binder with site descriptions and background history, allowing the group to quickly orient to the local issues. An electronic copy of the binder (Gardiner Basin Restoration Workshop Steering Committee, Briefing Binder, March 2005, Yellowstone National Park, Wyoming) is available on CD from the Yellowstone Center for Resources, Yellowstone National Park.)

The group then took to the field to visit several of the sites. During the evening, the invited guests reconvened to discuss their observations and identify driving forces to address during the restoration process.

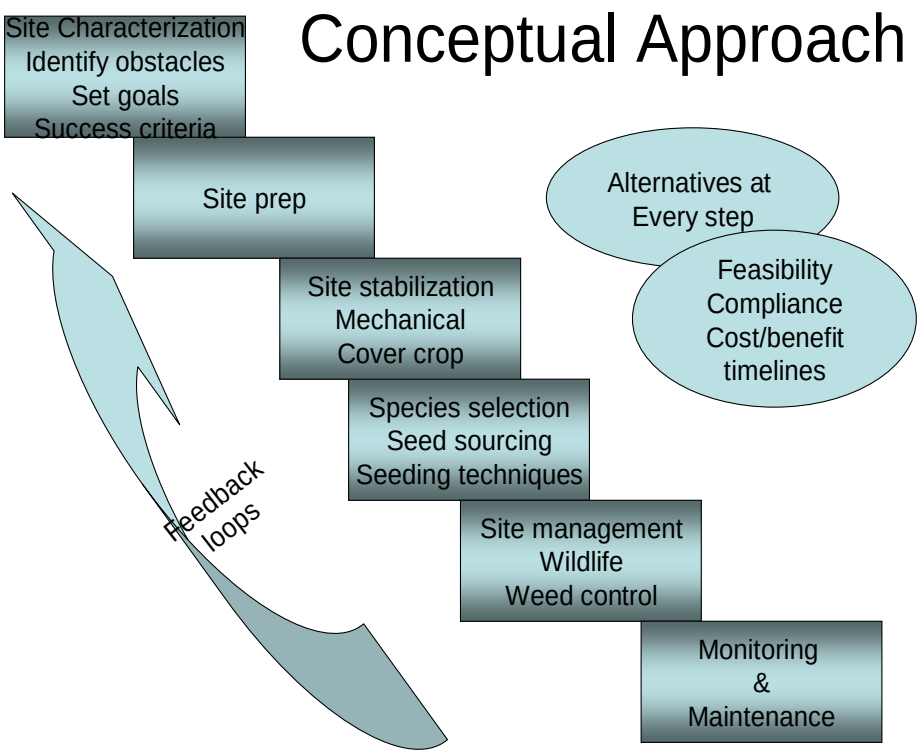
On the second day, the group listed and described values to be achieved through restoration and the desired vegetation condition necessary to realize those values. They created restoration strategies to achieve the desired soil and vegetation conditions and other values, and then assessed the feasibility, cost and timing necessary to implement the strategies

On the third day, the group created alternative approaches to restoring the park's fields "C" – "R" and developed guiding principles to oversee all the restoration work. The group also had a detailed discussion of the genetics of different types of plant materials, then listed action items, made final comments and adjourned.

Will Murray of Conservation Impact conducted the workshop and recorded the results.

Conceptual Approach

The group used a stepwise conceptual approach to develop the recommended restoration strategies:



Setting Restoration Goals

Setting goals for the restoration projects is vital. A clear articulation of desired natural community and its acceptable range of variation, as well as natural processes, is indispensable. From the goal, outlined criteria for success follow and provide a method to detect the trends in progress toward desired direction.

Restoration Sites

The group visited several potential restoration sites in Yellowstone National Park (YNP) and Gallatin National Forest (GNF). Restoration recommendations were developed for the following sites:

- Fields A and B (also known as the “Triangle”) - YNP
- Fields C-R (variously known as the Boundary Lands, the Game Ranch Preserve and Stevens Creek) - YNP
- Beattie Gulch - GNF
- Cutler Meadows - GNF
- OTO and Hayes Horse Pastures - GNF
- OTO Ranch West Pasture - GNF
- Hayes and McPherson Pasture - GNF
- Travertine mine site - GNF

Fields A and B (also known as the "Triangle") - YNP Restoration Strategy

Driving Forces:

- Sodium flocculated surface soil and possible salt accumulation in soils due to past land uses, including irrigated agriculture pasture, bus parking, golf course and firing range
- Soil (wind) erosion
- Low diversity and cover of desired plant species.
- Non-native invasive weeds present.
- Heavy winter ungulate use may prevent long-term sustainability of the native plant association.

Alternative 1:

Alternative 1 - Restoration Goal:

Restore functioning water, soil, and energy cycles; soil properties; and a sustainable native shrub-grassland plant association reflecting the site potential and possible pre-disturbance vegetation. Potential species may include but are not limited to:

- rubber rabbitbrush (*Ericameria nauseosa* syn. *Chrysothamnus nauseosus*)
- greasewood (*Sarcobatus vermiculatus*)
- saltsage (*Atriplex gardneri* var. *gardneri*)
- Sandberg's bluegrass (*Poa secunda* var. *elongata* syn. *Poa sandbergii)*
- aster (*Ionactis alpine* syn. *Aster scopularum*)
- western wheatgrass (*Elymus smithii* syn. *Agropyron smithii, Pascopyrum smithii)*
- needle-and-thread (*Hesperostipa comata* syn. *Stipa comata*)
- additional forbs for antelope forage (e.g. flax, *Linum lewisii*; nine-leaf lomatium, L*omatium triternatum;* scarlet globe mallow, *Sphaeralcea coccinea;* hoary aster, *Machaeranthera canescens*)

Alternative 1 - Restoration Strategy:

- Characterize soils: conduct soil analysis to assess the type, amount and fine-scale location of soil amendments needed

  - Determine where to sample: transects by gradient, changes in soil surface, vegetation, include the rocky areas as potential reference sites

- Sample at depths of 0-6, 6-12, 12-24 inches
- Analyze soils for pH, Exchangeable Sodium Percentage (ESP), organic matter, presence/depth of clay pan, % particle size separation, Sodium, salt accumulation (electrical conductivity - EC)

- Repair soil properties:

  - If soils are sodic (as assessed above), apply gypsum at about 22 tons/acre as soil testing to reduce ESP to <10. Gypsum will restore infiltration/percolation IF soils are deep enough.
  - If a plowpan is present, rip soil to 1 foot depth (or below pan), at 1 foot spacing with a chisel plow. Rip soils in two cross-hatching passes to avoid rows and lines visual effects. Ripping will incorporate the gypsum, reduce soil compaction, and decrease water and nutrient movement off-site.
  - Investigate application of polyacrylamide if necessary to control erosion. (Note: There is conflicting information in the literature about the effectiveness of polyacrylamide for wind erosion control (see, for example, articles found at http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=404339&showpars=true&fy=2004 and http://www.weru.ksu.edu/symposium/proceedings/armbrus2.pdf)

- Fence the restoration site and a reference site nearby to decrease grazing pressure on establishing plants. Maintain fence until at least 50 percent of the seeded species are reproducing.
- Use a no-till drill to plant a preparatory cover crop in ripped area.
- Consider using Re-green® (sterile hybrid cross of *Triticum aestivum* x *Elytrigia elongata*), 'Otis' barley (*Hordeum vulgare*) or sorghum (*Sorghum vulgare*). The preparatory crop is useful for adding organic matter, holding the soil and decreasing weed competition prior to planting desired native species.
  - Spray preparatory crop at milk stage (approximately July) with of Roundup® (2 quarts/acre) to terminate crop and to leave stubble to capture moisture and soil and add organic matter. Spot treat weeds with Roundup® or a broadleaf herbicide through rest of growing season.
  - Conduct dormant seed planting into the preparatory crop stubble after October 15 using a no-till drill and native seed mixture. Fall dormant seeding has been found to be the most successful for plant establishment in the region. By seeding with two cross-hatching passes, undesired visual effects of drill rows can be minimized.

- Determine if local ecotypes and seed increase (3-7 years) or cultivars such as Pryor's slender wheatgrass (*Elymus trachycaulus*), Rosanna western wheatgrass, Nuttall's saltbush (*Atriplex nuttalii*) will be used for the revegetation.
- Broadcast seed shrubs and small-seed species. This can be done at the same time as seeding the other species. Simply put these species in a separate seed box on the no-till drill and unhook the tubes so the seed falls freely on the ground. Broadcasting behind the drill can also reduce the drill row effect.
- Do NOT irrigate. Irrigation can lead to shallow rooting and decreased survival. Establish plants under natural moisture conditions. The plants that do become established will have a better chance of long-term survival.

Alternative 1 - Monitoring and Management Strategy:

- Continue to mow and / or spot spray invasive species while desired species establish.
- Develop monitoring program.
- Establish transects and consider measuring trend related to species, bare ground, % cover based on reference site in spring of the year following the native planting.
- Monitoring will continue indefinitely on the site.

Alternative 1 - Feasibility:

- Estimated cost: $4000-10,000 per acre for soil and revegetation treatments (driving cost is the repair of soil properties via gypsum)
  - Gypsum, ripping, seed purchase, drilling, herbicide monitoring
- Additional cost for monitoring and maintenance
- $25,000 for fence

Alternative 2:

Alternative 2 - Restoration Goal:

Provide an opportunity to present the plants of Yellowstone National Park and orient the visitors to the Park. Site potential may include:

- walking paths
- visitor center or kiosks
- interpretive plantings
- parking
- volunteer opportunities

Alternative 2 - Restoration Strategy:

- The group believes that the challenges of Alternative 1 are formidable to restoring this site to a sustainable native plant association. The soil resources have many chemical and physical restrictions that may prohibit restoration at a reasonable expense and very heavy winter ungulate use may prevent long-term sustainability of the native plant association.
- Given the proximity of this site to the town of Gardiner and its situation at the gateway to the Park, the group offered an alternative use of the site as an administrative and orientation site for Park visitors.
- Fence the interpretive site to decrease grazing pressure on plants and protect park visitors.
- Address damaged soil properties on the small scale using methods in Alternative 1 while developing a native plant garden / interpretive walkway.
- Consider providing drip irrigation to interpretive plantings if sodium levels are not high.
- Develop interpretive signs and handouts.
- Provide additional parking for YNP and Gardiner visitors.
- Spot treat weeds as needed.

Alternative 2 - Monitoring Strategy:

- Little to no monitoring will be needed

Alternative 2 - Feasibility:

- Cost undetermined because this is not the expertise of the workshop participants.
- Benefits to visitors, the park, and Gardiner may outweigh costs.
- $25,000 for fence

Fields C-R (also known as the Boundary Lands, Game Preservation Ranch and Steven's Creek) - YNP Restoration Strategy

Driving Forces:

- Weed competition (existing and future)
- Site stability, due to alteration of soil, presence of plow layer (compaction), current wind and water erosion, potential for additional erosion if tilled in the restoration process
- Difficulty of spraying to control annual weeds while encouraging native shrubs
- Lack of knowledge about how to control *Alyssum* spp.
- Presence of crested wheatgrass (*Agropyron cristatum*)
- Heavy winter ungulate use

Because of many uncertainties at the site, workshop participants developed three alternatives for this site, and recommended a test trial site to determine which restoration strategy will be most feasible and successful.

Alternative 1:

Alternative 1 - Restoration Goal:

Restore functioning water, soil, and energy cycles; soil properties; and a sustainable native shrub-grassland plant association similar to the site potential. Potential species may include but are not limited too:

- bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata* syn. *Agropyron spicatum* and *Elymus spicatus*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. Poa sandbergii)
- western wheatgrass (*Pascopyrum smithii* syn. *Elymus smithii* and *Agropyron smithii)*
- thickspike wheatgrass (*Elymus lanceolatus* syn. *Agropyron dasystachum*)
- needle-and-thread (*Hesperostipa comata* ssp. *comata* syn. *Stipa comata*)
- Indian ricegrass (*Achnatherum hymenoides* syn. *Oryzopsis hymenoides*)
- Junegrass *(Koeleria macrantha* syn. *Koeleria cristata*)
- rubber rabbitbrush (*Ericameria nauseosa* syn. *Chrysothamnus nauseous*
- green rabbitbrush *Ericameria visidiflorus syn. Chrysothamnus viscidiflorus*)
- big sage (*Artemisia tridentate* var. *tridentata*)
- onion (*Allium textile*)
- prickly pear cactus (*Opuntia polyacantha*)
- fleabane (*Erigeron pumilus*)

- native legumes (e.g. *Astragalus purshii*)
- fringed sage (*Artemisia frigida)*
- biscuitroot (*Lomatium* spp.)
- saltbush (At*riplex gardneri*)
- greasewood (*Sarcobatus vermiculatus*)
- winterfat (*Kraschennikovia lanata* syn. *Eurotia lanata*)
- sedge (*Carex stenophyla*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. *Poa sandbergii*)
- additional forbs for antelope forage (e.g. flax, *Linum lewisii*; nine-leaf lomatium, L*omatium triternatum;* scarlet globe mallow, *Sphaeralcea coccinea;* hoary aster, *Machaeranthera canescens*)

Alternative 1 - Full Treatment Restoration Strategy:

- Soil is believed to be compacted and prohibitive to plant growth and water infiltration. Characterize soil to determine if the soil is compacted at the 4-6 inch depth and to ascertain other soil limitations such as elevated sodium or salts. Use an infiltrameter test. If the test indicates a 4-6 inch impermeable layer, which encourages weed growth and prevents sustainable establishment of native plants, then mechanical fracturing of this plow layer will be necessary.
- Rip soil to one foot depth to fracture impervious layer, if it exists, at one foot spacing using a chisel plow. Rip soils in two cross-hatching passes to avoid rows and lines visual effects. Ripping will break the plow layer and soil compaction, decrease water and nutrient movement off-site, and restore water infiltration and percolation for storage of the water for plant growth.
- Test the soil for chemical properties (Electrical Conductivity, Exchangeable Sodium Percentage, and pH).
- Conduct a literature review on *Alyssum* to describe life history, seed bank properties and other information necessary to control it.
- If *Alyssum* is not competitive, plant a preparatory crop using a no-till drill (consider using 'Otis' barley because it is 47% carbon, has 90% below-ground biomass, and has stiff shoots that capture soil and moisture) to produce stubble to increase moisture capture. Plant preparatory crop in the early spring, mow or spray when the seed is in the "milk" stage to keep it from going to seed, and repeat annually until acceptable level of reduction in weeds occurs.
- Spot treatment of alyssum and other weeds may be necessary while the site is in the preparatory crop stage.
- After weeds have decreased, fall dormant seed native species into the preparatory crop stubble using a no-till drill and native seed mixture. By seeding with two cross-hatching passes, undesired visual effects of drill rows can be minimized. Drill seeding increases

soil to seed contact and seed is placed at the right depth in soil. Broadcast seeding alone is not likely to be successful (90% for drilled versus 20% for broadcast) and would require harrowing to make rills & ridges, then roller to compact seed into surface.

- Broadcast seed shrubs and small-seed species behind the drill seeder. This can be done at the same time as seeding the other species. Simply put these species in a separate seed box on the no-till drill and unhook the tubes so the seed falls freely on the ground. Broadcasting behind the drill can also reduce the drill row effect.
- Consider treating 50-acre at a time and phased in additional acres over the years if strategy is successful.
- Control weeds in non-treatment areas using broadleaf herbicides and/or non-selective herbicides, particularly to prevent any further weed spread.
- Fence the restoration site(s) and reference site(s) to decrease grazing pressure on establishing plants.
- Do NOT irrigate.

Alternative 1 - Monitoring and Management Strategy:

- Develop monitoring program.
- Weed control will be necessary during establishment years
- Monitoring will continue indefinitely on the site.

Alternative 1 – Feasibility:

- Implementation cost: (none was provided)
- It is the feeling of the workshop participants that if you address and repair the damaged soil properties, restoration attempts will be successful. Without repairing the soils, restoration attempts are likely to fail, as they have in the past.

Alternative 2:

Alternative 2 - Restoration Goal:

Restore functioning water, soil, and energy cycles; soil properties; and a sustainable native shrub-grassland plant association similar to the site potential. Potential species may include but are not limited too:

- bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata* syn. *Agropyron spicatum* and *Elymus spicatus*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. Poa sandbergii)
- western wheatgrass (*Pascopyrum smithii* syn. *Elymus smithii* and *Agropyron smithii)*
- thickspike wheatgrass (*Elymus lanceolatus* syn. *Agropyron dasystachum*)
- needle-and-thread (*Hesperostipa comata* ssp. *comata* syn. *Stipa comata*)
- Indian ricegrass (*Achnatherum hymenoides* syn. *Oryzopsis hymenoides*)
- Junegrass *(Koeleria macrantha* syn. *Koeleria cristata*)
- rubber rabbitbrush (*Ericameria nauseosa* syn. *Chrysothamnus nauseous*
- green rabbitbrush *Ericameria visidiflorus syn. Chrysothamnus viscidiflorus*)
- big sage (*Artemisia tridentate* var. *tridentata*)
- onion (*Allium textile*)
- prickly pear cactus (*Opuntia polyacantha*)
- fleabane (*Erigeron pumilus*)
- native legumes (e.g. *Astragalus purshii*)
- fringed sage (*Artemisia frigida)*
- biscuitroot (*Lomatium* spp.)
- saltbush (*Atriplex gardneri*)
- greasewood (*Sarcobatus vermiculatus*)
- winterfat (*Kraschennikovia lanata* syn. *Eurotia lanata*)
- sedge (*Carex stenophyla*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. *Poa sandbergii*)
- additional forbs for antelope forage (e.g. flax, *Linum lewisii*; nine-leaf lomatium, L*omatium triternatum;* scarlet globe mallow, *Sphaeralcea coccinea;* hoary aster, *Machaeranthera canescens*)

Alternative 2 – Reduced Inputs Restoration Strategy:

- Conduct soil characterization to see if the soil is uncompacted to a depth of 12-18 inches by percolation test. If the percolation test indicates a 4-6 inch impermeable layer, which encourages weed growth and prevents sustainable establishment of native plants, then mechanical fracturing of this plow layer will be necessary and another alternative approach should be considered.
- Test the soil for chemical properties: Electrical Conductivity, Sodium absorption rate (SAR), pH.
- If the soils are uncompacted, implement this strategy on 50 acres to determine the likely hood of success.
- Erect fencing 6' high, (higher on slopes) with lots of posts and electricity for bison exclusion and include one-way gates for native ungulate grazing management.
- Broadcast plant a native seed mix. Include slender wheatgrass or 10# barley which germinates fast to create some cover. Broadcast seeding removes rows for aesthetic values, but may take 2-3 operations and may disturb soil, so wind erosion may be a

factor. Use a harrow to roughen the soil surface, broadcast seed, and then use a packer roller.
- Mulch is not recommended.
- Do NOT irrigate.

Alternative 2 - Monitoring and Management Strategy:

- Develop monitoring program.
- Weed control will be necessary during establishment years
- Monitoring will continue indefinitely on the site.

Alternative 2 - Feasibility:

- Implementation Cost (none was provided)

Alternative 3:

Alternative 3 Restoration Goal: Develop a living history farm demonstration and interpretive site.

- If restoration to a native plant association proves infeasible due to cost, poor species establishment, or other reasons, another consideration is to reconstruct the irrigation ditch system and plant the area to alfalfa to replicate the farming history in the valley. (This would still require soil investigations and remediation treatments.)
- This alternative will reduce soil erosion, decrease weed infestations, provide wildlife forage, and educate visitors on the early agricultural development of the Gardiner Basin.

Alternative 3 - Historical Approach Strategy:

- Plow historic agricultural field and plant alfalfa (*Medicago sativa*).
- Acquire water rights and reconstruct history irrigation ditch system.
- Flood irrigate
- Develop interpretive signs and/or kiosks.
- Control weeds on the field edges

Alternative 3 - Monitoring and Management Strategy:

- Alfalfa will need to be replanted every 7 years.
- Weed control around the field edges may will be necessary

- No monitoring will be necessary.
- Irrigation during the spring and summer are recommended.

Alternative 3 - Feasibility:

- Implementation cost: (none was given).
- Because farming the site was successful in the past, it will most likely be successful now.

Test Trial Approach:

There are many uncertainties associated with repairing this site. For example, there was discussion about the need to 1. fence or not-fence, 2. spray alyssum or not, 3. rip the soil, etc. Therefore, workshop participants recommended testing several of these strategies on a small scale prior to large scale implementation. This may increase restoration success and reduce costs in the long-term.

Test Trial Restoration Strategy:

- On a relatively small area (40 acres) establish several experimental plots to test the following. These treatments will include all factorial combinations, and be replicated and randomly arranged. All treatments will be seeded using a rangeland no-till drill to seed in the fall: western wheatgrass, Sandberg's bluegrass, slender wheatgrass and needle-and-thread at 20 lbs/acre.
- Soil compaction treatment: 1) rip the soil to a 1' depth, 2) no soil ripping.
- *Alyssum* control treatments: 1) spray with 1 oz/acre Escort® in the fall; 2) high soil pH promotes long herbicide residence, therefore consider a Buctril® herbicide treatment as an alternative to Escort to encourage shrubs: sagebrush, rabbitbrush, winterfat, 3) no herbicide treatment.
- Preparatory crop: 1) seed a preparatory crop two years prior to seeding natives, 2) seed a preparatory crop with the native seed mix, 3) no preparatory crop.
- Fence treatment: 10fence site to prevent wildlife grazing while plants establish, 2) no fencing.

Test Trial Feasibility:

- Costs include herbicide, seed, researcher and field technician salary, fence, equipment rental. No cost was given.
- By testing these treatments on a small scale, we may be able to apply the most successful approach on the large scale.

Test Trial Indicators of Success:

Sites (treatments) will be monitored for:

- Desired plant species density, cover, and survival
  - Year 1 establishment (40 Daubenmire frames/site)
  - Survival (Annual for 5 years)
- Undesired plant species density and cover
- Late seral mosses/lichens percent cover
- Soil erosion (rills or plant pedestals)

Comparison of Approaches

Method	**Herbicide**	**Spring prep crop**	**Chemical fallow or mowing**	**Fall drill seed**	**Broadcast seed**	**Harrow**	**Irrigation**	**Success probability**
Previous attempts	+			+	+		+	Mixed results, none persisted
Reduced inputs Alt 2.		optional	+		+	+		Low
Full treatment Alt. 1	+	+	+	+				High

Comparison of Alternative Strategies

Alternative	**Short-term Impact**	**Long-term Impact**	**Implementability**	**Permanence & Sustainability of desired community**	**Meeting goals**	**Cost**	**Agency acceptance**
No Action	low	low	high	low	low	low	low
Historical use Alt. 3	high	high	medium	low	High if goal is historical use	medium	High if agreed to
Reduced inputs Alt. 2	medium	low	medium	low	low	medium	low
Full treatment Alt. 1	low	high	medium	Medium to high	high	Medium to high	medium

Comparison of Issues Addressed

	Wildlife	**Weeds**	**Compaction**	**Erosion**	**Aesthetics**
Past Methods	Seed desired species	Herbicide			No rows
Low Impact Options **Alt 2**	Seed desired species	Cover Crop Herbicide	Cover Crop	Cover crop, seed desired species	-Cris-cross Planting
Full Mechanical Treatment **Alt 1**	Seed desired species	Cover Crop Herbicide	Cover Crop Ripping	Cover crop, seed desired species, ripping for soil texture	-Cris-cross Planting

Beattie Gulch - GNF Restoration Strategy

Driving Forces:

- Farmed and abandoned
- Good productive soils, moderately moist, plow pan present
- Flooded in 1996-7
- Minimal to no soil erosion
- Lower wildlife usage than sites closer to the Park boundary
- Weed infested

Restoration Goal:

Restore a sustainable plant association similar to potential at the site that provides native wildlife habitat and forage. Vegetation may include a mosaic of sagebrush / bluebunch wheatgrass plant community that grades toward more mesic communities toward river and including the riparian community along the river banks. Site potential may include:

- bluebunch wheatgrass (*Pseudoroegneria spicata* syn. *Agropyron spicatum*)
- western wheatgrass (*Elymus smithii* syn. *Agropyron smithii, Pascopyrum smithii)*
- sagebrush (*Artemisia* spp.)
- Rabbitbrush (*Ericameria nauseosa* syn. *Chrysothamnus nauseosus*)
- Great Basin wildrye (*Elymus cinereus*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. *Poa sandbergii*)
- green needlegrass (*Nassella viridula* syn. *Stipa viridula*)
- slender wheatgrass (*Elymus trachycaulus*)
- additional forbs for antelope forage (e.g. flax, *Linum lewisii*; nine-leaf lomatium, l*omatium triternatum;* scarlet globe mallow, *Sphaeralcea coccinea;* hoary aster, *Machaeranthera canescens*)

Restoration Strategy:

- Conduct soil test (1 pit/20 acres)
- N, P, K, S, B soluble salts, exchangeable Na, electrical conductivity, pH, organic matter, plow layer
- Apply initial weed control in the spring 2005.
- No cover crop will be needed.
- Apply Starane® and Banvel® for first pre-plant weed control treatment to take out alfalfa to reduce attraction to deer and other wildlife.

- Treat crested wheatgrass with Roundup® at 3-4 inches of growth, and annual light disturbance to tease out seed bank, then Roundup® again.
- Let the alfalfa wear out or apply herbicide (e.g. Landmaster) during crested wheatgrass treatment.
- Chisel plow to a 10 inch depth to fracture historic plow layer.
- Use tine-type harrow to prepare surface for planting and remove annual weeds (twice).
- Set up temporary irrigation pre-planting to load the profile with 3" additional water in August-September. This may improve seedling germination and establishment.
- Harrow once or twice after irrigation to make surface more friable.
- Fence 1.5 miles to exclude ungulates, including one-way gates to regulate the amount of use per season. Decide whether to fence the river side of the site. It's possible that this site may not need a fence, as it does not have as much native ungulate use as sites closer to the Park boundary. Consider testing the fence in a small area.
- Seed using Tye drill or Truax no-till drill in October or early November.
  - C3 grass mix of cultivars, adding sand dropseed, big sage, yarrow, lupine. Interseed forbs after grasses establish, 8-11 pounds per acre, crisscross or angle to avoid rows.
- Watch out for cheatgrass replacing alfalfa in areas high in soil nitrogen.
- Do NOT irrigate.

Monitoring and Management Strategy:

- Conduct post-planting weed control in spring of following year
- Control Kochia using Buctril® preferably, or Starane® if necessary
- Spot-treat spotted knapweed (*Centaurea maculosa*) and Canada thistle (*Cirsium arvense*) with Transline.®
- Conduct qualitative monitoring for erosion rills, gullying, surface movement, and vegetation through photopoints.
- Take quantitative measurements every five years
  - Nested frequency for a few species, % cover, species composition, species richness, evenness
- Tie monitoring to weed control and other management activities.
- Coordinate with other efforts concerning biocontrol.

Feasibility:

The direct cost estimate is $400-420 per acre. This cost does not include overhead and administration or monitoring and maintenance.

Cutler Meadow - GNF Restoration Strategy

Driving Forces:

- Farmed and abandoned
- Good productive soils, moderately moist, plow pan present
- Flooded in 1996-7
- Not as much wildlife impact as sites closer to Park boundary
- Little to no soil erosion
- Weed infested

Restoration Goal:

Restore a sustainable plant association that provides native wildlife habitat and forage. Vegetation may include a mosaic of sagebrush / bluebunch wheatgrass plant community that grades toward more mesic communities toward river and includes a riparian community along the river banks. Site potential may include:

- bluebunch wheatgrass (*Pseudoroegneria spicata* syn. *Agropyron spicatum*)
- western wheatgrass (*Elymus smithii* syn. *Agropyron smithii, Pascopyrum smithii)*
- sagebrush (*Artemisia* spp.)
- Rabbitbrush (*Ericameria nauseosa* syn. *Chrysothamnus nauseosus*)
- Great Basin wildrye (*Elymus cinereus*)
- Sandberg's bluegrass (*Poa secunda* var. *secunda* syn. *Poa sandbergii*)
- green needlegrass (*Nassella viridula* syn. *Stipa viridula*)
- slender wheatgrass (*Elymus trachycaulus*)
- *See potential proposed seed mix at the end of this section.

Restoration Strategy:

- Conduct soil test (1 pit/20 acres = 7 pits)
  - N, P, K, S, B, soluble salts, exchangeable Na, electrical conductivity, pH, organic matter, plow layer
- Do initial weed control phase in spring 2005.
- No cover crop will be needed.
- Apply Starane® and Banvel® for first pre-planting weed control treatment to remove the alfalfa and reduce the attraction to wildlife.
- Chisel plow whenever soil analysis indicates a plow layer is present (currently estimated to be present at 10 inches).

- Use tine-type harrow to ready surface for planting after irrigation and removing annual weeds (twice).
- Set up temporary irrigation before planting to load the profile with 3" additional water in August-September.
- Harrow once or twice after irrigation to make surface more friable.
- Fence 1.5 miles to control wildlife, one-way gates to regulate the amount of use per season. Decide whether to fence the river side of the site.
- Seed using Tye drill or preferably a Truax drill in October to early November.
- C3 grass mix cultivars, adding sand dropseed, big sage, yarrow, lupine. Consider using no more than 8 pounds of grass seed to better support forb and shrub establishment. Interseed forbs and shrubs after grasses establish through crisscross or angle planting to avoid rows for aesthetic reasons. Use different seed boxes for wide enough sagebrush spacing
- Supplement riparian community with cottonwood and willow and maybe Juniper plantings.
- Conduct post-planting weed control in spring of the following year.
- Kochia control using Buctril® preferably, or Starane® if necessary.
- Spot-treat spotted knapweed, Russian knapweed and Canada thistle with Transline.®
- Do NOT irrigate.

Monitoring and Management Strategy:

- Qualitative monitoring for erosion rills, gullying, surface movement, and vegetation through photo-points
- Take quantitative measurements every five years for
  - Nested frequency for a few species, % cover, species composition, species richness, evenness
- Tie monitoring to weed control and other management activities
- Coordinate with other efforts e.g. bio-control

Feasibility:

The direct cost estimate is $350-400 per acre. This cost does not include overhead and administration or monitoring and maintenance.

Cutler Meadow Proposed Treatments and Costs

Item:	Cost Per 150 Acres	Average Cost Per Acre	Chance Stand Failure Without Doing Particular Activity
Soil testing	1,000	6.67	2-5 %
Killing Existing Alien Plants, Including Alfalfa	3,300	22.00	25-35 %
Spot treating Noxious Weeds	300	2.00	3-5 %
Chisel Plowing and Harrowing	3,000	20.00	20-30 %
Irrigation	13,500	90.00	20-35 %
Fencing	16,000	106.67	5-10 %
Harrowing and Packing	3,000	20.00	30-55 % %
Native Seed	5,672	37.82	100 %
Drilling Seed	3,750	25.00	30-50 %
Post Plant Spraying	3,000	20.00	85-90 %
Monitoring	1,000	6.67	0 %
Total	**$53,522**	**$356.81**	

Gallatin National Forest - Cutler Meadow Proposed Seed Mix

Group	Priority	Common Name	"Variety"	Seeds Per Pound	Need Per Acre 1/ PLS Lbs	Need Per Acre 1/ Bulk Lbs	PLS/Sq. Foot	Project Needs 2/ Acres	Project Needs 2/ PLS Lbs	PLS Cost Per Lb	Total Cost
1	**1**	**Western Wheatgrass**	**Rosanna**	**110,000**	**2**		**5.0505**	**150**	**240**	**1.5**	**360**
	1	Bluebunch Wheatgrass	"Local"	140,000							
	2	**Bluebunch Wheatgrass**	**Anatone**	**140,000**	**2**		**6.4279**	**150**	**240**	**2.5**	**600**
	3	**Bluebunch Wheatgrass**	**Goldar**	**140,000**							
	1	**Thickspike Wheatgrass**	**Critana**	**154,000**	**1**		**3.5354**	**150**	**150**	**2.75**	**412.5**
	1	Idaho Fescue	"Local"	450,000							
	2	**Idaho Fescue**	**Winchester**	**450,000**	**1**		**10.331**	**150**	**150**	**5**	**750**
	1	**Sand Dropseed**		**5,300,000**	**0.1**		**12.167**	**150**	**15**	**4.6**	**69**
	1	Annual Ryegrass		227,000							
2	1	Sandberg's Bluegrass	"Local"	925,000							
	2	**Sandberg's Bluegrass**		**925,000**	**1**		**21.235**	**150**	**150**	**4.5**	**675**
	3	Big Bluegrass	Sherman	882,000							
	4	Canby Bluegrass	Canbar	926,000							
3	1	**Basin Wildrye**	**Trailhead**	**130,000**	**3**		**8.9532**	**150**	**450**	**2.5**	**1125**
4	1	**Lupine**		**20,000**	**0.25**		**0.1148**	**150**	**37.5**	**14**	**525**
	1	**Buckwheat**		**200,000**	**0.2**		**0.9183**	**150**	**30**	**25**	**750**
	1	Yarrow	"Local"	2,770,000							
	2	**Yarrow**	**Great Northern**	**2,770,000**	**0.1**		**6.359**	**150**	**15**	**9**	**135**
5	1	Great Basin Big Sagebrush	"Local"	2,500,000							
	2	**Great Basin Big Sagebrush**		**2,500,000**	**0.05**		**2.8696**	**150**	**7.5**	**18**	**135**
	1	**Great Basin Wyo Sagebrush**		**2,500,000**	**0.05**		**2.8696**	**150**	**7.5**	**18**	**135**
	Drill Total				**10.75**		**80.831**	**150**	**1492.5**		**5671.5**
	Cost per pound with forbs and shrubs							**1**		**3.8**	
	Cost per pound without forbs and shrubs (ie. Less Groups 4 and 5)							**1**		**2.8613**	

OTO and Hayes Horse Pastures - GNF Restoration Strategy

Driving Forces:

- Competition from weeds
- Horse pasturing
- Low wildlife usage and soil erosion

Restoration Goal:

Maintain vegetation compatible with horse usage, while not creating a source of invasive species for surrounding areas.

Restoration Strategy:

- Characterize the site to determine the vegetation present, horse carrying capacity (forage lbs/acre), and the appropriate grazing timing and intensity.
- Interseeding the site with desired forage species may be necessary.
- Do not plant non-native pasture species that will spread from this site or that horses can disperse.
- Plant some nitrogen-fixing species, (e. g. alfalfa) and repair ditch to bring water to the site.
- Irrigate, and possibly fertilize if soil test indicates.
- Plant western wheatgrass and Great Basin wildrye in barren areas. These species, however, are slow to establish and may be susceptible to wildlife grazing.
- Consider chisel plow to break up the ground but with consideration that any tillage might create barren ground that will not recover with horse use and will invite invasive species.
- Use a light treatment of Buctril® to treat *Alyssum* during dry periods, and monitor *Alyssum* to see if it drops out with irrigation.
- Control cheatgrass (*Bromus tectorum*) and invasive species (spotted knapweed) in the area through spot herbicide application.
- Rest pasture until 50 percent of the seeded species are reproducing.

OTO West Pasture Restoration Strategy

Driving Forces:

- Invasive species such as spotted knapweed are present
- Pasture seems to be repairing itself

Restoration Goal:

Maintain a sagebrush community with desired perennial grasses.

Restoration Strategy:

- Spot-spray spotted knapweed
- Promote reestablishment of rabbitbrush and sagebrush, drag sagebrush-seeded branches in December to January to disperse seed, and inter-seed in bluebunch wheatgrass through broadcast application.
- Control cheatgrass by weed whacking seed heads prior to seed set or spraying with Arsenal and seeding afterwards. Do not try to control cheatgrass by controlling rodents and earthworms. Rodent re-establishment will likely be rapid. The treatment for rodents and earthworms (Timic®, which is mobile and persistent) might be worse than the problem.

McPherson Pasture Restoration Strategy

Driving Forces:

- Fencing not practical due to high bison usage and movement
- Competition from invasive grasses such as smooth brome (*Bromus inermis*)

Restoration Strategies:

- Control smooth brome by chisel plowing and Roundup™, then seed in western wheatgrass, bluebunch wheatgrass, thickspike fescue, Sandberg bluegrass, Great Basin wildrye, yarrow, lupine, big and Wyoming sagebrush.
- Alternatively, leave the brome so as not to create a bare patch that won't regenerate, and wait to see how natives are establishing on their own.

Travertine Mine Restoration Strategy

This site was not a part of the original sites to be examined. It was never farmed, but because of its proximity to other sites, the group stopped and gave the following recommendations for restoration:

Driving Forces:

- Formerly mined site
- Rocky area with little to no top soil
- Heavy compaction

Restoration Goal:

Establish a rabbitbrush, juniper, sagebrush shrub community and let herbaceous species self establish.

Restoration Strategy:

- Consider applying compost or some fine material to create seedbed, but be careful not to introduce weed seeds.
- Consider deep compost to enhance water holding capacity for shrubs.
- Spot spray weeds.
- Do NOT irrigate.
- Consider re-contouring to address aesthetics.
- Control illegal dumping.
- Look into Abandoned Mine Land program for potential funding.

Alternatively consider using these mines sites as fill sites from NPS road building work, being careful to control emerging invasives.

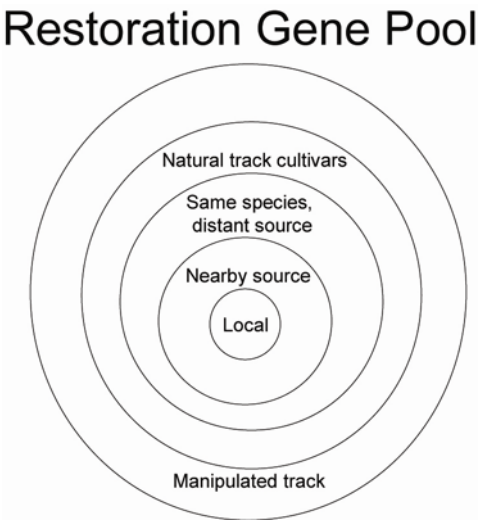
Discussion on Wildlife Fencing

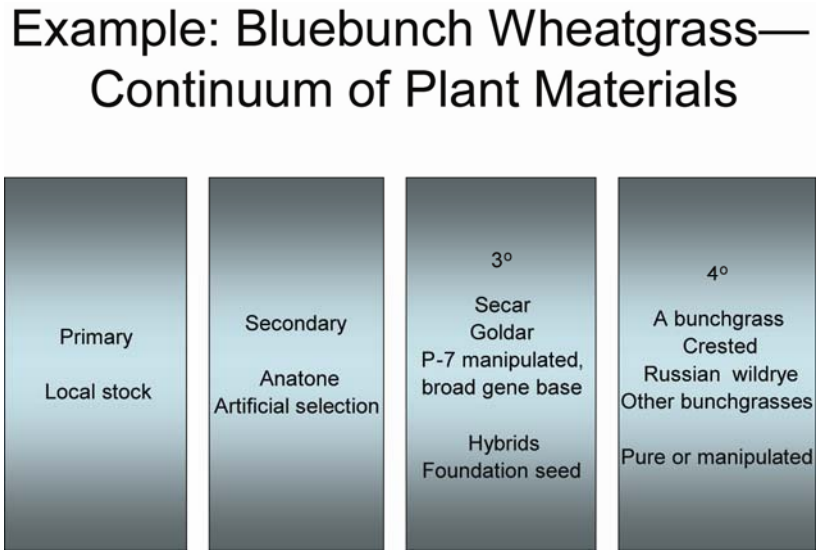
Fencing to exclude various wildlife species should be:

- Bison: 60” high, solid bracing and support posts
- Elk: 6’ or higher
- Antelope: Woven to stop from going under
- Mule Deer: 6’ or higher

Discussion on Genetics and Restoration Materials

Roger Rosentreter led a discussion on the appropriate use and continuum of genetic materials for restoration. Wherever possible, locally collected seed source is probably best, depending on availability factors. In some instances, the restoration project may require that increasingly far-removed plant materials are necessary.





"Next Steps"

- Steering Committee revise will this draft then sends the revised version to whole group for feedback.
- Monica Pokorny will add comments on best practices and rational for treatments, and insert highlighted questions for group regarding specific-issue references citations and unanswered questions.
- Larry Holzworth, Dennis Neuman and Greg Eckert will send templates for restoration plans to Mary Hektner.
- Greg Eckert send will a handbook on describing desired future conditions to Mary Hektner.

Closing Comments

Individual group members had a chance to make summary comments at the end of the workshop. Their comments:

- Determine the exact soil condition in farmed areas and decide how to repair the soil.
- Top 12 to 18 inches of the soil profile typically needs to be free of compaction.
- Drill seeding might provide for 90% success while broadcast seeding 20%.
- Firming up the seed bed through cultipacker or Brillian packing helps seal moisture with seed drawing through capillary processes.
- NPS is working on a program to fine tune definition of “what is local” and is creating a handbook to help restorationists describe desired future condition.
- I won’t say that what you’ve got it easy, but with some good planning and a solid approach, in ten years you won’t remember how bad these sites looked. Year one will look bad, but years two and three will look better.
- Need to look at the bigger picture with wildlife and restoration interactions.
- Remember to address processes in restoration plans, keep addressing causes of problems and not just symptoms.
- Top 12 to 18 inches of the soil profile typically needs to be free of compaction.
- Drill seeding might provide for 90% success while broadcast seeding 20%.
- Firming up the seed bed using a cultipacker or brillian seeder helps seal moisture with seed drawing through capillary processes.
- You have to have a lot of patience to do restoration.

Appendix A: Workshop Participants

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The names of the Gardiner Basin Restoration steering committee are shown in **bold**.

Appendix B: Gallatin National Forest's Implementation Plan for Cutler Meadows

Cutler Meadow Restoration
Scoping Document
Gardiner Ranger District
Gallatin National Forest

March, 2006

Introduction

The Gardiner Ranger District proposes to restore a native plant community to the Cutler meadow, a former 155 acre agricultural alfalfa field acquired from the Royal Teton Ranch though the Rocky Mountain Elk Foundation in 1999. The Cutler meadow is located west of the Yellowstone River about 13 miles north of Gardiner, Montana, just upstream from Yankee Jim Canyon. The restoration project is the first in a series that will focus on restoring native plant communities to acquired agricultural lands in the Gardiner Basin. The Cutler meadow was tilled and irrigated throughout the twentieth century until 1999. A water right was acquired with the purchase. Native vegetation has disappeared and a variety of weeds have invaded the site.

Cutler meadow looking north toward Dome Mountain

In April, 2005, Yellowstone National Park, the Gallatin National Forest, and the Center for Invasive Plant Management at Montana State University sponsored the Gardiner Basin Restoration Workshop. A group of restoration experts convened to develop recommendations for a restoration plan for acquired properties within the Gardiner Basin.

Cutler Meadow Restoration Goal

Restore a mosaic of sustainable native plant communities that provides for wildlife habitat and forage.

Restoration Strategy

1. Soil tests – Spring, 2006
2. Treat existing vegetation with herbicide when plants are fully emerged – Summer, 2006
3. Follow up spot herbicide treatment of alfalfa, Canada thistle and Russian knapweed – Summer, 2006
4. Chisel plow to fracture historic plow layer – Fall, 2006 or Spring, 2007
5. Harrow – immediately following plowing
6. Fertilize as prescribed by soil tests
7. Irrigate (water rights were acquired with the property) – Summer, 2007
8. Install an 8-foot temporary woven wire fence (with gates) on 3 sides of the 155 acres (not the river side). Gates will be opened during wildlife migration periods and during winter months (volunteer projects if possible) – Summer, 2006 and 2007
9. Drill seed into plowed field – Fall, 2007
10. Spot treat invasive weeds as necessary – Summer, 2008
11. When native plants are established, remove woven wire fence (volunteers).

Cutler meadow looking south

Plants Under Consideration

- Bluebunch wheatgrass
- Western wheatgrass
- Great Basin big sagebrush
- Great Basin Wyoming sagebrush
- Rabbitbrush
- Great Basin wildrye
- Sandberg's bluegrass
- Green needlegrass
- Slender wheatgrass
- Idaho fescue

- Sand dropseed
- Lupine
- Buckwheat
- Yarrow

Restoration Steps

1. Soil test – 7 pits (1 pit/20 acres), test for N,P,K,S,B, soluble salts, exchangeable Na, electrical conductivity, pH, organic matter, plow layer. Be prepared to till the trace elements in well during the harrowing stage, especially any needed phosphorous. Needed nitrogen, on the other hand, wouldn't be applied until after the grass seedlings are 12 to 16 months old. Identify depth of plow layer and need for fertilization
   Who: Gallatin Forest Soil Scientist
   When: Spring, '06

2. Treat existing vegetation when fully emerged – Spring application of roundup (16 oz/Acre) with ammonium sulfate (NH4SO4) enhancer OR a fall application followed by a spring application if needed. Consider a fall and spring application if fall rains support a fall green up flush of annuals.
   Who: Contract Boom Sprayer
   When: Earliest would be Fall, '06 followed by Spring, '07

3. Spot treat Canada thistle and spotted and Russian knapweed at bud to early flowering stage – Milestone (5-7 oz/Acre) or Transline (1 pint/Acre) as an alternate if Milestone isn't permitted. All broadscale applications should consider using non-persistent herbicides instead such as roundup, 2,4-D, etc.
   Who: Current weed spraying contractors
   When: Ongoing through life of project

4. Spot treat alfalfa to reduce wildlife attraction at pre flower stage, ie maximum foliage – Starane (3/4 pint/acre) and Dicamba (4 oz/Acre).
   Who: Current weed contractor
   When: OPTIONAL if prior weed treatments are not successful in killing or minimizing alfalfa

5. Chisel plow 10" deep (minimum) to fracture historic plow layer in early summer– Use a 135 to 145 horse tractor, such as the Challenger Cat, which rents for about $40/hr. Churchill Equipment suggests we consider using a conservation chisel which does deep tillage well at $5/acre with a 180 to 200 horse power tractor at $40/hr. Since there isn't much residue on the surface it probably doesn't matter what we use so long as we don't turn over the ground like a plow. A plow puts a lot of pressure on the sublayer and that compaction is what we are really trying to break up. Also strive for no more than 12 to 14 inch spacing between the tines. Consider cost-share purchase of chisel plow if YNP tractor is available to do the plowing.
   Who: Contract
   When: April, May '07 as early as possible

6. Harrow immediately after plowing with a tine-type harrow to breakup the clods.
   Who: See #5 above
   When: See #5 above

7. One time irrigation – August/September to add 3 inches moisture to the soil profile. This will force the grass seedlings to go deep for moisture as they become established the following growing period.
   Who: Contract or Forest Service force account
   When: August/September, 2007

8. Harrow one more time to remove annual weeds prior to planting with the tine-type harrow again. Fertilize as recommended by soil scientist after his soil tests. Probably post-irrigation so fertilizer does not leach out during irrigation.
   Who: See #5 above
   When: Early October, '07

9. Optional: Install preferably 8, not 6, foot high net wire fence on at least the west side of the field to keep a majority of the wildlife out. Install large enough gates that big game may be allowed to cross when necessary.
   Who: Obtain cost estimate for both contract fence building and constructing force account or with volunteers
   When: Fence can be built anytime prior to emergence of plants following seeding. Summer, '06 or Summer, '07

10. Pack the seedbed so that the seed isn't planted too deep – the spiral packer. Prefer using a cultipacker if planting will follow in the fall.
    Who: Contract
    When: Just prior to planting. October, '07

11. Seed Grasses – Utilize preferably the truax drill to plant the grass seed. A Tye drill would be a substitute if the truax is not available. Avoid leasing the truax "rough rider" model. Timing of planting maybe more suited to spring if seed can be planted just before ample early spring rains. This would lesson the chances of mortality due to winter emergence, and freezing with a October/early November seeding.
    Who: Contract
    When: October/November, '07 or April, '08 if we want to bet on ample spring rains (optimum)

12. Post seeding herbicidal control of annual weeds in the early spring when broadleaf plant rosettes are 1 inch diameter or less and the young grasses have no more than 2 leaves with the focus being the young annual alien grasses. The need for treatment may be overlooked if there isn't enough alien annuals present: thus, requiring close monitoring. Roundup (3 oz/acre) application, preferably by helicopter. If the window is missed then consider mowing instead.
    Who: NPS or NRCS personnel would be excellent sources of help.
    When: May/June, '08

13. Kochia control using a mix of Buctril (1 pint/Acre) and Starane (3/4 pint/acre). Herbicide is selective to Kochia and not persistent.

Who: Contract
When: June, '08 or when there is a good flush of Kochia

14. Interseed, criss cross, forb and shrub seed after grasses become established – Utilize the truax drill again and alternate seed boxes for spacing the sagebrush seed. Dilute the seed with rice hulls. Idealy, place the seed on the surface and then press it into the soil surface with the press wheels as is the case for most forbs and shrubs. Identify flood plain and avoid planting sagebrush in flood plain, instead encourage the wildrye.

Who: Contract
When: 1-2 years following establishment of grasses

15. Spot treat knapweeds and Canada thistle with Milestone (5-7 oz/Acre) or Transline (1 pint/Acre) as an alternate if Milestone isn't permitted.

Who: District Contract
When: Annually

Timeline

2006

- Soil testing - spring
- Herbicide treatment of existing vegetation - summer/fall

2007

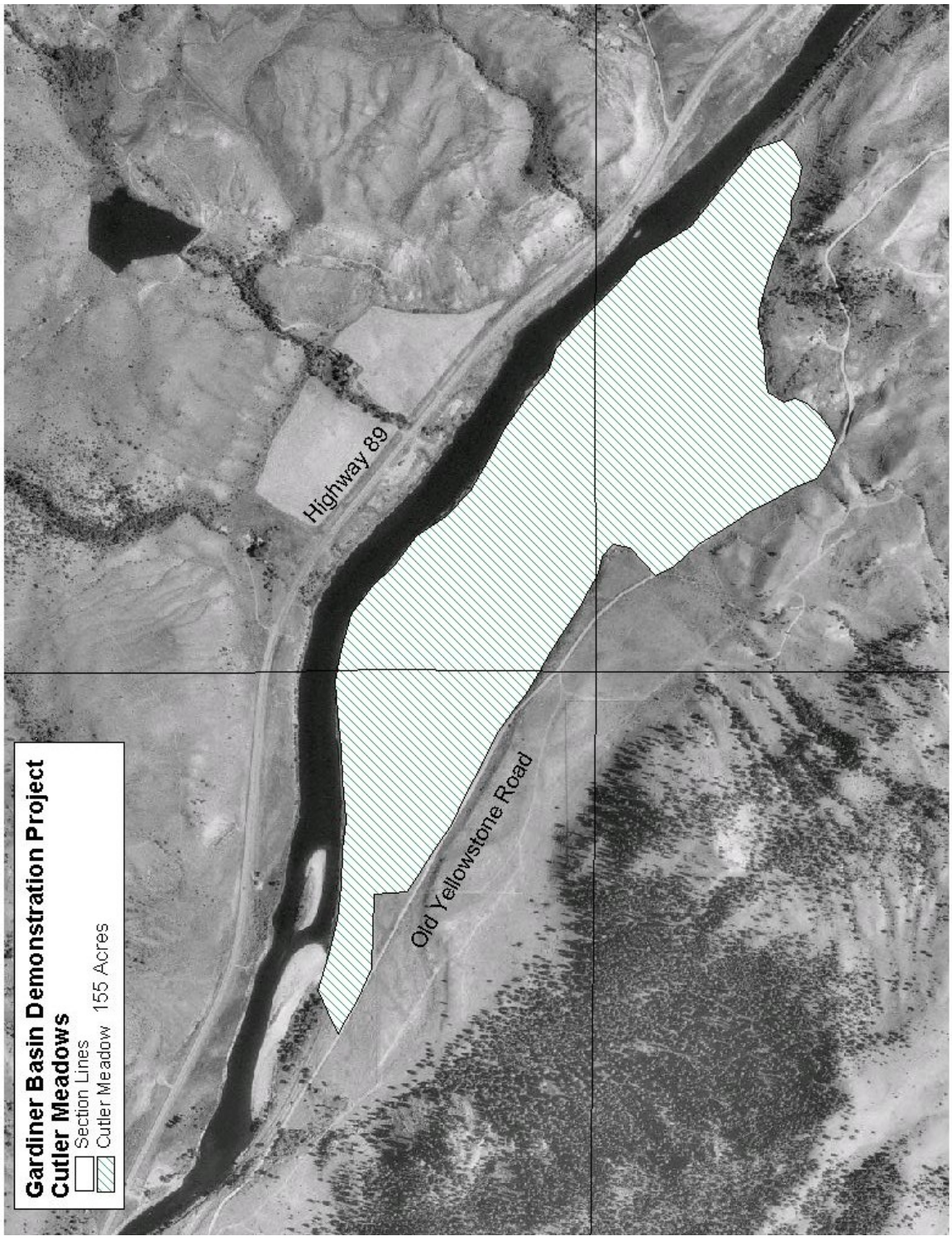
- Spot herbicide treatment – spring/summer
- Plow and harrow – spring/early summer
- Irrigate – summer
- Harrow & cultipack – fall
- Seed – Fall

2008

- Seed grasses – spring (if not done fall, '07)
- Spot herbicde treatment as needed – summer

2009 and Beyond

- Inter-seed forb and shrub seed when grasses are established – spring
- Monitor and treat noxious weeds as necessary


Gardiner Basin Demonstration Project
Cutler Meadows
Section Lines
Cutler Meadow 155 Acres
Highway 89
Old Yellowstone Road

Appendix C: Yellowstone National Park's proposal for Implementation of a Pilot Restoration Project

United States Department of the Interior

NATIONAL PARK SERVICE
P.O. Box 168
Yellowstone National Park
Wyoming 82190

Vegetation Restoration in the Gardiner Basin, Yellowstone National Park

Yellowstone National Park is proposing to restore native plant communities to approximately 700 acres of former agricultural fields located west of the Yellowstone River between Gardiner, Montana and the park's northern boundary at Reese Creek. The work would be done in stages over many years, subject to availability of funding.

Background: In the 1930s, over 7,000 acres of land was added to the northwest corner of Yellowstone National Park though purchase and eminent domain to provide key low elevation winter range for elk, pronghorn, bison and deer. Approximately 700 acres of the addition were irrigated agricultural fields. Following acquisition, the park ceased irrigation and seeded the fields to crested wheatgrass (*Agropyron cristatum*), an exotic perennial grass which was recommended because it was aggressive, would crowd out weeds, was drought resistant, undergoes early green up and was (erroneously) thought to provide better forage than native plants. It thrived and for many decades was almost the only plant species present. In the past few years of drought, however, even the crested wheatgrass has been dropping out leaving large patches of unvegetated soil, or areas which have been invaded by monotypic stands of an exotic mustard, desert alyssum (*Alyssum desertorum*). We fear that cheat grass (Bromus tectorum) and various knapweeds (*Centaurea* sp) could be the next wave of exotic plants to invade the Gardiner Basin.

The current vegetation provides poor forage for ungulates and the physical and ecological condition of these sites continues to degrade. The park has attempted a variety of native revegetation experiments that have failed. In retrospect, they were too small in scale, too short term, and failed to recognize the special remedial actions needed to repair these degraded semi-arid soils so that they can again sustain the native vegetation.

The Gardiner Basin (defined as the Yellowstone River valley between Yankee Jim Canyon and Gardiner, Montana) lies within the rain shadow of the Madison and Absaroka/Beartooth mountain ranges. It typically receives less than 10 inches of precipitation per year, and stays relatively free of snow. Summertime temperatures can exceed 100 F. High levels of sodium are common, affecting productivity, erosion potential, and plant communities. High clay content causes the soil to compact and "seal" when wet. During dry periods, large amounts of soil are lost through wind erosion.

Recognizing that the park staff did not have the experience in arid land restoration that was needed, the park joined with Gallatin National Forest and the Montana State University-based-Center for Invasive Plant Management to convene a restoration workshop in April 2005. Ten specialists in arid land restoration were invited to help Yellowstone and Gallatin National Forest (which acquired similar former agricultural lands for wildlife habitat adjacent to the park) develop recommended long-term restoration/ management plans for approximately 1,200 acres of former agricultural fields within the Park and Gallatin National Forest.

The workshop resulted in recommended strategies and extended timeframes specific for arid land restoration. The park is currently seeking funding to implement those recommendations:

Gardiner Basin Restoration Goal

To restore a mosaic of sustainable native plant communities that provides wildlife habitat and forage.

Desired species include, but are not limited to Sandberg's bluegrass (*Poa sandbergii*), bluebunch wheatgrass (*Agropyron spicata*), needle and thread (*Stipa comata*), Junegrass (*Koeleria macrantha*), Indian ricegrass (*Oryzopsis hymenoides*), wild onion (*Allium textile*), winter fat (*Krascheninnikovia lanata*), saltsage (*Atriplex garderni*) rabbit brush (*Chrysothamnus nauseosus* and *C. viscidiflorus*), greasewood (*Sarcobatus vermiculatus*), western bluegrass (*Agropyron smithii*), Wyoming Big Sage (*Artemisia tridentata* var. *wyomingensis*) and prickly pear cactus (*Opuntia polyacantha*).

Proposed Restoration Steps

Implementation would proceed in multi-year phases to allow for plant establishment under natural conditions, monitoring and refinement of methods to maximize success, and to allow wildlife to continue to use portions of the surrounding area during the restoration work.

Twenty to fifty-plus acre plots would be temporarily fenced to exclude ungulates while the vegetation is becoming established. (The number and size of sites is dependent on funding.) We would monitor to see how quickly the vegetation is established, but the experts told us to expect that the fences would have to stay in place at least 5 years.

The sites would be sprayed with Roundup or other appropriate herbicides in the early spring to kill the emerging exotics which are predominantly mustards and crested wheatgrass. This would be followed by no-till drilling of a preparatory cover crop—such as "Otis" barley or a sterile cereal crop species which are drought tolerant and early spring germinators. Wind erosion is a serious problem and the experts told us that we had already lost tons of organic matter—further exacerbating the soil's ability to hold moisture. The preparatory crop would hold the soil, provide competition to the weeds and as it rots, add organic matter back to the soil. The no-till method doesn't fluff up the soil and therefore it is less susceptible to blowing away.

Before the preparatory cover crop goes to seed, it would either be mowed, or if weeds are a problem, sprayed with an herbicide to terminate the crop (and weeds). The stubble would be left to capture moisture and soil and add organic matter. Weeds would be spot-treated throughout the growing season as needed.

The second year (and possibly a third year—depending upon the success of the preparatory crop) would be a repeat of the first year in order to further reduce the weeds and build up the soil.

In late fall of the second or third year, native species would be no-till drill seeded into the stubble of the cover crop. The restoration sites will not be irrigated. Irrigation can lead to shallow rooting and decreased survival. It is better to establish the plants under natural conditions. The plants that do become established will have a better chance of long-term survival.

The work would be monitored throughout, and methods adjusted to maximize success. Noxious and other weeds would be spot-treated as necessary.