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RESTORATION WITH NATIVE INDIGENOUS PLANTS IN YELLOWSTONE AND GLACIER NATIONAL PARKS

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ABSTRACT

The U.S. Department of Interior National Park Service has adopted a policy of 'restoration' with native indigenous plants on all disturbances related to road construction, visitor impact, and facility maintenance. The National Park Service is committed to maintaining the genetic integrity of the, often, unique native flora, with secondary goals of erosion control, competition with exotic and noxious invasive plants, and improved aesthetics. Since 1986, Yellowstone and Glacier National Parks have been working cooperatively with the USDA-NRCS Plant Materials Center in Bridger, Montana to determine which native plant species can be readily collected, increased, and successfully reestablished on disturbed sites. To maximize species diversity and compatibility, plant mixtures are designed to minimize competitive interactions. Seed mixtures are a combination of short-lived perennials (early colonizers) and long-lived perennials (late seral dominants). To capture the genetic diversity of early successional (primarily selfed) plants, seed is collected from several populations within a project area. However, with the late seral dominants (primarily outcrossed) the number of populations needed to harvest is significantly less. Early colonizing species usually have abundant and consistent seed production, effective seed dissemination, higher germination percentages, and broad tolerances of disturbed sites. Late seral dominants are found on older, less severely impacted areas. They are included in mixtures to accelerate succession, but they may not always be suited to the edaphic conditions of a severely impacted site. The production of seed and/or plants of native species at a site remote to the Parks had been found to be possible with minimal genetic drift or natural selection. With topsoil salvage and utilizing native indigenous plant material, Yellowstone and Glacier National Parks have developed very successful restoration programs.

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INTRODUCTION

Revegetation, reclamation, and restoration--all imply the reestablishment of plant cover on a disturbed site, but if taken literally may imply three levels or intensities of site mitigation. 'Revegetation' is simply the re-establishment of a plant cover, often a monoculture of an introduced plant species. Although relatively inexpensive, revegetation may not offer permanence or ecological stability. 'Reclamation' has been defined historically as the process of returning disturbed land to a condition that approximates the original site conditions and is habitable by the same or similar plants and animals which existed on the site before disturbance (Redente et. al 1994). 'Restoration' strives to emulate the structure, function, diversity, and dynamics of a specific ecosystem. Topsoil salvage can preserve the soil biota along with viable propagules of indigenous plant materials. By utilizing native indigenous plant material (seed, cuttings, transplants), the genetic integrity and diversity of the native plant communities will be maintained. Even with soil salvage and the use of native indigenous plant materials, restoration must not be interpreted as a discrete event, but rather as an ongoing process involving the reestablishment of nutrient cycling, plant succession, and plant community dynamics.

The U.S. Department of Interior National Park Service (NPS) has adopted a policy of 'restoration' of all disturbed sites related to road construction, visitor impact, and facility maintenance. The NPS is committed to maintaining the genetic integrity of the, often, unique native flora, with secondary goals of erosion control, competition with exotic and noxious invasive plants, and improved overall aesthetics of disturbed sites. In 1985, with financial support from the Federal Highway Administration, both Yellowstone National Park (northwestern Wyoming) and Glacier National Park (northwestern Montana) initiated a restoration program that involved topsoil and plant salvage, native indigenous seed collection and production, plant propagation from seed and cuttings, and extensive seeding and planting of disturbed sites. A nationwide cooperative agreement between the National Park Service and the U.S. Department of Agriculture--Natural Resources Conservation Service Plant Materials Centers (PMCs) was established in 1986 to assist in the determination of which native species could be readily collected, increased, and successfully reestablished on disturbed sites. The decision by the NPS to adopt a restoration policy has generated many unanswered questions and much controversy concerning the protection and preservation of the indigenous gene pools, e.g.,

- +What plant species can be considered indigenous to an open disturbance in a forest community?
- +What constitutes the limits of a genotype? How far away from the project area can plant propagules be collected and still be within these limits?
- +What species can be readily collected and produced using standard agricultural techniques?
- +By taking seed outside of the park to a dissimilar environment to increase seed or plants, is genetic drift or natural selection going to impact the genetic integrity of the plant material?
- +What plant species will be compatible in mixtures and what type of plant community is an acceptable restoration goal?

SPECIES SELECTION

Once the NPS made the decision to utilize native indigenous plant materials in its restoration efforts, its next decision was to determine what species would naturally colonize on open disturbances within forest communities. In Yellowstone National Park, the first road project was through lodgepole pine (*Pinus contorta*) habitat types, whereas in Glacier National Park, the first project was along Lake McDonald through a cedar-hemlock (*Thuja plicata/Tsuga heterophylla*) habitat type. It was assumed that the understory species of the adjacent forest communities would not be adapted for use on the open road corridors. By examining abandoned roads, burns, old disturbance areas (both manmade and natural) the early colonizing species were identified and by examining open parks and meadows the late seral dominants were identified. Chambers et al. (1984), working in the alpine zone of the Beartooth Mountains of South-Central Montana, found early colonizing species to have characteristics most desirable for reclamation of alpine disturbances. These species exhibited an ability to establish and grow on harsh phytotoxic sites, frequently have larger ecological amplitudes, and are distributed over wide geographic areas. Harper (1977) stated that early colonizing species usually had abundant and consistent seed production, effective seed dissemination, higher germination percentages, and broad tolerance for establishment on disturbed sites. Late seral dominants, on the other hand, as defined by Johnson and Billings (1962), are found on older and less severely disturbed sites. These species are often included in seed mixtures to accelerate succession, but may not be completely successful because of competition from early colonizers, or simply may not be suited to the edaphic conditions of the disturbed site. Both Yellowstone and Glacier Parks are creating mixtures for each specific project that include both early colonizing and late seral dominant species (table 1). Mixtures are relatively simple, relying somewhat on existing propagules in the salvaged topsoil and seed rain from adjacent areas to compliment the seeded material.

Table 1. Native plant species found to reestablish naturally on disturbed sites in Yellowstone and Glacier Parks.

COLONIZERS			
<u>Short-lived Perennial Grasses</u>		<u>Perennial Forbs</u>	
Elymus trachycaulus	slender wheatgrass	*Achillea millefolium*	western yarrow
Bromus marginatus	mountain brome	*Anaphalis margaritacea*	pearlyeverlasting
Elymus elymoides	bottlebrush squirreltail	*Phacelia hastata*	silverleaf phacelia
Elymus glaucus	blue wildlrye	*Aster integrifolius*	thickstem aster
		Solidago canadensis	goldenrod
		Viguiera multiflora	showy goldeneye
LATE SERAL DOMINANTS			
<u>Long-lived Perennial Grasses</u>		<u>Perennial Forbs</u>	
Poa ampla	big bluegrass	*Lupinus argenteus*	silvery lupine
Deschampsia cespitosa	tufted hairgrass	*Eriogonum umbellatum*	sulfur eriogonum
Pseudoroegneria spicata		bluebunch wheatgrass	*Penstemon confertus*
	yellow penstemon		
Festuca idahoensis	Idaho fescue	*Geranium viscosissimum*	sticky geranium
Poa alpina	alpine bluegrass	*Potentilla gracilis*	cinquifoil

Phleum alpinum	alpine timothy
Agrostis scabra	rough bentgrass

GENOTYPE DETERMINATION

The genetic variability within and among plant populations vary by species as a function of geographic range, reproduction mode, mating system, seed dispersal mechanism, and stage of succession (Hamrick 1983). Whether a species is self-pollinating or outcrossing makes a difference in genetic variability. The selfing mode of reproduction limits the movement of alleles from one population to another, so these species are found in small disjunct populations with little variation within a population, but distinct variation among populations. Outbreeding plants have widely dispersed pollen and seed, and tend to exhibit significant variation among individuals but less variation among populations. Species with winged or plumose seeds have the greatest potential for gene movement and subsequently have less variability among populations.

To capture the genetic diversity of early successional stage (primarily selfed) plants, seed would have to be sampled from several populations within a project area. However, with late seral dominants (primarily outcrossed), the number of populations that would need to be harvested is significantly less.

When a disturbed site is planted with seed from an adjacent or close proximity site there is a possibility that a distinct, new genotype may develop. Jain and Bradshaw (1966) found that those species that evolve on a disturbed site may actually be genetically different than individuals of the same species on adjacent undisturbed sites. Antonovics (1968) found that on harsh sites characterized by low pH and heavy metals, grass species had the ability to change from an outcrossing to a self-pollinating mode of reproduction in order to prevent dilution of the gene pool by adjacent unadapted populations. This raises the question of the need to harvest from many sites if a new distinct genotype will evolve on disturbed sites as influenced by the harshness and edaphic conditions of the site.

At this point, what actually constitutes a genotype is more theory than fact. Presently, some national parks have self-imposed collection restrictions of 5 km for short-lived, self-pollinating species, 8 km for short-lived outcrossing species, and up to 16 km for long-lived outcrossing species. These distances may be smaller if there are major changes in geography and plant community types within the project area. Yellowstone Park has adhered to these collection radiuses, while Glacier Park is collecting in close proximity of the projects sites in the alpine region (Logan Pass) and the fescue grasslands (east slope of Continental Divide), but have gone outside the park to burned areas and forest clearcuts to meet the needs for colonizing species to use along road corridors through the dense Cedar\Hemlock habitat types west of the Continental Divide.

SEED AND PLANT PRODUCTION

There is some question as to how much natural selection and genetic drift will occur when seed is grown at a site remote from the original source. Merrell (1981) stated that individuals developing at the same time, but under different environmental regimes, may have different phenotypes develop, even though their genotype is essentially the same. Seed production at a site remote from and dissimilar to the original collection site, has the potential for natural selection and genetic drift. There is a potential for a decrease in genetic diversity at several stages of production, i.e., the sizing nature of the cleaning process may exclude the largest and smallest seeds, harsh conditions at the time of germination and emergence may limit the survival to only the most viable seeds, as individual plants compete for space and nutrients in the seed production field some individuals may succumb to others, and during the harvesting process only those seeds that are mature at the time of harvest will be represented--early and late maturing individuals will be excluded. Samples of three generations of mountain brome were evaluated both phenotypically and genotypically by Dr. Thomas Mitchell-Olds and Dianne Pavek at the University of Montana-Missoula. The original collection (G_0) was collected in the Dickie Creek drainage at the southern border of Glacier Park (1987), the second generation (G_1) was produced at the Bridger PMC (1990) in a field established with G_0 seed, and the third generation (G_2) was produced at the Bridger PMC (1992) from a stand established with G_1 seed. Mitchell-Olds (1993) found the phenotypic variation (comparing morphological characteristics at three common garden sites in GNP) and genotypic variation (isozyme electrophoretic analysis utilizing 25 scorable bands) was non-significant among the three generations of mountain brome. The distance coefficients (after Johnson and Wischern 1982) and the similarity coefficients (after Gottlieb 1977) indicated that there was very little difference among the original mountain brome collection and the two subsequent generations grown at the Bridger PMC. Although this data is for only one species, it supports the potential for producing native indigenous plant materials at sites remote from their source with minimum impact on the genetic integrity of the original gene pool.

If commercially produced native seed is to be used in restoration projects, the planning process must allow at least three years; the first to collect seed, the second to plant and establish a seed production field, and the third to make the first seed harvest. Three to four harvests can be taken from a field before production drops to an uneconomical level. The cost of producing seed under commercial conditions varies greatly with species, size of field, yearly environmental conditions, and the timing of harvest. Seed production under cultivated conditions, however, produces a more reliable quantity and quality of seed than under natural conditions. Both Yellowstone and Glacier National Parks utilize multiple sources of plant material for their restoration projects. Salvaged plant material is either directly transplanted or potted for later use. Seed of native indigenous plants is collected for direct seeding, seeding of flats or containers, or for seed increase at the Bridger Plant Materials Center; cuttings are propagated at each Park's own nursery facilities, and containerized material is grown at their nurseries or contracted to commercial nurseries.

To date, there are only a few private growers that are attempting to grow native indigenous ecotypes under contract with the National Park Service and the U.S. Forest Service. Contracts with private growers include stipulations to guarantee genetic purity, and usually a set price and maximum/minimum amount of seed that will be purchased. Many of the native species of grasses and forbs that are under consideration for use in restoration projects have not been grown commercially—leaving questions about germination and dormancy problems, establishment techniques, cultural management, and harvest. The cost of production is dependent on the size of the production field, difficulty in maintaining a clean pure stand, uniformity of ripening, ease of harvesting, and ease of cleaning (table 2).

Table 2. Average cost of production of seed production of native plants based on field size, ease of production, and ease of cleaning. Average of several Plant Materials Centers involved in National Park Restoration Projects.

	Ease of Production and Cleaning		
	Easy	Moderate	Difficult
GRASSES			
Small amount (0.1 acre or less)	$35/lb	$50/lb	$100/lb
Medium amount (0.1 to 0.25 acres)	$25/lb	$40/lb	$ 75/lb
Large amounts (0.25 + acres)	$15/lb	$30/lb	$ 60/lb
FORBS	$50-$100/lb	$100-$300/lb	$300+/lb

The cost of production varies drastically among different native species. Grasses such as mountain brome and slender wheatgrass are relatively easy to grow and are very productive under cultivated conditions. Species like needlegrasses and bottlebrush squirreltail are difficult to harvest and process because of awns, while some sedges, junegrass (*Koeleria macrantha)*, and reedgrasses/hairgrasses (*Calamagrostis/Deschampsia)* are notoriously poor seed producers. Seed of the forbs are relatively difficult to produce because stands are often difficult to establish by direct seeding and control of broadleaf weeds is limited to hand rogueing and a few agricultural chemicals.

The production of large quantities of seed of a few collections is far more cost-affective than the production of small quantities of several collections. More work needs to be done to determine what constitutes a genotype or how broad of an area can a specific collection be used and still protect the genetic integrity of the indigenous plant material.

PLANTING AND MONITORING

To maximize species diversity and compatibility, plant mixtures are designed to minimize competitive interactions. The goal of the restoration effort is to produce a plant community that is as stable as the adjacent undisturbed area, which can sustain itself while progressing through successional stages. The nature of the disturbance may place constraints on both the ability to restore the site and the subsequent success that occurs on that site (Chambers et al. 1990). To minimize competition, seed mixtures should not be too complex. With linear disturbances, in particular, seed rain from adjacent areas will provide added species diversity to a seeded plant community.

Restoration within Yellowstone and Glacier National Parks begins with the salvage of topsoil. The topsoil is carefully stripped and stored in windrows along the upper edge of the road project and redistributed on the prepared cuts and fills during the same growing season. The surface is left rough and downfall logs and rock are strategically placed to create micro-niches. Most of the seeding is done by hand broadcasting, followed by hand-raking or dragging the surface to bury seed and improve seed-soil contact. Mulching with wood chips, extruded aspen fiber, or straw is done on most projects to protect against surface soil erosion and reduce soil surface drying during germination and emergence. Seed mixtures are a combination of short-lived perennials (colonizers) and long-lived perennials (late seral dominants). The seed mixtures are relatively simple, consisting of four to six grasses and three to five forbs (table 3). Shrubs and some forbs are planted as transplants, containerized material or as bareroot stock.

Table 3. Basic seed mixtures developed for different vegetation types in Glacier and Yellowstone National Parks (other species are used as available).

GNP--Alpine	GNP--Fescue Grassland	GNP--Cedar\Hemlock
*Poa alpina**	*Bromus marginatus**	*Bromus marginatus**
*Phleum alpinum**	*Pseudoroegneria spicata**	*Elymus glaucus**
*Poa gracillima**	*Festuca idahoensis**	*Deschampsia cespitosa**
*Deschampsia atropurpurea**	*Festuca campestris**	*Calamagrostis rubescens*
*Carex hoodii**	*Koeleria macrantha**	
	*Elymus trachycaulus**	*Achillea millefolium**
Aster laevis		*Penstemon confertus*
Sibbaldia procumbens	*Gaillardia aristata**	*Penstemon albertinus*
Senecio triangularis	*Hedysarum boreale**	*Aster laevis*
Epilobium alpinum	*Geranium viscosissimum*	*Antennaria neglecta*
Hypericum formosum	*Heuchera cylindrica*	
	*Potentilla gracilis**	
YNP--Lodgepole Pine Forest	YNP--Northern Grasslands	YNP--Wetlands
*Bromus marginatus**	*Stipa comata**	*Deschampsia cespitosa**
*Elymus trachycaulus**	*Pascopyrum smithii**	*Agrostis scabra**
*Elymus elymoides**	*Leymus cinereus**	*Elymus trachycaulus**
*Agrostis scabra**	*Nassella viridula**	
*Poa ampla**	*Bromus anomalus**	*Pedicularis groenlandica*
		Gentiana detonsa
*Achillea millefolium**	*Achillea millefolium**	
*Lupinus sericeus**	*Linum lewisii**	
*Phacelia hastata**	*Potentilla fruticosa*	
*Potentilla gracilis**		
*Eriogonum umbellatum**		
*Viguiera multiflora**		

* Species of which seed or plants have successfully been produced at the Bridger Plant Materials Center.

Monitoring is an integral part of the restoration process; providing information on the success of establishment techniques, individual species establishment and survival, species compatibility, and the long range stability of the established plant communities. Glacier National Park's monitoring program is loosely based on the U.S. Forest Service ECODATA (Jensen et al. 1992) ocular plot methodology. This technique utilizes both microplot and ocular surveys of ground cover, species cover, species composition, erosion status, plant mortality, plant growth, and invasion of exotics. Both Parks utilize varying intensities of monitoring: Level I is basic documentation of ground cover and the presence of exotics (often used to document conditions on small backcountry projects); Level II is a general evaluation of surface status and total vegetation cover including species lists, mortality, plant density and overall plant vigor (most commonly used along road shoulders); Level III involves microplots and shrub transects to collect data suitable for statistical analysis (utilized on large obliterated turnouts and larger cut and fill slopes); and Level IV utilizes replicated plot designs to evaluate the effectiveness of various combinations of restoration treatments (seeded vs. unseeded, mulching vs. unmulched, fertilized vs. unfertilized, chemical control of weeds and exotics, nurse/cover crop alternatives).

The restoration attempts in Yellowstone and Glacier National Parks have made every effort to maintain the genetic integrity of the plant material, to salvage and protect the viability of the soil biota (micro-organisms, mycorrhizae, and plant propagules), and to create stable, self-sustaining plant communities on disturbed sites. These new plant communities continue to change as some of the colonizer species give way to the late seral species and as additional species appear as a result of seed rain from adjacent sites and topsoil borne plant propagules. Research results indicate that seeding and associated mulching practices provide erosion control, but do not totally restrict the encroachment of exotics without additional weed control measures.

Glacier Park has seeded the entire road-cut/fill, the barrow-ditch, and the road-edge. Much of the road-edge is periodically mowed. This mowing has had a significant impact on native species, reducing the stand density and cover. Most of the native species indigenous the higher elevations are bunchgrasses and many of the species used for restoration are short-lived perennials (pioneer-early colonizers). The bunchgrasses do not tolerate mowing and the short-lived perennials rely on seed shatter and reestablishment to maintain themselves in a plant community. Rhizomatous species would better tolerate mowing, but these species may not be indigenous to these sites.

Both Parks are satisfied that the seeding and planting of native indigenous plant material on major disturbances, rather than letting nature take its course, is the proper procedure for the preservation and protection of the native gene pools.

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