NATIVE, INDIGENOUS PLANTS FOR PARK SERVICE REVEGETATION[1]

by
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Abstract. Yellowstone National Park (Wyoming) and Glacier National Park (Montana) both have ongoing road construction projects. In the past, the Park Service has relied on propagules in replaced topsoil and natural invasion from adjacent native plant communities for the reclamation of disturbed sites. In 1986, both Glacier and Yellowstone Park entered into a cooperative agreement with the USDA-Soil Conservation Service, Plant Materials Center (PMC) at Bridger, Montana, whereby the PMC would assist in the collection, testing, and propagation of seed and plants of native, indigenous species. Seed and plants are successfully propagated outside of the parks, using standard commercial techniques, and returned to the parks for revegetation of disturbed areas.

Additional Key Words: plant propagation, seed collection

Introduction

With the passage of the National Surface Transportation Assistance Act of 1982, Congress recognized a nation-wide need for rehabilitating and upgrading deteriorating road systems in national parks. In 1987, Yellowstone National Park (YNP) initiated road construction on the Craig Pass road project, a 30-km stretch from Old Faithful to West Thumb. The next project, proposed for 1992, will involve a 16-km stretch from Steamboat Point (northeast edge of Yellowstone Lake) to Sylvan Pass. Glacier National Park (GNP) began construction on a 16-km section of road along Lake McDonald, near the west entrance, in October 1990. The second, 9-km phase will be near the east entrance, from St. Mary to Rising Sun.

In the past, revegetation within park boundaries was accomplished by natural means (i.e., plant propagules originating from salvaged topsoil or dispersing from adjacent, undisturbed plant communities). In 1986, through a cooperative agreement between the National Park Service (NPS) and the USDA-SCS Plant Materials Center (PMC) at Bridger, Montana, collections of seed were made of native, indigenous grasses, forbs, and shrubs. Seed collections were taken to the Bridger PMC, cleaned, and planted in seed production fields or propagation beds. Produced seed and plants are returned to the parks for revegetation of disturbed roadsides.

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The reasoning behind this revegetation approach is to be able to seed large areas with native, indigenous plant material and produce a plant cover faster than would be realized with natural succession. A quick plant cover will protect road cuts and fills from surface wind and water erosion, and will hopefully compete with invading, weedy species. The decision to take this approach in road construction revegetation has created many unanswered questions and much controversy concerning the protection and preservation of the indigenous gene pool. Some of these questions are:

1. Because the roadway creates an artifically exposed site within a forest community, what species can be considered indigenous to this site?
2. What constitutes the limits of a genotype? How far away can you collect and still be within these limits?
3. What species can be collected and produced using cultivation techniques?
4. By taking seed outside the park to a dissimilar climate to produce seed, is genetic drift or natural selection going to affect the genetic integrity of this plant material?
5. Is the planting of this collected and produced material going to significantly affect the development of plant material from naturally occurring seed sources?

Through the activities of the Bridger PMC, an attempt is being made to answer some of these questions.

Seed Collection

The Craig Pass road project in YNP passes through a forested area classified as lodgepole pine/grouse whortleberry (*Pinus contorta/Vaccinium scoparium*) habitat type and lodgepole pine/elk sedge/Ross sedge (*Pinus contorta/Carex geyeri/Carex rossii*) habitat type. The Lake McDonald road project in GNP passes through dense forest communities characterized as western hemlock/queencup beadlily (*Tsuga heterophylla/Clintonia uniflora*) or western redcedar/queencup beadlily (*Thuja plicata/Clintonia uniflora*) habitat types (Pfister et al 1977).

When a roadway is constructed through a forest plant community, the native species for these exposed road cuts are no longer the forest and understory species, but rather those species that would invade and colonize these exposed sites. By examining abandoned roads, burns, old disturbances, and open parks and meadows within the predominantly forest types, it was possible to get an idea of the species that should be utilized. All YNP seed collections were made within Park boundaries and within 8-10 km of the reclamation sites for which they were to be used. In GNP, seed was not only collected within the Park, but also from adjacent Forest Service land having similar habitat types. The genetic variability within and among plant populations varies by species based on geographic range, reproductive mode, mating system, seed dispersal mechanism, and stage of succession (Hamrick 1983). Whether a species is self-pollinating or outcrossing also makes a difference in genetic variability. The selfing mode of reproduction limits the movement of alleles from 1 population to another and consequently increases genetic differences among populations. Plant species with wide ranges, long generation time, wind pollination, outcrossing mating systems, and that occur in the later stages of succession tend to have low variability within populations and high variability among populations. Pioneer (early, successional) species also have less genetic variation within populations. The NPS is proposing a collection restriction of 5 km on short-lived, selfing species; 8 km on short-lived, outcrossing species; and 16 km on

long-lived, outcrossing species. Currently, the interpretation of what constitutes a gene pool and the limits of a plant population does vary among the different national parks.

Seed collection within YNP utilizes a variety of seasonal laborers and volunteers under the supervision of the landscape architects (Maintenance Division) and PMC plant specialists. In GNP, seed was collected by seasonal laborers and volunteers under supervision of the Resource Management Division. Although various vacuum harvesters had been tried, most of the collection is done by hand stripping or using hand scythes. Harvested material is air dried and then transported to the Bridger PMC for cleaning. Since 1985, 360 seed collections of 119 species have been made from 100 separate sites in YNP, and 260 seed collections of 89 species have been made from 60 sites in and around GNP. Table 1 lists the major species collected in YNP and the rate of seed harvest. The speed at which seed can be collected depends on the stand density, degree of seed set, and the people collecting. This table gives an idea of the time and expense of hand harvesting native plant materials.

Table 1. The major species collected in Yellowstone National Park and the rate at which the seed can be hand collected.

Genus & Species	Average Collection Rate	Average Collection Range
	g/manhr	g/manhr
Leymus glaucus	512	75-2552
Elymus trachycaulus	454	136-976
Poa species	349	54-580
Bromus marginatus	294	33-1008
Agrostis species	95	29-140
Deschampsia cespitosa	87	38-141
Festuca idahoensis	85	56-162
Elymus elymoides	78	16-195
Stipa occidentalis & richardsonii	49	18-66
Stipa comata	36	21-68
Achillea millefolium	162	125-188
Penstemon species	156	20-454
Chaenactis douglasii	148	2-267
Helianthella uniflora	130	69-214
Eriogonum umbellatum	121	37-263
Phacelia hastata	69	4-300
Lupinus species	61	9-222
Aster integrifolius	55	3-136
Anaphalis margaritacea	55	3-149
Solidago species	50	25-65
Potentilla species	40	12-110

Seed and Plant Production

The Bridger PMC is located approximately 160 km northeast of YNP and 560 km southeast of GNP on 55 hectares of irrigated land. The elevation is 1,128 m, and the average growing season is 130 days. Seed is being collected from sites at 1,800 to 2,400 m in YNP and from elevations of 970 to 2,050 m in GNP, most of which have less than a 100-day growing season. Seed of alpine plants (3,000 m elevation) have been successfully produced in the past at the PMC. The biggest shortcoming of this site for producing seed of mountainous species has been the hot, dry spring weather. However, seed of the short-lived, self-pollinating species such as mountain brome (*Bromus marginatus*), slender wheatgrass (*Elymus trachycaulus*), blue wildrye (*Leymus glaucus*), and bottlebrush squirreltail (*Elymus elymoides*) are relatively easy to raise.

Seed production fields are established by seeding 1-m spaced rows at a rate of 90 pure-live-seeds per linear meter of row. Fields are furrow irrigated, fertilized (60 kg nitrogen/ha, 40 kg phosphorus/ha) and cultivated following standard procedures used by most commercial seed growers. Extensive hand roguing is used to minimize contamination with weeds or off-types. Depending on the species and the size of the field, seed is harvested by hand or with a small

combine. A Woodward Flail-Vac[1] has been purchased to harvest the more difficult species (i.e., those with long awns or those that readily shatter).

In an attempt to determine if there is any genetic drift or natural selection when seed is produced at a site remote from the national park, GNP is funding a study at the University of Montana. Seed of 3 generations of mountain brome (original collection and 2 subsequent generations grown at the Bridger PMC) have been submitted for electrophoretical analysis and phenological comparison. Merrell (1981) stated that individuals developing at the same time, but under different environmental regimes, may have different phenotypes develop, even though their genotypes are essentially the same.

Forbs and shrubs for transplanting have been produced from seed and cuttings in containers in greenhouses in the GNP Nursery, or grown in outdoor propagation beds at the Bridger PMC. Species successfully grown are listed in Table 2 (YNP), and Tables 3 and 4 (GNP).

Seeding Trials

Construction on the first, 15-km section (Kepler Cascades to DeLacey Creek) was completed in the fall of 1988. At this time, all cut and fill slopes were seeded with native, indigenous plant materials that were either collected and grown at the Bridger PMC or collected for direct reseeding. Because this was the first planting of this kind within YNP, plots were set up to monitor plant establishment and longevity along this road project. Although construction is just starting in GNP, plots were set up in the nearby Coram Experimental Forest to evaluate species and establishment techniques for the upcoming road projects.

1 The use of trade names does not indicate endorsement by USDA.

Table 2. Species grown in cone-tainers in a greenhouse or in propagation beds for transplanting back into YNP on disturbed sites.

Cone-tainers/Greenhouse
Helianthella uniflora
Eriogonum umbellatum
Anaphalis margaritacea
Geranium viscosissimum
Geranium richardsonii
Achillea millefolium
Penstemon cyaneus
Chaenactis douglasii
Heterotheca villosa
Phacelia hastata
Potentilla species
Antennaria species
Aster integrifolius
Arenaria congesta
Arnica species
Propagation Beds
Berberis repens
Prunus virginiana
Rhus trilobata
Cornus stolonifera
Symphoricarpos species
Ribes idaeus
Ribes species
Acer glabrum
Rosa species

Methods and Procedures

Seed Mixture Trials

Yellowstone National Park. In October of 1988, plots were set up on 2 topsoiled slopes--a south-facing slope (near Scaup Lake) and a north-facing slope (Kepler Cascades). Replicated plots (22.5 m^2) were established in a split-split block design, with mulch treatments (mulch-no mulch) as the main plot. Bark mulch (1/3 cedar and 2/3 fir) was applied to a 2.5-cm thickness.

Table 3. Species grown in containers at the GNP Nursery or private nurseries and in propagation beds at the Bridger PMC for transplanting within GNP.

Containers		Propagation Beds
Acer glabrum	*Luzula hitchcockii*	*Symphoricarpos albus*
Achillea millefolium	*Mimulus* species	*Rosa woodsii*
Anaphalis margaritacea	*Oxyria digyna*	*Shepherdia canadensis*
Arctostaphylos uva-ursi	*Penstemon albertinus*	*Prunus melanocarpa*
Carex haydeniana	*Penstemon confertus*	*Berberis repens*
Carex paysonia	*Phleum alpinum*	*Crataegus douglasii*
Cornus stolonifera	*Poa alpinum*	*Cornus stolonifera*
Deschampsia atropurpurea	*Potentilla glandulosa*	*Acer glabrum*
Dryas drummondii	*Potentilla gracilis*	
Elaeagnus commutata	*Rosa woodsii*	
Erigeron peregrinus	*Shepherdia canadensis*	
Festuca idahoensis	*Sibbaldia procumbens*	
Gaillardia aristata	*Solidago canadensis*	
Hedysarum boreale	*Spiraea betulifolia*	
Heuchera cylindrica	*Symphoricarpos albus*	
Juncus drummondii	*Xerophyllum tenax*	

Table 4. Species successfully established from cuttings in GNP Nursery.

Arctostaphylos uva-ursi	*Populus tremuloides*
Berberis repens	*Populus trichocarpa*
Cornus stolonifera	*Potentilla fruticosa*
Elaeagnus commutata	*Salix scouleriana*
Linnaea borealis	*Shepherdia canadensis*
Pachistima myrsinites	*Symphoricarpos albus*

The fertilizer treatments (fertilizer-no fertilizer) were arranged as subplot treatments. Fertilizer was applied at a rate of 10 kg nitrogen/metric ton of bark mulch. Seed treatments (seed-no seed) were arranged as sub-subplots. The seeded plots were hand broadcast with a mixture of native, indigenous grasses and forbs (see Table 5), while the unseeded plots relied on a seed bank in the replaced topsoil and seed dispersal from adjacent, undisturbed plant communities.

Ten random, 20- by 40-cm frames in each plot are being sampled 3 times during the growing season, at approximately 5-week intervals, so as to document plant mortality and plant composition changes.

Table 5. Species and amounts seeded in test plots at Kepler Cascades and Scaup Lake in Yellowstone National Park on October 14, 1988.

Genus & Species	Seeds/g	Seeds/m^2
Elymus trachycaulus	335	123
Agrostis scabra	6,060	260
Bromus marginatus	150	96
Leymus glaucus	280	73
Phleum alpinum	1,575	136
Elymus elymoides	270	69
Lupinus argentea	65	0.3
Potentilla gracilis	3,330	358

Glacier National Park. In the fall of 1987, GNP personnel established replicated plots (randomized complete block design) on a 1964 road cut in the USFS Coram Experimental Forest. This site is in close proximity to the Lake McDonald road project, has similar exposure, and is within the same habitat type. The 2:1 slope was cleared of small shrubs and trees, and hand scarified to simulate a new road cut. Ten treatments were applied (see Table 6) to help determine the species and establishment techniques to use on road revegetation in the Park. The entire test area was hydromulched with Jacklin Mulch[1] and J-tack[1], an organic tackifier at 3,360 kg/ha and 90 kg/ha, respectively. Cover and plant density were estimated using 24 random, 10- by 10-cm quadrats in each of the 1 m^2 plots. Plots were examined 3 times during the establishment year and annually, thereafter.

Forb Trials

Yellowstone National Park. In the spring of 1989, on the first 15-km section of road, several greenhouse-grown, containerized forbs were transplanted along the roadway. This was a very labor-intensive and impractical method of establishing forbs. If some of the pioneer-type forb species could be established from seed, the reclamation process would be simplified and more expedient. On the second 15-km section of road, replicated plots were established in October 1989 to compare germination, establishment, and longevity of 12 forb species (see Table 7). Five random, 20- by 40-cm frames in each plot were also evaluated 3 times during the growing season to monitor seedling survival and mortality.

Results

Seed Mixture Trials

Yellowstone National Park. The fertilizer that was applied to the fertilized plots (10 kg/metric ton of bark mulch) was the recommended amount to compensate for the nutrients required for the microbial decomposition of the mulch. During the first 2 growing seasons, there were no significant differences in plant density or composition among the fertilized and nonfertilized plots on either the south-facing (Kepler) or

Table 6. Treatments on cut slope and road shoulder plots located in the Coram Experimental Forest. Established fall 1987.

1. *Calamagrostis rubescens* (seed)
2. *Calamagrostis rubescens* (rhizomes)
3. *Xerophyllum tenax* (seed)
4. *Xerophyllum tenax* (wildlings)
5. Native Mix
   - *Calamagrostis rubescens*
   - *Bromus carinatus*
   - *Pseudoroegneria spicatum*
   - *Arnica latifolia*
   - Anaphalis margaritacea
   - Antennaria microphylla
   - Antennaria neglecta
   - Aster laevis
   - Xerophyllum tenax
   - Lolium multiflorum (Nurse Crop)
6. Mix #5 Fertilized* at planting, 1987
7. Mix #5 Fertilized June 1988
8. Control
9. Road Shoulder Mix #1--Fertilized 6/88
   - Calamagrostis rubescens
   - Bromus carinatus
   - Pseudoroegneria spicatum
   - Lolium multiflorum
10. Road Shoulder Mix #2--Fertilized 6/88
    - *Poa compressa*
    - *Festuca rubra*
    - *Poa pratensis*
    - *Lolium multiflorum*

* Fertilizer was applied at a rate of 225 kg/ha of 16-16-16.

1/ The use of trade names does not indicate endorsement by USDA.

north-facing (Scaup) plots (see Tables 8, 9, and 10). Apparently, there is no need to apply fertilizer, at least at this low rate.

The bark mulch treatment was applied to the cut and fill slopes along the entire road project to protect against surface erosion and to help retain surface moisture for better seedling establishment. When the contractor applied mulch to the plots, portions of the Scaup Lake plots were covered with 5-10 cm of mulch. The excessive mulch resulted in slower establishment and a significantly lower stand density the first year. However, during the second year there were no significant differences among the mulched and unmulched plots at either site. On the unmulched, unseeded plots at Kepler Cascades (south-facing slope), an annual forb, groundsmoke *(Gayophytum diffusum)*, established a dense stand, while on the mulched, unseeded plots there were only a few scattered plants. Mulching had considerably restricted this plant's establishment. Although mulching did not help develop better plant stands on the first section of road (1988 seeding), the late mulching (June rather than previous October) may have been a contributing factor to the relatively poor stands on some of the slopes on the second section (1989 seeding).

Table 7. Species included in the Forb Trials* (1.5 m X 4.5 m plots, 3 reps CRB) on a south-facing cut near Little Thumb Creek, along the Craig Pass road project in Yellowstone National Park. Planting was established September 28, 1989.

Genus & Species	Seed Size	Seedling Rate
	seeds/g	g/plot
Achillea millefolium	5,950	2
Antennaria umbrinella	13,200	1
Anaphalis margaritacea	18,100	2
Arnica latifolia	900	3
Aster species	440	5
Chaenactis douglasii	680	5
Chrysopsis villosa	595	5
Eriogonum umbellatum	460	8
Lupinus species	65	25
Phacelia hastata	340	15
Penstemon cyaneus	395	8
Solidago species	1,540	4

* All plots were overseeded with a mixture of *Elymus trachycaulus* (68 g) and *Bromus marginatus* (147 g), equivalent to 70 seeds/m^2 of each species.

Significantly better plant cover was established by seeding with a mixture of native, indigenous species than by relying on the seed bank in the salvaged topsoil. An analysis of topsoil samples, prior to planting, indicated that only seed of sedges *(Carex* species), lodgepole pine *(Pinus contorta)*, lupine *(Lupinus* species), and pussypaws *(Spraguea umbellata)* were present. In the unseeded plots at Kepler Cascades and Scaup Lake, these were the only species to establish the first year.

Germination was later and plant development was slower at the Scaup Lake plots than at the Kepler Cascade plots because of the cooler soils and less exposure on the north-facing slope. After 2 growing seasons, all the seeded grasses at Kepler Cascades were headed out and produced viable seed; while at Scaup Lake the plants had a much shorter stature, and only a few of the grasses headed out. Also at Kepler Cascades, most of the forb and tree seedlings perished by the end of the first growing season, while at Scaup Lake most have survived 2 growing seasons. Thus far, the best seeded grasses have been mountain brome, rough bentgrass, and slender wheatgrass (see Table 12). The sedges--Ross sedge *(Carex rossii)* and elk sedge *(Carex geyeri)*--are dominating the unseeded plots. There are similar numbers of sedge plants established in the seeded

Table 8. Percent cover of grasses and sedges in plots at Scaup Lake and Kepler Cascades. A comparison of 3 treatments at 3 dates during the 1990 growing season.

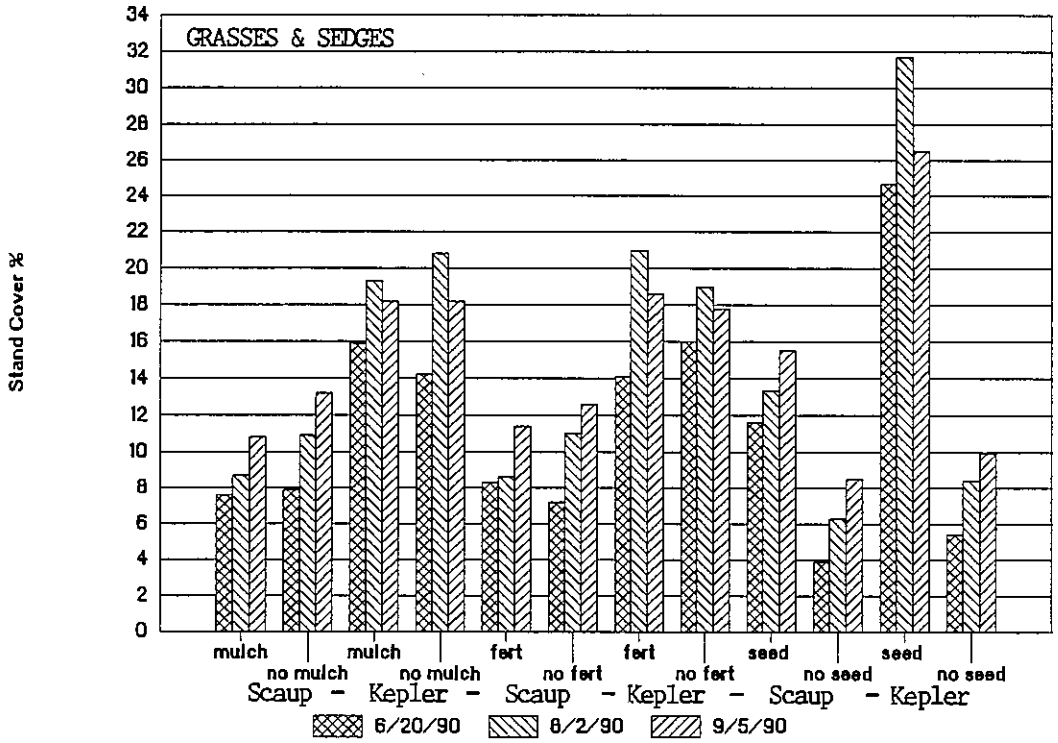

Table 9. Plant density of forbs (both seeded and invading) in plots at Scaup Lake and Kepler Cascades. A comparison of 3 treatments at 3 dates during the 1990 growing season.

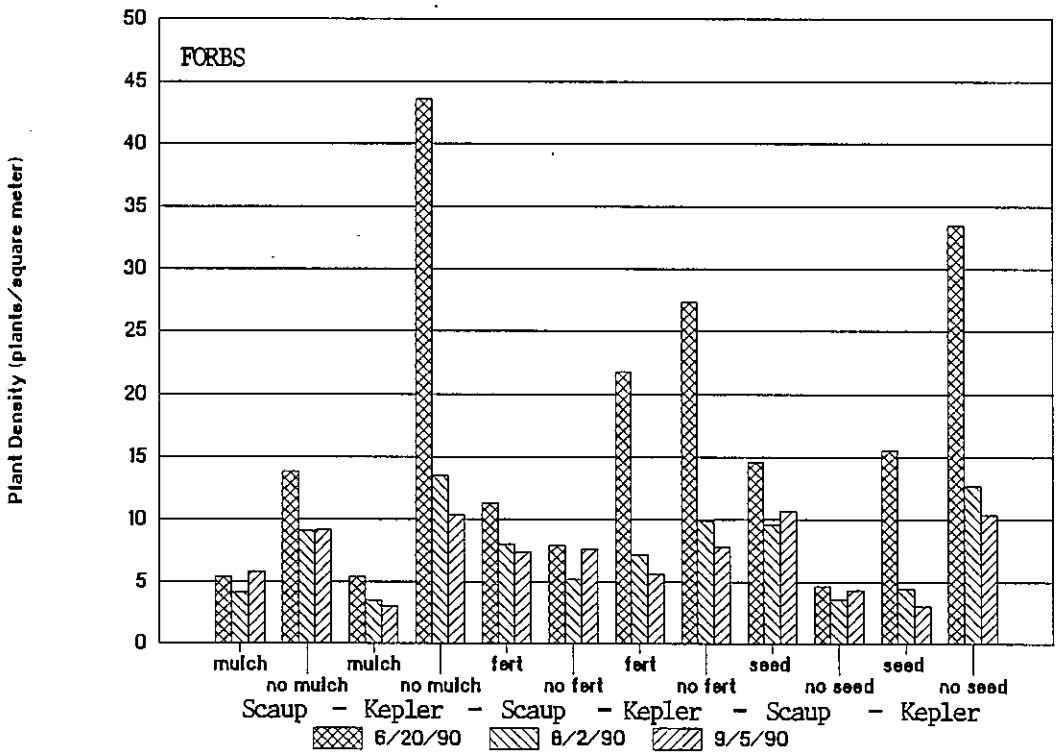

Table 10. Plant density of lodgepole pine in plots at Scaup Lake and Kepler Cascades. A comparison of 3 treatments at 3 dates during the 1990 growing season.

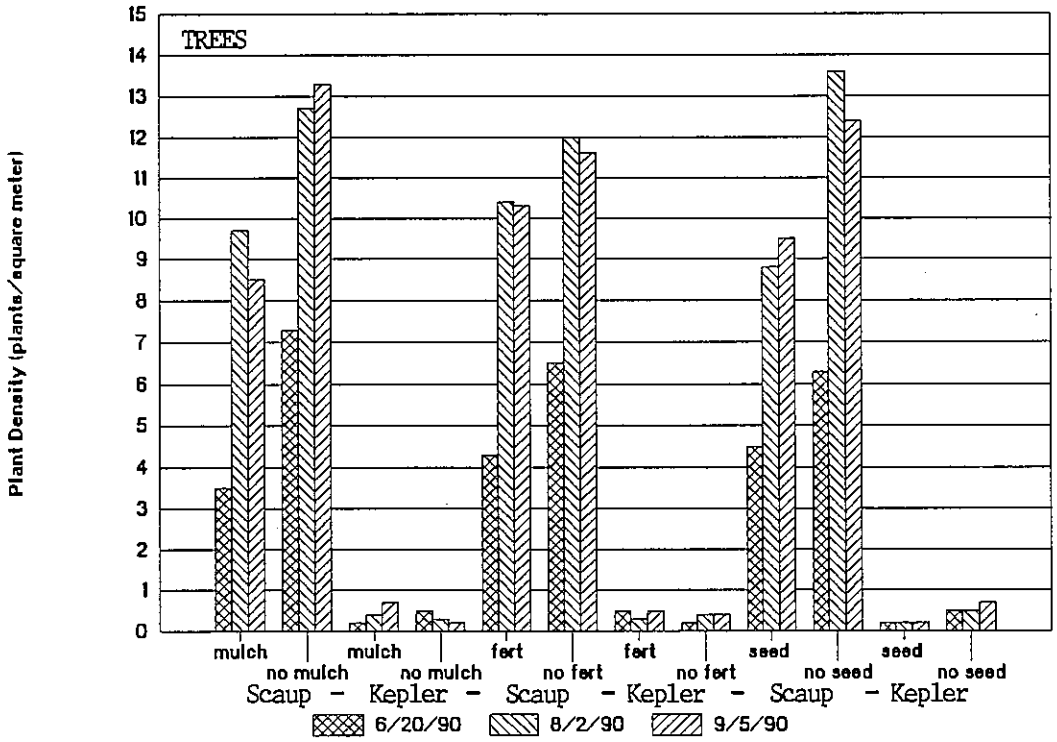

Table 11. Plant density of forb seedlings in replicated plots near Little Thumb Creek at 3 dates during the 1990 growing season.

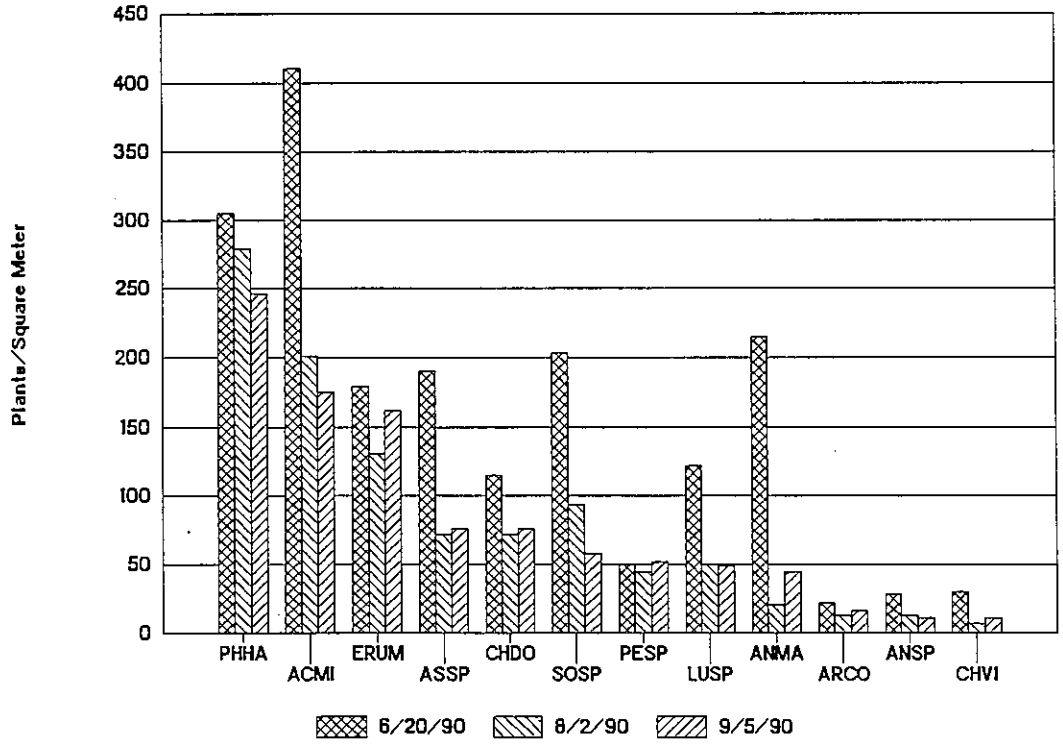

Table 12. Average plant composition of seeded and unseeded species over all seeded plots at the 2 test sites along the Craig Pass road project in Yellowstone National Park. Estimates made on 9/14/89 and 9/5/90.

	Genus & Species	Scaup Lake % Composition 1989	Scaup Lake % Composition 1990	Kepler Cascades % Composition 1989	Kepler Cascades % Composition 1990
SEEDED:	*Bromus marginatus*	19	26	21	34
	Elymus trachycaulus	14	18	15	24
	Agrostis scabra	18	20	30	15
	Elymus elymoides	5	10	8	7
	Leymus glaucus	10	1	5	2
	Phleum alpinum	9	1	7	4
	Lupinus species	3	2	2	1
	Potentilla gracilis	7	5	4	1
NONSEEDED:	*Carex* species	13	15	8	10
	Pinus contorta	2	2	<1	Trace
	Epilobium angustifolium	--	--	Trace	Trace
	Spraguea umbellata	Trace	Trace	Trace	Trace
	Gayophytum diffusum	--	--	Trace	2

plots, but because of competition from the seeded grasses, the individual sedge plants are smaller. The seeding of these slopes has not restricted the establishment of those plants originating from the natural seed bank. The plant communities that will persist on these slopes will be a combination of plants originating from the natural seed bank and the seeded material--all of which are indigenous to disturbed sites in close proximity to this road project.

Glacier National Park. The Coram plots were set up well in advance of road reconstruction so as to evaluate some potential revegetation species and techniques. Perennial ryegrass was included in several mixes as a cover/nurse crop. It was determined that in the mix which included mountain brome, the brome actually established quicker than the perennial ryegrass. Also, in other mixes, perennial ryegrass was of no benefit. Although the statistical analyses of these data have not been completed, there are obvious conclusions that can be derived from this test planting:

1. Establishing pinegrass (*Calamagrostis rubescens*) from seed was far more successful than from rhizomes (see Table 6, treatments 1 and 2).
2. At this site, beargrass (*Xerophyllum tenax*) did not readily establish from seed (treatments 3 and 4). However, at other sites within the park, seeded beargrass was successfully established, but plant development was very slow.
3. The complex mix (treatments 5, 6, and 7) was dominated by mountain brome, in part because of the high seeding rate (650 seeds/m^2). All of the forbs established, with broadleaf arnica (*Arnica latifolia*), smooth aster (*Aster laevis*), and pearlyeverlasting (*Anaphalis margaritacea*) having the best establishment and survival. Bluebunch wheatgrass (*Pseudoroegneria spicata*) didn't establish, and pinegrass was sparse.
4. Although the ditch and road shoulder mixes (treatments 9 and 10) each contained 4 species, only 1 species in each treatment

remained after 3 years. Only mountain brome (treatment 9) and red fescue (*Festuca rubra*) (treatment 10) survived--both of which have excellent stands.

The results of other reseeding attempts throughout GNP (Bowman Creek, River Campground, and Lake McDonald) support the use of yarrow (*Achillea millefolium*), northwest cinquefoil (*Potentilla gracilis*), Richardson needlegrass (*Stipa richardsonii*), Idaho fescue (*Festuca idahoensis*), and lupine (*Lupinus sericeus*) for future reclamation efforts.

Forb Trials

The south-facing slope used for the replicated forb plots was not mulched so as to provide a more severe environment on which to screen forbs for potential reclamation use. Yarrow (*Achillea millefolium*) had the highest plant density (400 plants/m^2) in early summer, but more than half of these seedlings died by September (see Table 11). Those yarrow plants that did survive are very strong and healthy. Silverleaf phacelia (*Phacelia hastata*) had the best seedling density at the end of the growing season. Sulfur buckwheat (*Eriogonum umbellatum*) not only had one of the lowest mortality rates during the summer, but it also had the highest rate of late germinating seeds. Most of these forbs can be easily collected, cleaned, and seeded. Yarrow is the easiest species to grow for seed production on a large scale. Because of poor seed set and often sparse native stands, both *Arnica* and *Antennaria* are difficult to collect and are not easily produced under cultivated conditions.

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