

Glacier National Park: Restoration Monitoring Report

2010

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I. INTRODUCTION

The Revegetation Monitoring Program, established in 1991, is designed to provide a systematic framework for describing a site prior to disturbance and for monitoring the success of seeded and planted species after revegetation. The goals of the monitoring program (Kurth and Potter, 1991) are to:

- (1) Develop revegetation techniques based on collected information;
- (2) Set feasible expected levels of success for revegetation and set reasonable time frames in which to expect those levels;
- (3) Establish appropriate site-specific goals for projects;
- (4) Determine the degree to which a project meets predetermined goals or expected levels of success;
- (5) Determine cause and effect relationships from revegetation treatments;
- (6) Determine spatial requirements for specific environments;
- (7) Identify sensitive areas where impacts must be avoided because revegetation is too costly or impossible;
- (8) Identify needs and methods for remedial work at a site; and
- (9) Reduce time and money spent on revegetation.

Based on these goals, four levels of monitoring have been established to document the success of revegetation projects. These levels range from a simple, quick assessment of a site (Level I) to complex experiments that test revegetation techniques (Level IV). Table 1 summarizes the main variables that are monitored within each level.

Table 1. Levels of Monitoring

Monitoring Level	Variables monitored
Level I	• soil erosion • estimated canopy cover of (1) mature, pole, sapling, and seedling trees; (2) tall, medium, and low shrubs; (3) native and exotic grasses; and (4) native and exotic forbs • ground cover description (% soil, rock, gravel, litter, moss/lichen, wood, and basal vegetation) • disturbance history • evidence of animal use
Level II	• data from Level I • species list of at least the dominant native and exotic species and their respective canopy covers • description of planted and seeded material (estimated density, mean height, phenology, vigor)
Level III	• data from Level II • permanent transects and microplots established to monitor the number of species, and their respective canopy covers, densities, and mean heights • permanent circular plots established to monitor height, width, vigor and damage of planted shrubs and trees
Level IV	• experiment using replicate and control plots to evaluate revegetation techniques

In addition, a site analysis procedure has been designed to collect information on revegetation sites prior to disturbance. Site analysis data includes information on:

- Parent material (weathered mineral or organic material from which the soil develops)
- Slope shape and aspect;
- Soil surface status and soil texture analysis
- Ground cover description (% soil, rock, gravel, litter, moss/lichen, down wood and basal vegetation)
- Estimated canopy cover of (1) mature, pole, sapling, and seedling trees; (2) tall, medium, and low shrubs; (3) native and exotic grasses; and (4) native and exotic forbs
- Species list of at least the dominant exotic and native species and their respective canopy covers

- Evidence of animal use
- Disturbance history
- List of species or cultural resources of special concern
- Recommendations for revegetation (target plant community, site preparation, use of plant or soil salvage, use restrictions and safety considerations)

Revegetation areas are listed in Table 2. The monitoring report for the appropriate year should be referenced for further information.

Table 2. Monitoring projects to date

LOCATION	Monitoring Level	Monitoring Dates
303-B: Lake McDonald segment of GTSR	Level III	1992, 1993, 1994, 1996, 2001
303-B Road shoulders	Level II	1993, 1994, 1995, 1998
303-C: St. Mary segment of GTSR	Level II	1993, 1994, 1995, 1998, 2003
303-C Road shoulders	Level II	1994, 1995, 1998, 2003
Two Dog Flats	Level IV	1993, 1995, 1997, 2002
303-D: Rising Sun segment of GTSR	Site Analysis, Level IV	1993-1997, 1999, 2004, 2005
303-D: Road shoulders	Level II	1996, 1997
303-E: Logan Pass and Oberlin Bend	Site Analysis, Level IV	1993, 1996, 1997, 1998, 1999, 2001, 2006
303-E: Logan Pass Seeding/ Planting Plots	Site Analysis, Level IV	1997, 1998, 1999, 2000, 2008
303-F: McDonald Creek segment of GTSR	Site Analysis, Level II	1994, 2000, 2001, 2002, 2009
303-F: Avalanche Campground & Picnic Area	Site Analysis	1995, 1996
Phase VI: West Tunnel to Haystack section of GTSR	Site Analysis, Level II	2007, 2010
Phase VII: Avalanche to West Tunnel section of GTSR	Site Analysis	2004, 2010
Phase VIII: Big Bend to Logan Pass section of GTSR	Site Analysis	2010
Phase IX: Haystack to Big Bend section of GTSR	Site Analysis	2010
Phase XI: Logan Pass to Siyeh Bend section of GTSR	Site Analysis	2010
Phase XII: Siyeh Bend to Rising Sun section of GTSR	Site Analysis	2010
Apgar Transit Center	Site Analysis, Levels II & IV	2006, 2007, 2008, 2009, 2010
Bowman Creek Campground	Level II	1993, 1998
Camas Road - Revegetation	Site Analysis, Level II	1995, 2000, 2002, 2003, 2008
Camas Road - Hydromulch	Level II	2004, 2005, 2007, 2009
Granite Park Chalet	Site Analysis	1994
Grinnel Point Picnic Area	Site Analysis	2010
Herbicide / Revegetation Experimental Plots	Level IV	2008, 2009, 2010
Hidden Lake Social Trails	Level II	2003, 2005, 2010
Lake McDonald Lodge dorm site	Site Analysis, Level II	2007, 2009, 2010
Logan Pass Comfort Station	Level II	1993
Polebridge Bridge	Level II	1993, 1998
Polebridge Ranger Station	Level II	1993, 1998
River Campground	Level II	1993, 1998
Sperry Chalet	Site Analysis	1996
St. Mary housing area	Level II	1993
St. Mary Visitor Center	Site Analysis, Level II	2006, 2010
Swiftcurrent Apartments	Level II	1993
Three Bears Lake	Level II	1993, 2000
Two Medicine housing area	Site Analysis	1994
West Glacier Bike Path	Level II	2005, 2007, 2009
West Glacier Entrance Station	Level II	2009, 2010

The objectives of this report are to document the results of the 2010 season. The report includes: (1) data from six revegetation projects (Apgar Transit Center, Lake McDonald Lodge dorm site, West Entrance Station, St. Mary Visitor Center, Hidden Lake social trails, and Phase VI of the GTSR reconstruction); (2) site analyses for Grinnell Point

Picnic Area and five phases of the GTSR reconstruction (Phases VII, VII, IX, XI, and XII); (3) year two results of herbicide impacts at two sites in weed treatment-revegetation projects; (4) results from whitebark and limber pine restoration projects; (5) results from whitebark and limber pine plus tree monitoring; (6) assessments of vegetation and weeds at transit stops; and (7) overall recommendations for the monitoring program, including a schedule for future monitoring. All road projects are based on and are evaluated against the following revegetation goals and objectives (Lange, 1988; Lapp, 1994):

Overall goal: Within 5 years following construction, a vegetative cover of native plants will be established that will potentially blend with the adjacent plant communities, is ecologically compatible with the surrounding community, and is consistent with maintenance and safety requirements. Within 20 years following construction, the color and structure of the vegetation will blend into the adjacent plant community and diversity of native species will resemble the plant community prior to disturbance.

Objectives:

- (1) Preserve genetic integrity of native floral populations.
- (2) Provide for optimum survival of plant material by using species collected at or near the disturbed site.
- (3) Quickly provide plant cover to stabilize soil and prevent erosion.
- (4) Keep coverage of exotic plants low in cut and fill slopes, and prevent invasion into undisturbed vegetation.
- (5) Restore aesthetic value of vegetation within disturbed area that blends in with adjacent undisturbed plant communities.
- (6) Use roadside vegetation that will not be a long-term food attraction to wildlife.
- (7) Select appropriate vegetation for cut slopes, ditches, and a turf shoulder that is low maintenance, durable, safe, and able to stand up under heavy visitor foot and automobile traffic.
- (8) Provide opportunity for research and technology transfer.

II. Apgar Transit Center

A. Background and Purpose

Construction of the Apgar Transit Center (ATC) took place in 2007 as part of a new transit system designed to reduce traffic on the Going to the Sun Road (GTSR) during road construction. It is located at the “T” intersection of the GTSR and Camas Road approximately one mile past the West Entrance. The project includes a 4,200 square-foot information building with restrooms, a large parking lot that accommodates 132 vehicles and 15 recreational vehicles, as well as the connection of water and sewer lines from the transit center to the existing utilities in Apgar Campground. Paved sidewalks and additional paved bike trails that lead to other visitor use areas in Apgar are also part of the project.

Overall, nearly 6 acres of former lodgepole forest were cleared, including an understory of hemlock, pine, fir and other maritime species. It is very evident that this was a cedar/hemlock forest prior to the stand-replacing 1929 fire. In total, 3.74 acres of this area required native plant restoration, in addition to 2.1 acres along the Camas Road that required hydroseeding. Figure 1 outlines the areas of disturbance requiring restoration, as well as the specific planting and seeding prescription areas.

As part of the construction process, 44 tall trees and 520 containers of trees, shrubs, and herbs were salvaged in 2006, including difficult to propagate species such as *Vaccinium membranaceum*, the rare *Vaccinium myrtilloides*, and *Xerophyllum tenax*. In addition, 778 ft² of moss/shrub/herbaceous mats were salvaged at the same time. Most of this salvaged material was replaced during the spring and fall of 2007 within the parking lot islands, east of the transit center, and along the sewer/water line swath that runs from the transit center to Loop E of Apgar campground (Figure 1). Mats of salvaged vegetation were also planted in various small locations along the bike path (Figure 1). Additionally, 7,035 nursery propagated plants were planted in the large islands within the parking lot, around the transit center and transit pickup area, along the edges of the parking lot, along the entrance driveway, and near Loop E of Apgar Campground (Figure 1). Finally, all of the area except the parking lot islands and landscaped areas around the transit center were seeded under five distinct seeding prescriptions (Figure 1 and Table 9). Hydroseeding was done on bike path shoulders (Seed mix A) and Camas Road utility disturbances (Seed mix B) but all other seeding was done by hand broadcasting and raking in seed.

It was recognized that the sewer/water line, existing as a linear swath that is uniform in topography and sun availability, would lend itself well to the installation of research monitoring plots that could evaluate a number of different revegetation treatments. In 2007, monitoring plots were installed within the swath to test seven revegetation strategies. These strategies focus on key revegetation species that the Park has had difficulty with in the past.

Monitoring of plots took place in 2008, 2009, and 2010, one, two, and three years after planting. Results are included for: (1) research monitoring plots; and (2) ten additional monitoring plots throughout the ATC area.

B. Methods

1. Research Monitoring Plots

In June 2007, research monitoring plots were installed along the sewer/water line that runs from the ATC to Loop E in Apgar Campground (purple area in Figure 1). In total, 56 plots were installed that each measured 2m x 2m (Figure 2). These plots represent eight replicates of seven different treatments. The seven treatments are as follows:

1. seeding *Xerophyllum tenax* at 25 seeds/ft²
2. seeding *Rubus parviflorus* at 25 seeds/ft²
3. seeding *Calamagrostis rubescens* at 50 seeds/ft²
4. seeding *Calamagrostis rubescens* at 30 seeds/ft² with a forb mix of 56 seeds/ft² (8 seeds/ft² of *Spiraea betulifolia*, *Chamerion angustifolium*, *Solidago canadensis*, *Achillea millefolium*, *Geum macrophyllum*, *Anaphalis margaritacea*, and *Symphyotrichum laeve*)
5. seeding *Carex athrostachya* at 30 seeds/ft² with *Achillea millefolium* at 20 seeds/ft² and *Spiraea betulifolia* at 20 seeds/ft²
6. planting *Calamagrostis rubescens* plugs at 1 plant/ft² (43 plants/plot)
7. control plot

Figure 1. Apgar Transit Center: Planting and Seeding Units

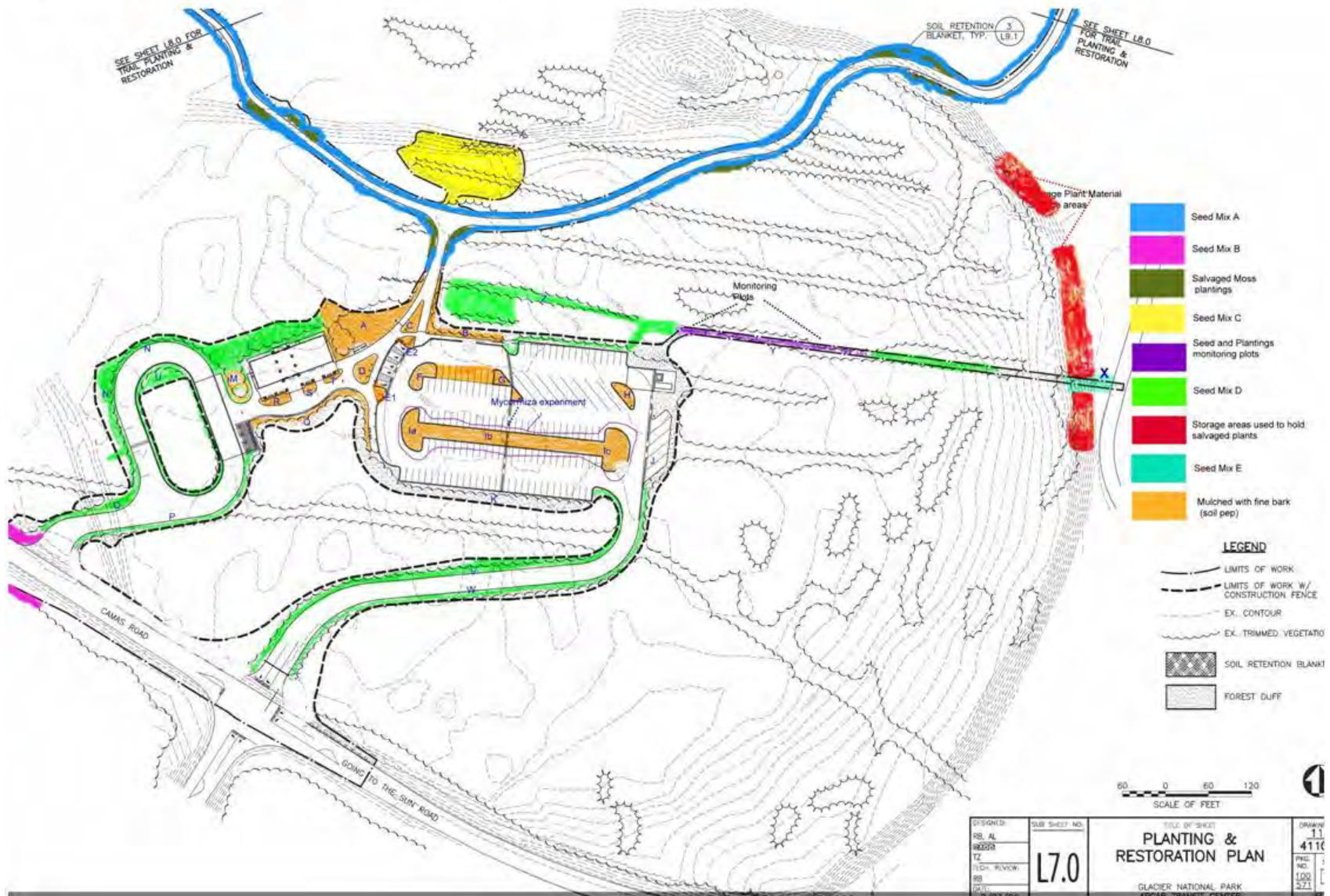
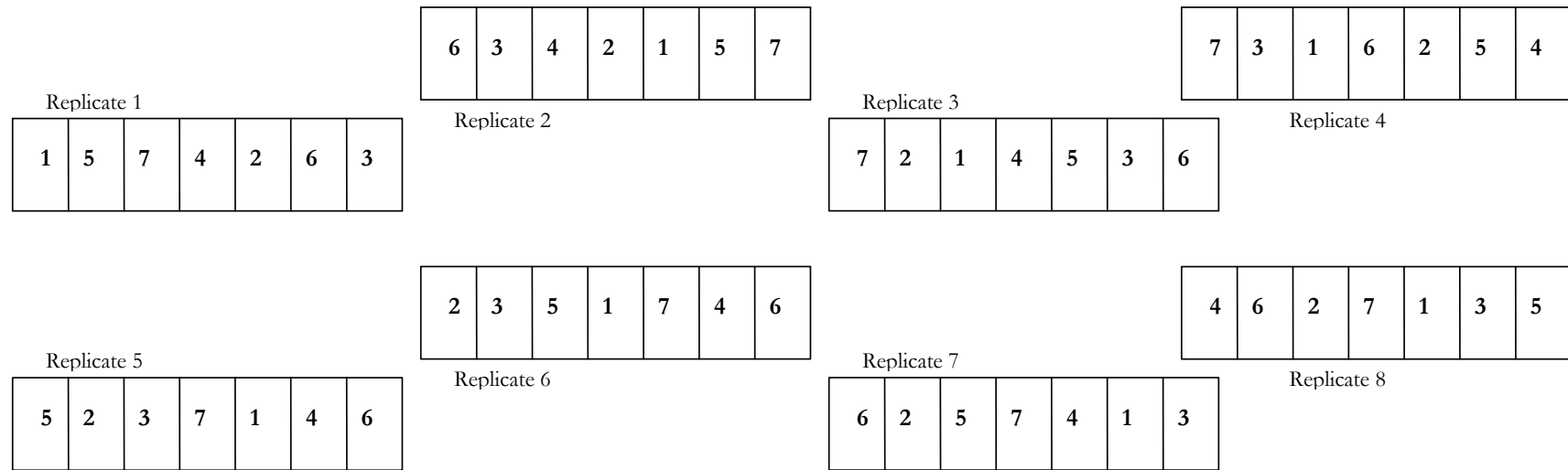


Figure 2. Apgar Transit Center: Schematic Layout of Research Monitoring Plots



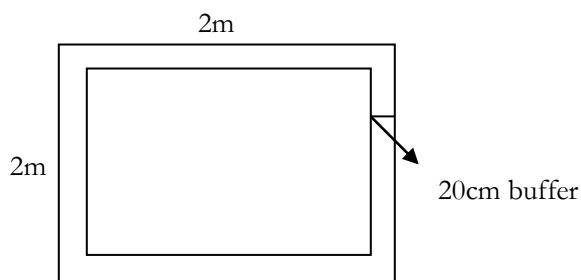
*Plots are offset in the field just slightly. This diagram does not accurately represent the spacing or offset of the replicates.

TREATMENTS:

1. seeding *Xerophyllum tenax* at 25 seeds/ft²
2. seeding *Rubus parviflorus* at 25 seeds/ft²
3. seeding *Calamagrostis rubescens* at 50 seeds/ft²
4. seeding *Calamagrostis rubescens* at 30 seeds/ft² with a forb mix of 56 seeds/ft²
5. seeding *Carex athrostachya* at 30 seeds/ft² with *Achillea millefolium* at 20 seeds/ft² and *Spiraea betulifolia* at 20 seeds/ft²
6. planting *Calamagrostis rubescens* plugs at 1 plant/ft² (43 plants/plot)
7. control plot

The plots were installed in a linear layout with one replicate of each treatment in each linear plot (Figure 2). Treatments were randomly located within each replicate plot. Nails mark the four corners of each plot and the upper left corner (when facing north) is marked with a tag describing the replicate number and treatment type. Although each plot measures 2m x 2m, there is a 20cm buffer along the inside of each plot (Figure 3) that was not included in monitoring to address any overlap from seed treatments and edge effect.

Figure 3. Apgar Transit Center: Diagram of individual monitoring plot



Plant material was installed in the experimental plots in October 2007. Seed plots were first lightly scarified using pulaskis, then seeded with appropriate species at the prescribed seed rate, and finally raked in within the first 1-3 inches of the surface soil. Treatment plots with *C. rubescens* plugs were lightly scarified with pulaskis and then each plot was planted with 43 conetainer-sized grasses at 1 plant/ft². Plants were planted at random within each plot. Finally, the control plot had no treatment installed or scarification of soil.

In October 2007, cover estimates were made for the plots planted with *C. rubescens* plugs. All *C. rubescens* plug plots were photographed to visually show plant cover in the plot.

Monitoring of all experimental plots took place in 2008, 2009, and 2010. Monitoring involved reading subsamples of three ¼ m² microplots within each individual monitoring plot. Random number tables were used to determine the placement of microplots within a plot. Microplots could share an edge but could not overlap, and as stated above, were not allowed to sample within the 20cm buffer zone along the edge of each plot. Ocular canopy cover determinations for all species within the plot were made and density for each seeded species in a given treatment was calculated by counting seeded germinants within each microplot. Ground cover estimates were also made. All plots were photographed to visually illustrate plant cover in the plots.

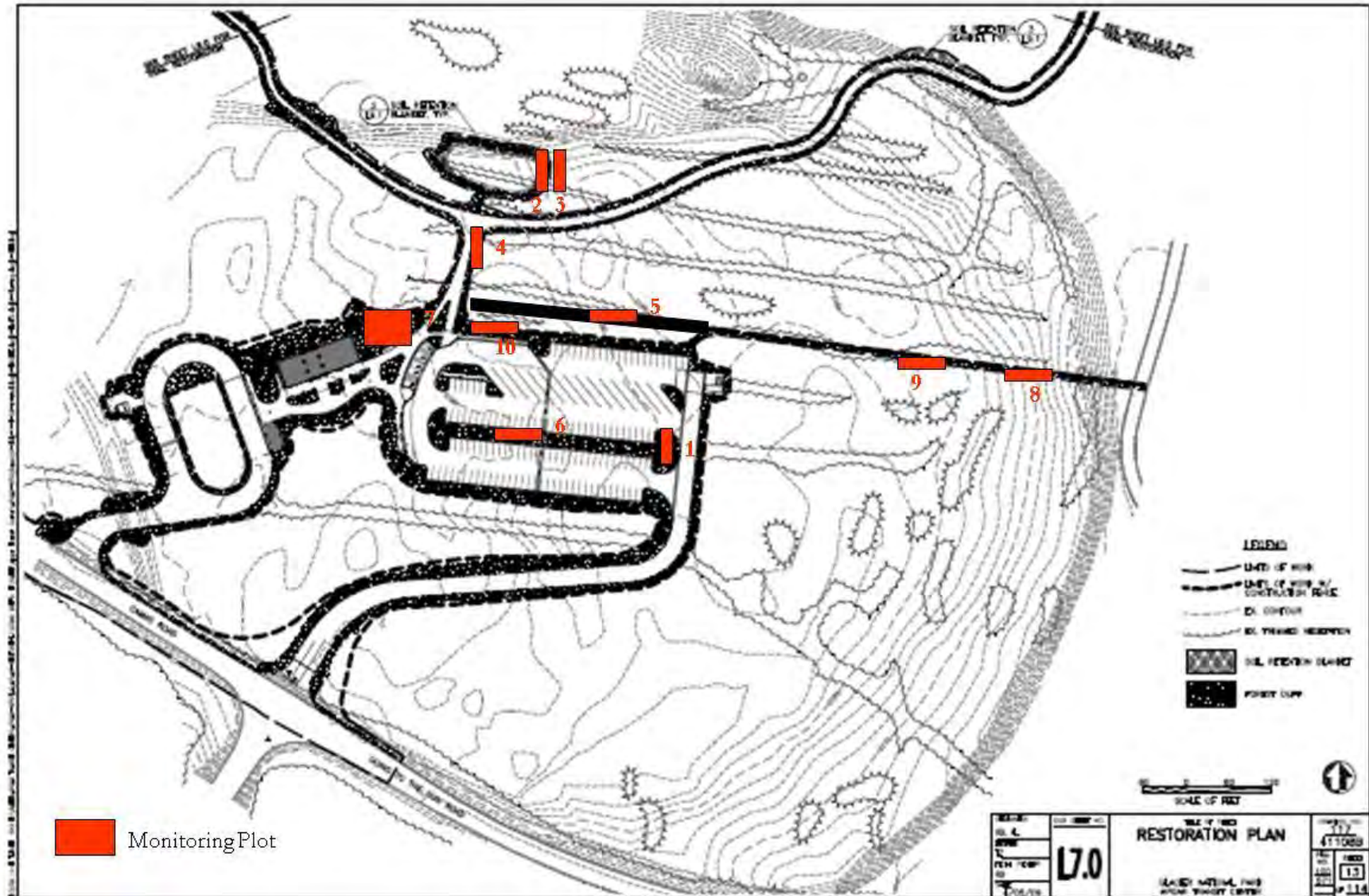
2. Revegetation Plots Monitored by Ocular Cover

Ten additional Level II revegetation monitoring plots were installed during August and October 2007 (Figure 4). Plot size varied to accommodate the planted area but most plots measured between 75 and 100 m². GPS points were recorded at two permanent plot markers at each plot. Plot locations and descriptions are listed in Table 3.

Table 3. Apgar Transit Center: Plot Descriptions

Plot #	Plot Size	Plot Location	Vegetation Monitored
ATC-07-01	15m x 5m	Parking lot island - east	Salvaged trees & nursery stock
ATC-07-02	15m x 5m	Slope on edge of retention pond	Seed material
ATC-07-03	15m x 5m	Flat area adjacent to retention pond	Seed material
ATC-07-04	15m x 1.5m	Along N/S bike path towards retention pond	Salvaged vegetation mats & seed?
ATC-07-05	24m x 4m	Utility line W of experimental plots	Salvaged trees/vegetation mats & seed
ATC-07-06	15m x 5m	Parking lot island - center	Salvaged trees & nursery stock
ATC-07-07	15m x 10m	Just N of transit center	Salvaged trees & nursery stock & seed?
ATC-07-08	12m x 8m	E end of utility line on slope before swale near Loop E of campground	Salvaged trees/vegetation mats (includes <i>X. tenax</i> & <i>V. myrtilloides</i>) & seed
ATC-07-09	20m x 5m	Flat area between Plot 08 and experimental plots	Salvaged trees/vegetation mats (includes <i>V. myrtilloides</i>) & seed
ATC-07-10	20m x 3m	North of sidewalk adjacent to parking lot; at entrance to bike path	Salvaged trees & nursery stock & seed?

Figure 4. Apgar Transit Center: Location of Revegetation Monitoring Plots.



Level II monitoring for revegetation plots included ocular estimates of canopy cover for all native and exotic species within the plot, as well as estimates of ground cover. Photographs were taken of each plot at each monitoring event.

C. Results

1. Research Monitoring Plots

In August 2010, experimental plots were monitored, three years after seeding and planting. Each of 56 plots were read, including canopy cover estimates for each species and density counts for each seeded or planted species. Three $\frac{1}{4}$ m² microplots were read per plot and percent cover was averaged per plot. Results are listed in Tables 4, 5, 6 and 7.

1a. Treatments

Similar to results from 2008 to 2009, all treatments increased in native and exotic cover from 2009 to 2010. The highest native cover three years after revegetation was produced by planted *Calamagrostis rubescens* plugs, the treatment that had the highest native cover in 2008 and the second highest native cover in 2009. This treatment had 23.48% native cover, a dramatic increase from 12.32 % last year. Native cover of seeded *C. rubescens* with a forb and *Spiraea betulifolia* mix, which had the highest overall native cover last year, also has relatively high native cover at 22.40%. Additionally, cover of seeded *Carex athrostachya* with a forb and *S. betulifolia* mix had relatively high native cover at 21.36%. The remaining four treatments had moderate native covers ranging from 11.33% to 13.06%, almost half of the three treatments listed above. Currently, seeding *C. rubescens* alone has resulted in the lowest overall native cover at 11.33%. The control plot, where nothing was seeded or planted, remained similar to last year with the fourth highest native cover of the seven treatments at 13.06%.

i. *Calamagrostis rubescens* plugs (Treatment 6)

Although initially, planted *Calamagrostis rubescens* plugs had at least double the vegetation cover at year one after planting, other treatments have been catching up to the cover of this treatment over the past two years. This treatment, however, has remained one of the most successful treatments of the experiment with consistently high overall vegetation cover, consistently high native cover, and consistently low exotic cover. Currently, overall cover of this treatment is 32.58%, the second highest overall total cover, with 23.48% native cover, the highest native cover of any treatment. This treatment has the lowest exotic cover of all the treatments, resulting in the highest native to exotic ratio at 72.1%. It is significant that this treatment has also had the highest native to exotic ratio one year after planting at 98.4% and two years after planting at 83.8%. It is possible that this very high initial cover during the first year prevented the establishment of weeds and maintains a higher percent native cover over time.

Native grass cover under the *C. rubescens* plug treatment remains far higher than any other treatment and is the dominant lifeform on this treatment. Native grass cover increased from 10.43% in 2009 to 16.29% in 2010, three to four times as high as native grass cover on other treatments. Most of this is due to cover of *C. rubescens* plugs which were estimated to be 13.79% this year, increasing from 9.54% last year. Although the increase is not significant from 2009 to 2010, the cover of *C. rubescens* in 2010 is significantly higher than cover of this grass in 2008. Overall, the density of *C. rubescens* plugs is not decreasing (similar to last year, approximately 32 plugs/macroplot remain from the original 43 plugs/macroplot that were planted – Table 6), indicating that the grass plugs are growing in size to achieve greater cover. In addition, *Carex rossii* (lumped in with *Carex spp.* in previous years due to lack of seed heads) significantly increased under this treatment this year from 0.13% to 1.92%, adding noticeable cover. This sedge species, along with *Agrostis scabra*, *Carex concinnoides*, *Danthonia spicata*, *Elymus glaucus*, and *Festuca occidentalis*, are naturally recruiting to a number of treatments within this experiment.

While native forb cover under this treatment did significantly increase from 2008 to 2009 and increased from 0.98% to 3.11% from 2009 to 2010, native forb cover remains the second lowest of all the treatments. Species diversity and individual forb cover is very low with most forb cover resulting from *Chamerion angustifolium* that significantly increased from 2008 to 2009 and increased in cover from 0.62% in 2009 to 1.28% in 2010. The lack of seeded forbs is clearly driving the low forb cover, but naturally recruited forbs, like naturally recruiting weeds, may also have a difficult time getting established due to the higher grass cover. Certain naturally regenerating forbs, such as *Epilobium brachycarpum* and *Hieracium albiflorum* that significantly increased in cover this year, may offer a change to

that trend.

Tree cover, similar to several other treatments, increased significantly this year from 0.91% to 3.82%. Also like other treatments, most of the increase in tree cover is due to significant increases of *Pinus contorta* and *Populus balsamifera* seedlings that currently have 2.28% and 1.44% cover, respectively. At present, there is trace shrub cover in this treatment due to trace cover of naturally colonizing *Rubus idaeus*.

Lastly, as stated above, this treatment has the lowest cover of exotic species. Currently, exotic grass is 0.13%, the lowest overall exotic grass cover. Similar to last year, a small amount of *Agrostis stolonifera* accounts for this low cover. Like all other treatments, exotic forb cover significantly increased from 2.35% in 2009 to 8.55% this year. This, however, is the lowest overall exotic forb cover of any treatment. Increases were due primarily to a significant increase of *Trifolium hybridum* that occurred in all treatments. *Medicago lupulina* also significantly increased in cover while *Veronica officinalis* continued to increase slightly in cover over the last year.

ii. *Calamagrostis rubescens* seeded with forb mix and *Spiraea betulifolia* (Treatment 4)

In contrast to 2009 when all lifeforms except exotic grass significantly increased since 2008 under this treatment, only exotic forb cover significantly increased from 2009 to 2010. Tree and native forb cover, however, did have notable increases in cover this year, resulting in this treatment having the second highest native cover at 22.4% and the second lowest exotic cover at 9.88%. This results in the second highest native to exotic ratio at 69.4%, clearly indicating that this treatment is dominated by native vegetation, and improving its status from last year when it had the third highest native to exotic ratio of all treatments. Last year, this treatment had the highest overall vegetative cover at 18.31%, nearly doubling to 32.28% in 2010 (currently third highest total vegetation cover of all the treatments). This treatment also has the highest native cover last year with 14.16% cover. It should be noted that this treatment had the highest seed rate of any of the treatments at 925 seeds/m² (Table 7), perhaps enhancing its success.

Although results were not statistically significant, native forb cover under this treatment increased from 10.31% in 2009 to 17.17% in 2010, making native forbs the dominant lifeform under this treatment. This is also the highest native forb cover of any of the treatments, similar to last year. Increases were due to significant increases of three seeded forb species including *Anaphalis margaritacea*, *Chamerion angustifolium*, and *Symphyotrichum laeve*. *Achillea millefolium*, *Anaphalis margaritacea*, and *Symphyotrichum laeve*, all seeded species, remain with the highest native forb cover on this treatment. *Geum macrophyllum* and *Solidago canadensis*, the remaining seeded forbs under this treatment, did not significantly increase since last year, but both species have notable cover at 0.88% and 1.88%, respectively. Native forb cover was significantly higher than forb cover of all other treatments except seeded *C. athrostachya* with a similar seeded forb mix. Similar to last year, native forb cover under this treatment was slightly higher than the seeded sedge treatment with forbs but results were not statistically significant. Finally, covers of *Anaphalis margaritacea*, *Geum macrophyllum*, *Solidago canadensis*, and *Symphyotrichum laeve* were also significantly higher under this treatment than all other treatments, while *Achillea millefolium* had significantly higher cover than all other treatments except the sedge/forb mix treatment (Table 5A and 5B). There were no significant differences for cover of *Chamerion angustifolium* between treatments.

After significantly increasing last year, native grass cover remained the same from 2009. Native grass cover was estimated to be 2.48% in 2009 and estimated to be 2.44% in 2010. No native grass species increased significantly over the past year. Currently, dominant grasses within this treatment include *Carex* spp. which has 0.31% cover and *Calamagrostis rubescens* which has 1.75% cover. While this treatment has the third highest native grass cover of all treatments last year, it now has the lowest overall native grass cover of all treatments, including three treatments that were not seeded with native grass. This may be due to the fact that density of *C. rubescens* seed has significantly decreased since last year, dropping from 148.5 germinants/m² to 75.2 germinants/m² (Table 7). Initial germinants are clearly not surviving to the third year after seeding, perhaps from competition of other establishing vegetation. This trend was also observed in treatment 3 where *C. rubescens* was seeded alone; currently, the density of *C. rubescens* is almost identical whether it is seeded alone or with a forb mix. The difference, however, is that currently, cover of *C. rubescens* under this mixed seed treatment is half the cover of *C. rubescens* when it is seeded alone. It is also much lower than cover of planted *C. rubescens* plugs. Clearly, the surviving germinants under this treatment are growing since half the density produced the same cover as last year. They are, however, not growing as quickly as other treatments, specifically treatment 3 where *C. rubescens* was seeded alone, with similar densities.

Native shrub and tree cover did not significantly increase since last year. Native shrub cover decreased slightly from 0.41% in 2009 to 0.31% in 2010. This decrease was due primarily to a small decrease in *S. betulifolia*

cover, the only seeded shrub in this treatment. Although *S. betulifolia* was seeded in a mix under this treatment and treatment 5, cover of *S. betulifolia* is now significantly higher on treatment 5. This is different from last year when cover of *S. betulifolia* was statistically equal under both treatments. In addition, cover of *S. betulifolia* under this treatment, despite being seeded, is now not significantly higher than the control plots (treatment 7) or the treatment where *Rubus parviflorus* was seeded (treatment 2). It is uncertain why this shrub is not increasing in cover like treatment 5 where it was seeded, but it may be having a harder time competing with the high cover of native and exotic forbs. *S. betulifolia* also had a higher seed rate on treatment 5, adding to its success, compared to this treatment. Both treatments with seeded *S. betulifolia* decreased somewhat in density from last year but density of plants remains higher on treatment 5 than on this treatment. This higher density is likely contributing to the higher cover of this shrub.

Tree cover was relatively the same throughout all treatments with all tree cover not significantly different between treatments. Tree cover did increase on this treatment, although results were not significant. Tree cover increased from 0.96% in 2009 to 1.88% in 2010 due mostly to a significant increase of *Pinus contorta*. *Populus balsamifera* also maintains notable cover under this treatment. Both tree species have naturally colonized throughout the project and provide the most consistent cover across all treatments.

Similar to all other treatments, exotic forb cover significantly increased while exotic grass cover did not significantly increase. Exotic forb cover increased from 3.85% in 2009 to 9.65% in 2010. Although this increase is significant, the percent change in exotic forb cover remained the lowest for the second year in a row, resulting in the third lowest exotic forb cover of all treatments. This is an improvement over last year when exotic forb cover was the fourth lowest. Most of the increase was due to a continuing significant increase of *Trifolium hybridum*, however, *Veronica officinalis* also had a small increase in cover, similar to last year. Exotic grass cover actually decreased slightly from 0.30% in 2009 to 0.18% in 2010. *Agrostis stolonifera* and *Poa pratensis*, the two exotic grasses present on this treatment, both decreased slightly in cover.

iii. *Carex athrostachya* seeded with *Achillea millefolium* and *Spiraea betulifolia* (Treatment 5)

Treatment 5, where *Carex athrostachya* was seeded with *Achillea millefolium* and *Spiraea betulifolia*, had the highest overall vegetation cover at 33.75% and the third highest native cover at 21.36%. These are significant increases in cover where overall cover was 14.8% and native cover was 10.28% last year. Overall, native forb cover significantly increased while native grass, tree and shrub cover all had smaller increases in cover. This resulted in a native to exotic ratio of 63.3%, the third highest of all the treatments and a clear indication that this treatment is dominated by native vegetation, particularly native forbs. This is an improvement from last year when the native to exotic ratio was the fourth highest compared to other treatments. Similar to all other treatments, exotic forb cover significantly increased as well while exotic grass remained with low cover. Of note, this treatment had the second highest seed rate of the project with 753 seeds/m² (Table 7).

Overall, results of this treatment have been and remain generally similar to treatment 4 described above with only a few dissimilarities. Despite the fact that native forb cover significantly increased on this treatment in 2010, native cover still remains somewhat higher on treatment 4, similar to results of 2008 and 2009. This is primarily due to the fact that four seeded species on treatment 4, none of which were seeded on this treatment, continue to have higher covers on treatment 4 compared to treatment 5. These species include *Anaphalis margaritacea*, *Geum macrophyllum*, *Solidago canadensis*, and *Symphytotrichum laeve*. Only *Achillea millefolium*, seeded under both treatments, had significantly higher cover on this treatment compared to treatment 4. This significant increase of *A. millefolium*, increasing from 6.13% in 2009 to 11.46% in 2010, is the main cause for the significant increase in native forb cover this year and makes up 92% of the native forb cover. This is the second highest cover of any individual native species on the project, other than the planted *C. rubescens* plugs. *A. margaritacea* and *Hieracium albiflorum* also significantly increased in cover in 2010 while *Chamerion angustifolium* had a small increase in cover, remaining the native forb with the second highest cover. It is important to note that several forb species that have become established under this treatment may be due windblown seed from other treatments, confusing the results of this experiment. *A. margaritacea*, *C. angustifolium*, and *S. laeve* likely have become established by windblown seed. Other species, such as *Antennaria rosea*, *Maianthemum stellatum*, and *Viola orbiculata*, are naturally recruiting to this treatment. It the combination of these species that have resulted in the second highest native forb cover compared to all other treatments except treatment 4.

Native grass cover continued to increase from 0.94% in 2009 to 3.13% in 2010, although results were not

statistically significant. This increase in cover was due primarily to significant increases of *Carex* spp. (presumed to be *Carex athrostachya*) and *Poa palustris*. Small increases in cover were also noted for *Agrostis scabra*, *Carex concinnoides*, *Carex rossii*, *Danthonia intermedia*, and *Festuca occidentalis*. Despite this increase, cover of total native grasses remains one of the lowest on the project, even lower than several treatments that had no grass seed application. Although *C. athrostachya* had the same seed rate as *C. rubescens* on treatment 4 (323 seeds/m²), the germination rate of the sedge species over the last two years has been 2%-3%, compared to 23%-47.0% of *C. rubescens* (Table 7). This low germination rate for *C. athrostachya* appears to be low for this species in comparison to nursery testings. Time will tell if there will be additional germination of this species and if the currently germinated sedges will grow to produce substantial cover.

While there are no significant differences between tree cover on any of the treatments, shrub cover is currently significantly higher on this treatment than all treatments except treatment 2 where *Rubus parviflorus* was seeded. Cover of *Spiraea betulifolia*, a seeded species under this treatment, significantly increased from 0.65% to 1.79% over the past year. This is the highest cover for this shrub species of all the treatments and the second highest cover of any shrub species under any treatment. As discussed above, cover of *S. betulifolia* is now higher under this treatment than on treatment 4 where it was also seeded. One contributing factor is likely the seed rate that was higher on this treatment (215 seeds/m²) compared to treatment 4 (86 seeds/m²). The result is a higher density of *S. betulifolia* plants on this treatment (Table 7) even though the actual germination rates have remained somewhat similar. In the end, more plants (42.3 plants/m² on this treatment vs. 22.33 plants/m² on treatment 4) are creating higher cover on this treatment. Tree cover increased slightly, due mostly from a significant increase of *Pinus contorta* for the second year in a row. *Populus balsamifera* remains with notable cover.

Finally, like most other treatments, exotic forb cover significantly increased over the past year while exotic grass remained with low cover. Exotic forb cover increased from 4.25% in 2009 to 11.98% in 2010, due primarily to significant increases of *Trifolium hybridum* and *Veronica officinalis*. Despite these increases, the range of increase for exotic forbs is not as great on this treatment as it is on other treatments. For instance, last year, this treatment had the second highest cover of exotic forbs while this year, exotic forb cover has dropped to the fourth highest. The increase of exotic grass cover was due primarily to a small increase of *Agrostis stolonifera*. *Poa pratensis*, which significantly increased last year, was not observed this year.

iv. Control plots (Treatment 7)

While the control plots had the highest native to exotic ratio last year at 81.3%, the lack of native seed is finally resulting in very little increase in native cover and subsequently, larger increases in exotic cover. This has culminated in a dramatic decrease in the native to exotic ratio to 49.8% in 2010. Not only does this indicate that the control plots are now slightly dominated by exotic plants, but the native to exotic plant ratio is now the third lowest of all the treatments. Despite having the fourth highest native plant cover, the control plots have the second lowest overall total vegetation cover and the third highest exotic cover of all seven treatments. While some of the species within control plots have naturally recruited, it appears that seed from some of the adjacent treatments may have blown into the control plots, confounding the results. Currently, overall vegetation cover has increased from 8.16% to 26.22% since last year, with total native cover increasing from 6.63% to 13.06% and total exotic cover increasing from 1.53% to 13.16%.

Although native forbs had a big increase in cover last year, native forbs only increased from 2.57% to 3.96% this year and are no longer the dominant lifeform of this treatment. This small increase was due primarily to a significant increase in cover of *Hieracium albiflorum*, a species that has naturally recruited to this project, and a small increase in cover of *Anaphalis margaritacea*. *A. margaritacea* and *Chamerion angustifolium*, both species that likely established on this treatment from blown-in seed of other treatments, have notable cover within the control plots. Other species native to the surrounding forest, such as *Antennaria rosea* and *Chimaphila umbellata*, are slowly recruiting to this treatment.

Native grasses increased more noticeably than native forbs, more than doubling in cover since last year, but increases were not statistically significant. Native grasses increased from 1.93% in 2009 to 4.48% this year, giving them the highest cover of any of the native lifeforms under this treatment. This increase was due to a significant increase of *Carex rossii* and a notable increase in cover of *Festuca occidentalis*, both species that have naturally recruited to this treatment. Other native grasses that have naturally recruited to this treatment, including *Danthonia intermedia* and *Agrostis scabra*, remain with low cover.

While tree cover continues to increase on the control plots, shrub cover remains negligible. Tree cover

increased from 2.04% to 3.90% this year, due mainly to a significant increase in cover of *Pinus contorta* and a slight increase in cover of *Populus balsamifera*. While overall tree cover on this treatment is the highest of any of the treatments, these results are not statistically significant as they were last year. Tree cover on other treatments is clearly catching up to tree cover on the control plots.

While cover of exotic species was the lowest of any treatment last year, exotic species cover is currently the third highest of all the treatments, indicating its dramatic increase in 2010. Like the other treatments, cover of exotic grasses remains low with only 0.42% cover of *Agrostis stolonifera*. Cover of exotic forbs, on the other hand, increased significantly from 1.48% in 2009 to 12.64% in 2010, having the second highest change in exotic forb cover over the past year of all treatments. Similar to other treatments, this dramatic increase in cover was due to a significant increase of *Trifolium hybridum* and a smaller increase of *Veronica officinalis*.

v. *Rubus parviflorus* seeded alone (Treatment 2)

While most lifeforms significantly increased under this treatment last year, only tree cover and exotic forb cover significantly increased in 2010. Similar to last year, this resulted in lowest overall vegetation cover of all the treatments. Unlike last year, however, when this treatment also had the lowest overall native cover of any treatment, native cover has risen to the fifth highest of the treatments. This treatment also had second lowest change in exotic cover, resulting in two trends: 1) the change in the native to exotic ratio changed very little since last year from 57.6% in 2009 to 55.8% in 2010, indicating that native vegetation still dominates this treatment; and 2) this native to exotic ratio is now the fourth highest of all treatments compared to the fifth highest status last year. Native plants on this treatment are holding their ground. That said, total vegetation cover significantly increased on the *R. parviflorus* treatment from 7.88% to 22.49% in 2010 due primarily to a significant increase in exotic forbs which now the highest cover of any lifeform on this treatment.

In keeping with seeding only a shrub species and similar to last year, treatment 2 had the highest shrub cover of any treatment. Shrub cover significantly increased from 2008 to 2009 and moderately increased this year from 1.45% in 2009 to 2.96% in 2010. This shrub cover is significantly greater (nearly ten times) than all other treatments except treatment 5 where *Spiraea betulifolia* was seeded in its mix. This high shrub cover is due exclusively to cover of *R. parviflorus* which had 2.79% cover, up slightly from 1.45% cover last year. It is important to note that cover of *R. parviflorus* is increasing despite a continual drop in density of this shrub species (Table 7). It was clear when monitoring that *R. parviflorus* germinants were bigger in size, adding to increased cover despite fewer individuals. Tree cover also significantly increased from 0.87% to 2.16% due to significant increases in cover of *Pinus contorta* and *Populus balsamifera*.

Native forbs had a moderate increase in cover, increasing from 1.43% in 2009 to 3.61% in 2010. This increase was not statistically significant. This increase was due to significant increases in cover of *Anaphalis margaritacea* and *Hieracium albiflorum*, as well as a notable increase in cover of *Chamerion angustifolium*. Like other treatments, some of these species may have become established due to windblown seed from adjacent treatments. At the same time, naturally regenerating species from the adjacent forest, such as *Antennaria bowellia*, *Maianthemum stellatum*, and *Viola orbiculata*, are becoming established as well. Although native grass cover increased from 0.78% to 3.60% this year, results are not statistically significant. Increases were due to significant increases of *Carex rossii*, a naturally regenerating grass, and *Calamagrostis rubescens*, a grass that perhaps became established from windblown seed of other treatments. Small increases of *Carex concinnoides*, *Elymus glaucus*, and *Festuca occidentalis*, all grasses of the adjacent forest, are adding to the increase in native grass cover.

As stated above, most of the cover within this treatment is due to exotic forbs that have the highest lifeform cover on treatment 2. Exotic forb cover significantly increased from 3.12% to 9.58% this year due mostly to significant increases in cover of *Veronica officinalis* and *Trifolium hybridum*, in addition to smaller increases of *Taraxacum officinale* and *Medicago lupulina*. With two years of significant increases, *V. officinalis* continues to have higher cover on this treatment compared to all other treatments. As this exotic forb spreads rhizomatously and can persist in shade, it is concerning that this species has established so quickly. At the same time, cover of *T. hybridum*, which significantly increased on all treatments this year, has the lowest cover on this treatment compared to all other treatments. Like all other treatments, exotic grass cover did not significantly increase and remains low. *Agrostis stolonifera*, with 0.26% cover, makes up most of the exotic grass cover.

vi. *Xerophyllum tenax* seeded alone (Treatment 1)

Although total vegetation cover significantly increased from 7.67% to 27.66% and total native cover significantly increased from 3.4% to 12.11% since last year, seeding *Xerophyllum tenax* alone resulted in the third lowest overall vegetation cover, the second lowest native cover, and the second lowest native to exotic ratio of all the treatments. This is an improvement over last year when this treatment had the lowest overall vegetation cover, the lowest native cover, and the lowest native to exotic ratio of all the treatments. Still, exotic species, particularly exotic forbs, continue to dominate this treatment as indicated by a 43.8% native to exotic ratio.

The main success of treatment 1, however, continues to show that seeding *X. tenax* by itself at a seed rate of 269 seeds/m² can result in 1.37% cover and approximately 31 plants/m² at only year three. While those numbers may sound low, these results are much more promising than other projects where *X. tenax* was seeded within a larger seed mix. Currently, cover of *X. tenax* in 2010 is significantly higher than cover in 2008, despite a consistent, small decrease in density over time (Table 7). This is an indication that surviving beargrass seedlings are growing in size, a result that was very visible during monitoring. Future monitoring will track how the seedlings grow into larger plants, data that will prove useful in trying to restore *X. tenax* to other areas dominated by this species. Overall, native forb cover significantly increased from 1.75% to 5.14%, due to significant increases of *Anaphalis margaritacea* and *Hieracium albiflorum*, as well as smaller increases of *Chamerion angustifolium*, *X. tenax* and the natural establishment of four new native forb species. High diversity of native forbs is also likely adding to the steady increase of native forb cover. Currently, *C. angustifolium*, *A. margaritacea*, and *X. tenax* have the highest native forb covers within this treatment and cover of *X. tenax* remains significantly higher on this treatment than all other treatments. Native grass also increased since last year from 1.17% to 3.78%, although results were not statistically significant. This increase was due to a significant increase of *Carex rossii*, smaller increases of *Calamagrostis rubescens*, *Danthonia intermedia*, and *Festuca occidentalis*, and the establishment of five new native grass species.

Like other treatments, tree cover significantly increased from 0.47% to 2.68%. Significant increases of *Pinus contorta* and *Populus balsamifera* seedlings resulted in the higher tree cover. Shrub cover remained at a low 0.03%, similar to last year.

Also like other treatments, cover of exotic forbs continued to significantly increase from 4.03% to 13.79% making exotic forbs the lifeform with the highest cover on this treatment for the second year in a row. This increase in cover was due primarily to an approximate 9% increase of *Trifolium hybridum*, a 1% increase of *Veronica officinalis*, and smaller increases in cover from other exotic forbs present within this treatment. Exotic grass cover also increased from 0.21% to 1.66% this year, resulting in the highest exotic grass cover of all the treatments (results not statistically significant). *Agrostis stolonifera*, an aggressive rhizomatous grass, accounts for all of the exotic grass cover. As with treatment 2, it is concerning that this grass is establishing so quickly due to its invasive nature.

vii. *Calamagrostis rubescens* seeded alone (Treatment 3)

While seeding *Calamagrostis rubescens* seed alone resulted in the fourth highest overall vegetation cover at 28.94%, over half of this cover is due to exotic forbs. Only 39.1% of the vegetation is from native cover, the lowest percentage of native cover of any treatment. Total native cover of 11.33% was also the lowest native cover of any treatment and total exotic cover of 17.61% was the highest of any treatment. The overall change in exotic cover, increasing 12.60%, was also the highest of any treatment. Despite the high exotic cover, overall native cover significantly increased from 5.29% to 11.33% this year, including a significant increase of trees and a notable increase of native grass.

As you might expect, native grasses are showing the most success. Native grass cover remains the second highest for two years in a row compared to the other treatments, second only to planted *C. rubescens* plugs. While results were not statistically significant, native grass cover increased from 3.07% in 2009 to 5.72% in 2010 due to increases of *C. rubescens* that was seeded as well as *Carex rossii* and *Carex* spp. that are naturally regenerating. Like total native grass cover, *C. rubescens* has the second highest cover on this treatment than all other treatments other than *C. rubescens* plugs. It is interesting to note that *C. rubescens* seeded alone has significantly higher cover at 4.19% than *C. rubescens* seeded with a forb/shrub mix that had 1.75% cover. This is the first year that cover of *C. rubescens* seeded alone is significantly higher than *C. rubescens* seeded with a forb/shrub mix. As literature and past revegetation experiments have suggested, *C. rubescens* seed does better without competition. Comparative results may be somewhat difficult, however, as *C. rubescens* was seeded at 538 seeds/m² under this treatment and only seeded at 323 seeds/m² under treatment 4.

While native forb cover increased slightly from 1.17% to 2.53% since last year, native forb cover on this treatment is currently the lowest in comparison to all treatments. Although *Hieracium albiflorum* significantly increased since last year and *Anaphalis margaritacea* and *Chamerion angustifolium* significantly increased since 2008, cover of all native forb species remains relatively low. It is likely that the establishment of *A. margaritacea* and *C. angustifolium* was due to blowing seed from adjacent seeded treatments. Overall diversity of forb species on this treatment is actually average considering no forb species were seeded. Forb cover may show larger increases in the future due to this higher diversity.

As under most other treatments, tree cover significantly increased due to significant increases of *Pinus contorta* and small increases of *Populus balsamifera*. With no shrub species seeded on this treatment, shrub cover remains negligible.

Also similar to other treatments, exotic forb cover significantly increased from 4.74% in 2009 to 15.99% in 2010, making exotic forbs remain the highest lifeform cover of this treatment for two straight years. As stated above, this treatment had the largest increase in exotic forb cover of any treatment. This is almost exclusively due to a significant increase of *Trifolium hybridum* on this treatment. *Veronica officinalis* had a significant increase in cover since 2008. Exotic grass cover remains relatively low at 1.48% with *Agrostis stolonifera* comprising most of that cover. Similar to treatments 1 and 2, this aggressive grass should be monitored closely in the future.

1b. Success of individual species

Three years after seeding, cover of several individual seeded species greatly increased with several species attaining cover over 1%. Due to the fact that most germination rates either decreased or did not significantly change over time (Table 7), the increased cover is primarily due to plants growing larger in size since 2009. Success of individual species are described by lifeform below.

i. Native Forbs

Treatments 4 and 5, where native forbs were seeded, continued to have significantly higher covers of native forbs at 17.17% and 12.5%, respectively, than all other treatments. These increased from 10.31% and 7.5% covers last year. Covers of other treatments where either no forbs were seeded or *Xerophyllum tenax* was seeded remain between 2.53% and 5.14% cover.

Last year, *Achillea millefolium* was the most successful seeded species under both treatments with significant increases in cover. In 2010, *A. millefolium* remains the most successful seeded species only on treatment 5 where it significantly increased from 6.13% to 11.46% cover. This remains the highest cover of any native species other than the planted *Calamagrostis rubescens* plugs. Conversely, *A. millefolium* did not increase on treatment 4, remaining at 3.69% cover. Currently, *Anaphalis margaritacea* with 5.95% cover and *Symphytotrichum laeve* with 4.22% cover are two other seeded forbs that have the highest cover on this treatment. Interestingly, treatment 4, where *A. millefolium* was sown at only 86 seeds/m², had 61.5 *A. millefolium* plants/m², a very high 71.5% germination rate similar to last year. *A. millefolium* was sown at a higher rate of 215 seeds/m² on treatment 5, and while this species currently has 104.0 plants/m² on this treatment, the overall germination rate was much lower at 48.4%. The higher seed rate did produce both higher cover and density, but in terms of germination of seed, there may be a 'point of no return' with *A. millefolium* that is closer to the seed rate on treatment 4.

As stated above, other successful seeded forbs on treatment 4 include *Anaphalis margaritacea* that significantly increased from 2.54% to 5.95% cover and *Symphytotrichum laeve* that significantly increased from 2.12% to 4.22% cover. *Solidago canadensis* also increased in cover from 0.88% to 1.88% since last year. Coincidentally, two of these species, *A. margaritacea* and *S. canadensis*, had notable increases in their germination rates this year that is likely contributing to their increase in cover. *S. laeve* had a decrease in density, indicating that some initial germinants may be dying off but that the surviving plants are clearly growing in size. *A. margaritacea* has the highest germination rate of any seeded species at 83.2%. *S. laeve* and *S. canadensis* have moderate germination rates at 42.7% and 31.2%, respectively. *Geum macrophyllum* and *Chamerion angustifolium*, the remaining seeded forbs on treatment 4, also increased slightly; however, their covers remain at a lower range of 0.49% to 0.88%. These two species were seeded at the same rate as *A. margaritacea*, *S. laeve*, and *S. canadensis* but have far lower germination rates, both of which are lower than last year. The overall lower density is likely preventing these species from greater increases in cover, although some plants are noticeably larger in size. Covers of *A. margaritacea*, *S. laeve*, *S. canadensis*, and *G. macrophyllum* are significantly higher or generally higher on treatment 4 than any other treatment, indicating that seeding these species is the most efficient

way to get these plants established. Conversely, cover of *C. angustifolium* remains the lowest under treatment 4, the only treatment where it was seeded, indicating it does not need to be seeded if this species is in the seed bank. Similar to last year, the highest cover of *C. angustifolium* remains under treatments 2 (*R. parviflorus* seed), 7 (control), and 3 (*C. rubescens* seed) where it was not seeded.

In general, species continue to naturally recruit to all of the plots within each treatment. Most of this recruitment is due to the existing seed bank and seeding into the plots from the adjacent forest. There may be, however, some plants that became established due to blowing seed from seeded treatments. This may be particularly true of *Geum macrophyllum*, *Solidago canadensis*, and *Symphyotrichum laeve* which do not naturally occur in the adjacent forest type. Native forbs that have already naturally recruited to this project in the past include *Chamerion angustifolium*, *Hieracium albiflorum*, *Epilobium brachycarpum*, *Viola orbiculata*, *Antennaria howellia*, *Campanula rotundifolia*, and *Osmorhiza berteroi*. New naturally recruiting species observed this year include *Antennaria rosea*, *Aster* sp., *Chimaphila umbellata*, and *Maianthemum stellatum*. *Epilobium brachycarpum* and *Hieracium albiflorum* continue to increase in cover in the treatments where they are present.

Lastly, treatment 1 where *Xerophyllum tenax* was seeded had significantly higher cover of *X. tenax* than any other treatment. There has been difficulty getting *X. tenax* established from seed in previous projects, particularly those projects with a diverse seed mix of grasses. This treatment may show us that it indeed is possible to get *X. tenax* established from seed with less competition. The germination rate for *X. tenax* remains low, slightly lower than last year at approximately 11.4%, illustrating that, while possible, it is difficult to get this species to grow from seed. Despite a continual lower germination rate over time, cover of this species continues to increase, however, documenting that those germinated plants are growing.

ii. Native Grasses

Similar to last year, the strategy to achieve the highest native grass cover at year three remains to plant *Calamagrostis rubescens* plugs. This treatment resulted in 16.29% native grass cover in 2010, significantly higher than all other treatments and much higher than seeding *C. rubescens* alone, the treatment with second highest native grass cover at 5.72%. Cover of *C. rubescens* plugs increased from 2.31% in 2007 to 7.21% in 2008 to 9.54% in 2009 to 13.79% in 2010. Native grass cover increased across all treatments, although none of the increases were statistically significant.

The long term question of these treatments is whether grass seed cover will eventually ‘catch up’ to planted grass cover. *Calamagrostis rubescens* that was seeded alone had the highest grass seed rate at 538 seeds/m², resulting in 4.19% cover this year and increasing from 2.70% cover last year. This cover is significantly higher than *C. rubescens* cover when it is seeded at a lower seed rate with a forb/shrub mix. *C. rubescens* sown at 323 seeds/m² along with a forb/shrub mix resulted in 1.75% cover, increasing from 1.63% cover last year. At the same time, however, *C. rubescens* at this lower seed rate currently has a higher germination rate at 23.3% in comparison to *C. rubescens* seeded alone with a higher seed rate that had a 14.6% germination rate. By this third year after seeding, the densities of *C. rubescens* are virtually the same under both treatments regardless of seed rate. *C. rubescens* had a density of 78.3 plants/m² on treatment 3 with a higher seed rate and 75.2 plants/m² on treatment 4 with a lower seed rate. Like *Achillea millefolium* described above, there appears to be a ‘point of no return’ with seed for this species as the higher seed rate is not returning the highest germination rate or densities. As for answering the question about whether grass seed will eventually ‘catch up’ with grass planting, the answer may be known within a few years. Considering, on average, there are only 33 plants per macroplot (almost 4m²) when *C. rubescens* is planted in comparison to 75 to 78 plants/m² when *C. rubescens* is seeded, it is anticipated that the seeding will eventually equal the cover of planted material if it survives. As *C. rubescens* is a rhizomatous grass, it will be interesting to note when planted material begins to send out rhizomes within the planted area, adding to the complexity of which method leads to the success of restoring this species.

The other seeded grass within this project is *Carex athrostachya*. Due to the lack of seed heads on many *Carex* plants at the time of monitoring, it is currently difficult to assess exactly how much *C. athrostachya* is actually present. Besides some *Carex rossii* and *Carex concinnoides* that were evident, most sedges were necessarily lumped as *Carex* sp. Like 2009, all treatments in 2010 had similar cover of *Carex* sp. (no significant differences) even though only treatment 5 was seeded with *Carex athrostachya*. However, while *Carex* cover on treatments 1, 4, 6, and 7 actually decreased, *Carex* that was seeded on treatment 5 had the biggest increase in *Carex* cover, nearly doubling in cover since last year. Density of *Carex* sp. on treatment 5 is also increasing, perhaps indicating that seeding this sedge species takes several years to germinate and start increasing in cover. Despite the increase in density, the overall germination rate of *C.*

athrostachya is currently 3.3%, the lowest of all seeded species in the project, indicating its difficulty to establish from seed. Future monitoring will reveal if seeded *Carex* is successful at establishing and increasing in cover. For now, naturally regenerating *C. rossii* has the highest cover of any sedge species. It may be that that restoration in forest types with *C. rossii* does not require the seeding of additional sedge species since this species is recovering so well. Finally, it is clear that seeding *Calamagrostis rubescens* results in higher germination, density and cover in comparison to seeding *Carex athrostachya*. Seeding *C. rubescens* at a rate of 323 seeds/m² resulted in a 23.3% germination rate, 75.2 plants/m², and 1.75% cover. By comparison, seeding *C. athrostachya* at a rate of 323 seeds/m² resulted in a 3.3% germination rate, 10.5 plants/m², and 1.00% cover.

Finally, natural regeneration of native grasses continued in all treatments throughout the project. Native grasses that have established by natural regeneration in the past include *Danthonia intermedia*, *Festuca occidentalis*, and *Agrostis scabra*. Each of these species generally has very low cover where they were observed except in the control treatment where cover was noticeably higher. This may be due to the lack of competition here from other seeded or planted species. New species observed this year include *Carex concinnoides*, *Deschampsia cespitosa*, *Elymus glaucus*, *Poa palustris*, and *Trisetum canescens*. *C. rubescens* remains present in all treatments regardless of whether it was seeded or planted. There is a chance that some seed from adjacent treatments has become established in neighboring treatments, however, *C. rubescens* naturally occurs adjacent to the treatment plots and is likely naturally regenerating throughout the project. Currently, cover of *C. rubescens* is significantly lower in areas where it was not seeded or planted, indicating that seeding or planting is the more efficient way to reestablish this grass.

iii. Trees and Shrubs

As in 2008 and 2009, shrubs remain negligible on the project unless seeded. Covers of total native shrub, *Rubus parviflorus* and *Spiraea betulifolia* remain highest in the treatments in which they are seeded. In treatment 2 where it was seeded, *R. parviflorus* remains significantly higher than all other treatments. Interestingly, cover of *R. parviflorus* on treatment 2 continues to increase each year while the density of this shrub continues to decrease. The overall germination rate of this shrub is a low 5.8%. It appears that *R. parviflorus* may be difficult to grow from seed in the field given its low germination rate for all three years and die-off of year-one and year-two germinants may occur given the decline in density at year three. However, those germinants that do survive seem to grow dramatically, providing significant cover. At year three after reseeding, it seems as if *R. parviflorus* is even quicker at establishing higher shrub cover than *S. betulifolia*. Very few other shrub species are naturally regenerating with significant cover.

Seed rates differed for *Spiraea betulifolia* on treatments 4 and 5 where it was seeded. *S. betulifolia* was seeded at 86 seeds/m² on treatment 4, resulting in a 26.0% germination rate at year three, while *S. betulifolia* was seeded at 215 seeds/m² on treatment 5 with a 19.7% germination rate at year three. Similar to *Achillea millefolium* and *Calamagrostis rubescens* described above, there appears to be a 'point of no return' with seed for this species as the higher seed rate is not returning the highest germination rate. That said, *S. betulifolia* only significantly increased on treatment 5 and cover of *S. betulifolia* is now significantly higher on treatment 5 than treatment 4. Similar to *A. millefolium* seed, the higher seed rate of *S. betulifolia* is still resulting in higher cover and density of this shrub species. Die-off of year one and year two germinants may be happening on treatment 4 along with a lack of growth of existing germinants. Die-off appears to be happening on treatment 5 as well, but existing germinants are clearly growing to achieve the higher cover. As stated above, *S. betulifolia* appear to grow at a slower rate than *R. parviflorus*. It has the same or higher density than *Rubus* but its cover ranges from 0.31% to 1.79% in comparison to 2.79% cover of *Rubus*.

In contrast, tree species have demonstrated high recruitment rates in the project. No trees were planted in the project but total native tree cover continues to increase under all treatments this year. This is due to significant increases of *Pinus contorta* seedlings under all treatments and significant or notable increases of *Populus balsamifera* under all treatments. Currently, *Pinus contorta* accounts for most of the tree cover, increasing ten-fold across all plots. While tree covers between treatments are generally not significantly different from each other, it is interesting that the highest native tree cover remains on the control plots.

iv. Exotic Species

Unfortunately, much of the natural regeneration in the project continues to come from exotic species. Like last year, the biggest concern is that exotic forb cover continues to significantly increase under all treatments, now ranging in cover from 8.55% to 15.99%, two to six times higher than in 2009. Exotic forbs now have the highest lifeform cover on treatment 1, 2, 3, and 7 and the second highest lifeform cover on remaining treatments 4, 5, and 6.

Exotic forb cover has remained the lowest on treatment 6 where *C. rubescens* plugs were planted.

Veronica officinalis and *Trifolium hybridum* consistently have the highest cover of any exotic forb species, similar to last year. *Trifolium hybridum* significantly increased under all treatments, while *Veronica officinalis* significantly increased under two treatments since last year, significantly increased under three treatments since 2008, and notably increased under the remaining two treatments. The increase of *V. officinalis* is of larger concern, due to its ability to spread in mats, its ability to survive under a shady forest canopy, and its difficulty to control. This species is now found in all 7 treatments, ranging in cover from 0.80% to 5.06%. *Trifolium hybridum* may be more ephemeral and may potentially be less of a problem than other weeds. Other weed species that have become established and are maintaining their cover include *Medicago lupulina*, *Taraxacum officinale*, *Lactuca serriola*, *Filago arvensis*, and *Cirsium* spp. Other than *Cirsium* spp. that could turn out to be noxious weed *Cirsium arvensis*, most of these other weeds are not overly aggressive and do not displace native vegetation.

Overall exotic grass cover has remained much lower, ranging from 0.13% to 1.66%, however, exotic grasses are increasing slightly in cover each year under most treatments. Despite the increases on several treatments, all exotic grass cover is statistically the same at this point in time. Similar to last year, *Agrostis stolonifera* is the most consistent exotic grass on the project, present under all treatments. Although it generally increased on six of the seven treatments, none of these increases were statistically significant. *Agrostis stolonifera* is of concern due to its rhizomatous nature and inability to be controlled with herbicide. All other exotic grasses remain with very low cover. *Triticum aestivum* (a sterile wheatgrass aka regreen), observed during the first two years of monitoring, is no longer present on the project.

1c. Conclusions for Experimental Plots

At year three after planting, some of the treatments, in terms of overall native cover, are beginning to be similar to each other. Even the treatments that have lower overall cover are significantly increasing in cover and showing positive results with specific planting schemes. In 2008, one year after seeding, *Calamagrostis rubescens* plugs clearly showed the biggest success at one year after planting with the highest overall cover, highest native cover, and lowest exotic cover. Similar to 2009, however, the treatments are becoming more complicated in 2010. One on hand, *C. rubescens* plugs are still providing by far the highest native grass cover, the lowest exotic cover, and the second highest overall vegetation cover in comparison to all other treatments. At the same time, however, this treatment has the lowest overall native diversity. Seeding *C. rubescens* with a forb and shrub mix is currently the treatment with the second highest native cover, the third highest overall cover, and the second lowest exotic cover. Native forbs clearly dominate this treatment but its native grass cover is quite low despite seeding this treatment with native grass. Besides *Carex athrostachya*, which has unclear results due to difficulties in its identification, all seeded and planted species on all treatments are showing positive trends by increasing in cover. Like in other restoration projects, exotic species have become more of an issue. Exotic forb cover significantly increased on all treatments, becoming the dominant lifeform on four treatments. Exotic grass cover remains fairly low on all treatments and did not significantly increase on any treatment over the last year.

Most previous revegetation projects involving seeding *Calamagrostis rubescens* and *Xerophyllum tenax* have not proven to be very successful. It was speculated that competition from other seeded species inhibited their success in those projects. In a 1987 study at the Coram Experimental Forest, *C. rubescens* seeded alone at 646 seeds/m² resulted in 49% canopy cover three years later, while *C. rubescens* seeded with native mix (including aggressive mountain brome) resulted in 5% canopy cover. While seeded *C. rubescens* did not attain 49% cover at the three year mark of this project as it did in the Coram study, results are showing positive trends concerning seeded *C. rubescens* alone or with a forb/shrub mix. Cover of *C. rubescens* is certainly higher on this project than cover results of *C. rubescens* on earlier roadside projects that were mixed with aggressive nurse grasses. *C. rubescens* cover only reached 0.3% ten years after planting under that scenario, where cover has reached 1.75% and 4.19% three years after planting under two different treatments of this project.

The same study at the Coram Experimental Forest determined that *Xerophyllum tenax* dislikes competition. When beargrass was seeded alone, 29% of seeds established the first year and 49% established the second year. When beargrass was seeded with a native mix, 22% of seeds established the first year with no further increase. This could explain the low germination of *X. tenax* in Apgar Transit Center plots at year one and the continuing decline in density in years two and three. The long-term question for this species is to see if these plants survive and eventually grow into substantially-sized plants.

Specific conclusions and recommendations are listed below:

- At year three after planting, the highest native cover is achieved by planting *Calamagrostis rubescens* plugs. Planting *Calamagrostis rubescens* plugs remains the quickest way to achieve a high cover of native grass which is three to four times as high as on other treatments. This treatment also has the lowest exotic cover of all the treatments, resulting in the highest native to exotic ratio at 72.1%. It also had the second highest overall vegetative cover. It is possible that very high initial cover during the first year prevented the establishment of weeds and maintains a higher percent native cover over time. At the same time, this treatment has the lowest overall diversity in terms of numbers of native plant species. While it may be preventing weed establishment, it may also be preventing natural regeneration of native species as well. If forb cover were an important part of the restoration project, it would be interesting in the future to add a forb seed mix after plugs were planted.
- Another treatment with excellent results is seeding *Calamagrostis rubescens* with a forb and *Spiraea betulifolia* mix. Overall, it appears that *C. rubescens* can have moderate to moderately high germination when seeded with other species as long as they are not fast-growing, aggressive colonizers. Cover of *C. rubescens* is statistically lower when seeded with a forb/shrub mix as it is when seeded alone. But the forb/shrub mix results in significantly higher native forb cover and overall native diversity than no forb seed at all.
- If forb cover is not as important, seeding *Calamagrostis rubescens* alone remains a good option to achieve high native grass cover. Cover of *C. rubescens* was significantly higher than cover of *C. rubescens* when seeded with a forb/shrub mix. It remains a long-term question to see if seeded *C. rubescens* will eventually ‘catch up’ to planted *C. rubescens* plugs. Considering, on average, there are only 33 plants per macroplot (almost 4m²) when *C. rubescens* is planted in comparison to 75 to 78 plants/m² when *C. rubescens* is seeded, it is anticipated that the seeding will eventually equal the cover of planted material if it survives.
- Shrubs of this forest type do not appear to naturally regenerate, and if they do, they recolonize slowly. Seeding is necessary to recolonize *Rubus parviflorus* and *Spiraea betulifolia*. Currently, seeding *R. parviflorus* appears to offer higher cover than seeding *S. betulifolia* despite higher germination rates of *S. betulifolia*. It may be that *R. parviflorus* plants are able to grow faster.
- Conversely, trees appear able to recolonize on their own. *Pinus contorta* and *Populus balsamifera* have each colonized in each treatment and currently provide the most consistent tree cover throughout the project.
- Until all *Carex* germinants can be identified to species, it is difficult to tell the effectiveness of seeding *Carex athrostachya*. Currently, it does not appear to be showing much success. *Carex rossii*, on the other hand, has been effective at recolonizing into six of the seven treatments. As this sedge is a natural part of the surrounding forest, it is showing better signs of being a productive native sedge species to use in this type of west-side forest.
- Seeding a mix of forbs is the most efficient way to get the highest cover of forbs. *Achillea millefolium*, *Anaphalis margaritacea* and *Symphyotrichum laeve* appear to be the most successful species on this project, having the highest germination rates and the highest covers. If *Chamerion angustifolium* is nearby, there appears no need to seed it. It naturally recolonized all treatments and had the lowest cover on the treatment where it was seeded.
- There may be a ‘point of no return’ in terms of seeding for several species. *Achillea millefolium*, *Calamagrostis rubescens*, and *Spiraea betulifolia* had lower germination rates (and sometimes lower densities in the case of *C. rubescens*) when seeded at a higher seed rate.
- Plots should be monitored at the following times: 2012 (year 5), 2014 (year 7), and 2017 (year 10).

Table 4. Apgar Transit Center Experimental Plots: Average canopy cover for each treatment by species, 2008-2010 (3 microplots per plot x 8 reps, averaged per treatment). * = Seeded species. Orange cells indicate that cover within treatments are significantly different (90% CI) between 2008/2009, 2009/2010, or 2008/2010.

TREATMENT#	1			2			3			4			5			6				7		
TREATMENT TYPE	XERTEN seed			RUBPAR seed			CALRUB seed			CALRUB seed with forb + SPIBET			CARATH seed with forb + SPIBET			CALRUB plugs				control		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2007	2008	2009	2010	2008	2009	2010
Basal vegetation	0.10	0.50	1.14	0.10	0.45	1.40	0.10	0.91	1.34	0.22	0.97	1.63	0.10	0.88	1.52		0.63	1.15	2.80	0.10	0.47	1.66
Litter/Duff	47.75	64.25	72.42	44.54	61.04	64.79	53.29	70.50	72.04	52.33	65.50	77.04	58.96	70.25	73.13		31.71	55.67	64.54	62.88	79.33	78.58
Moss	0.12	5.08	8.56	0.18	5.77	10.08	0.13	2.48	9.54	0.96	4.01	5.04	0.07	2.31	13.61		0.02	1.98	6.88	0.56	4.58	10.48
Bare Soil	24.58	9.54	3.04	22.71	10.58	4.67	21.58	9.33	2.90	20.25	7.29	1.66	17.08	9.38	2.19		26.88	14.75	2.75	17.50	6.29	1.31
Gravel	25.42	18.63	13.92	32.29	22.29	18.71	23.96	16.63	13.79	24.71	21.67	13.42	23.38	16.63	9.63		38.29	25.26	20.25	18.63	9.21	7.92
Rock	1.00	0.25	0.00	0.29	0.00	0.21	1.08	0.25	0.46	1.04	0.50	0.63	0.54	0.38	0.00		2.67	1.25	2.83	0.46	0.13	0.00
Wood	1.17	1.88	0.83	0.00	0.42	0.08	0.00	0.00	0.00	0.63	0.13	0.63	0.00	0.25	0.00		0.00	0.00	0.00	0.00	0.13	0.00
Other	0.00	0.00	0.17	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.17
TO TAL NATIVE TREE	0.18	0.47	2.68	0.20	0.87	2.16	0.33	1.04	2.55	0.22	0.96	1.88	0.31	1.16	2.40		0.35	0.91	3.82	0.38	2.04	3.90
<i>Abies lasiocarpa</i>						0.01																
<i>Betula papyrifera</i>																			0.05			0.09
Generic conifer seedlings	0.05	0.23	0.21	0.03	0.26	0.13	0.16	0.26	0.21	0.05	0.17	0.13	0.06	0.25	0.23		0.05	0.29	0.14	0.07	0.28	0.17
<i>Larix occidentalis</i>								0.08										0.13			0.04	
<i>Picea engelmannii</i>			0.01																	0.01		
<i>Pinus contorta</i>		0.19	2.01		0.10	1.36		0.22	1.87		0.11	1.31		0.40	1.53			0.10	2.28		0.59	2.22
<i>Pinus monticola</i>			0.04																			
<i>Populus balsamifera</i>	0.13	0.05	0.58	0.18	0.51	0.83	0.17	0.48	0.61	0.18	0.68	0.71	0.26	0.51	0.78		0.30	0.39	1.44	0.31	1.13	1.53
TO TAL NATIVE SHRUB	0.01	0.01	0.03	0.21	1.45	2.96	0.004	0.01	0.07	0.05	0.41	0.31	0.19	0.67	1.86		0.00	0.00	0.04	0.00	0.08	0.32
<i>Rubus idaeus</i>															0.04				0.04			
<i>Rubus parviflorus*</i>	0.01		0.01	0.21	1.45	2.79					0.01			0.01								
<i>Shepherdia canadensis</i>		0.01				0.04																
<i>Spiraea betulifolia*</i>			0.01		0.01	0.11		0.01	0.05	0.05	0.40	0.31	0.19	0.65	1.79						0.08	0.18
<i>Symphoricarpos albus</i>				0.004			0.004			0.004				0.01								
<i>Vaccinium caespitosum</i>						0.04																
<i>Vaccinium myrtilloides</i>															0.05							
Unknown shrub			0.01						0.02			0.01							0.01		0.02	
TO TAL NATIVE GRASS	0.11	1.17	3.78	0.05	0.78	3.60	1.08	3.07	5.72	1.01	2.48	2.44	0.28	0.94	3.13	2.31	7.29	10.43	16.29	0.18	1.93	4.48
<i>Agrostis scabra</i>			0.05			0.06		0.01	0.14		0.09	0.21		0.27	0.93				0.06		0.21	0.23
<i>Carex athrostachya*</i>																						
<i>Carex concinnoides</i>			0.09			0.13			0.05			0.08			0.09				0.17			0.13
<i>Carex rossii</i>		0.17	2.17		0.13	1.08			0.50		0.09			0.04	0.34			0.13	1.92		0.08	1.47
<i>Carex sp.</i>	0.11	0.73	0.70	0.05	0.49	0.57	0.08	0.29	0.50	0.05	0.50	0.31	0.27	0.52	1.00		0.12	0.76	0.14	0.13	0.74	0.68
<i>Calamagrostis rubescens*</i>		0.07	0.24	0.004	0.10	0.63	1.08	2.70	4.19	1.01	1.63	1.75	0.02	0.03	0.08	2.31	7.21	9.54	13.79		0.02	0.01
<i>Danthonia intermedia/spicata</i>		0.10	0.35		0.04	0.38		0.03	0.29		0.08	0.13	0.004	0.08	0.26				0.08	0.004	0.29	0.23
<i>Deschampsia caespitosa</i>			0.04																			0.05
<i>Elymus glaucus</i>						0.22			0.13								0.004		0.06			
<i>Festuca occidentalis</i>		0.10	0.23		0.02	0.34	0.004	0.04			0.08	0.01			0.20		0.004	0.01	0.13	0.04	0.58	1.81
<i>Festuca sp.</i>					0.01				0.01													
<i>Poa palustris</i>			0.05									0.01			0.31							
<i>Trisetum canescens</i>			0.01												0.01							
TO TAL NATIVE FORB	0.25	1.75	5.14	0.20	1.43	3.61	0.13	1.17	2.53	1.20	10.31	17.17	1.61	7.50	12.50		0.07	0.98	3.11	0.36	2.57	3.96
<i>Achillea millefolium*</i>		0.04	0.04	0.05	0.04	0.03	0.004		0.03	0.95	3.56	3.69	1.53	6.13	11.46			0.04	0.06			0.12
<i>Adenocaulon bicolor</i>		0.05																				
<i>Anaphalis margaritacea*</i>	0.03	0.15	1.25	0.01	0.15	1.00	0.02	0.08	0.37	0.16	2.54	5.95	0.01	0.11	0.63			0.05	0.33	0.01	0.36	0.88
<i>Antennaria howellii</i>		0.08	0.13		0.04	0.08													0.01			
<i>Antennaria rosea</i>			0.01																			0.04
<i>Aster spp.</i>			0.04			0.09			0.13													
<i>Campanula rotundifolia</i>												0.04								0.004	0.05	0.13
<i>Chamerion angustifolium*</i>	0.08	0.65	1.20	0.12	1.09	1.85	0.12	0.83	1.55	0.09	0.31	0.49	0.15	1.08	1.46		0.06	0.62	1.28	0.31	1.79	1.60
<i>Chimaphila umbellata</i>																						0.14
<i>Conyza canadensis</i>			0.08		0.01			0.04	0.02			0.01		0.01							0.01	0.02

Table 4 con'd. Apgar Transit Center Experimental Plots: Average canopy cover for each treatment by species, 2008-2010. **Orange cells indicate that cover within treatments are significantly different (90% CI) between 2008/2009, 2009/2010, or 2008/2010.**

TREATMENT#	1			2			3			4			5			6				7		
TREATMENT TYPE	XERTEN seed			RUBPAR seed			CALRUB seed			CALRUB seed with forb + SPIBET			CARATH seed with forb + SPIBET			CALRUB plugs				control		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2007	2008	2009	2010	2008	2009	2010
<i>Epilobium brachycarpum</i>		0.01	0.21	0.04	0.04	0.29	0.01	0.04	0.07	0.01	0.06	0.10	0.004	0.04	0.08		0.01	0.09	0.52	0.004	0.17	0.28
<i>Gnaphalium macounii</i>			0.33			0.01		0.08	0.04		0.04										0.04	0.13
<i>Geum macrophyllum</i> *										0.07	0.68	0.88		0.01								0.04
<i>Hieracium albiflorum</i>		0.06	0.62		0.04	0.41		0.02	0.45		0.09	0.18		0.04	0.25			0.13	0.75		0.10	0.96
<i>Maianthemum stellatum</i>						0.01									0.01							
<i>Melampyrum linare</i>																				0.04	0.04	
<i>Osmorhiza berteroi</i>								0.01	0.08					0.04								
<i>Penstemon confertus</i>					0.04			0.04														
<i>Solidago canadensis</i> *		0.04					0.004			0.06	0.88	1.88		0.04								
<i>Symphyotrichum laeve</i> *		0.01								0.13	2.12	4.22			0.01			0.01				
Unknown								0.01						0.01								
<i>Viola orbiculata</i>	0.02	0.05	0.08		0.02	0.03			0.02	0.004	0.04		0.01	0.01	0.05			0.04	0.01			
<i>Xerophyllum tenax</i> *	0.21	0.61	1.37					0.01									0.004					0.01
TOTAL EXOTIC GRASS	0.21	0.21	1.66	0.05	0.21	0.30	0.18	0.26	1.48	0.004	0.30	0.18		0.28	0.39		0.04	0.04	0.13	0.01	0.04	0.47
<i>Agrostis stolonifera</i>	0.21	0.21	1.66		0.13	0.26	0.17	0.25	1.48	0.004	0.22	0.13		0.05	0.30		0.04	0.04	0.13	0.004	0.04	0.42
<i>Elymus repens</i>					0.08																	
<i>Phleum pratense</i>				0.004		0.04																
<i>Poa compressa</i>							0.004		0.02					0.04								
<i>Poa pratensis</i>											0.08	0.05		0.19								
<i>Triticum aestivum</i>	0.004			0.05			0.01	0.01												0.004		
TOTAL EXOTIC FORB	0.38	4.03	13.79	0.11	3.12	9.58	0.16	4.74	15.99	0.19	3.85	9.65	0.33	4.25	11.98		0.06	2.35	8.55	0.20	1.48	12.64
<i>Cerastium fontanum</i>						0.04																
<i>Cirsium sp.</i>		0.03	0.04					0.01	0.01													
<i>Cirsium vulgare</i>			0.01						0.01			0.01						0.01	0.04			
<i>Filago arvensis</i>		0.05	0.13		0.03	0.06	0.004	0.01	0.04		0.004	0.01	0.004	0.02	0.03			0.05	0.02		0.08	0.13
<i>Lactuca serriola</i>		0.01	0.02			0.08			0.01			0.01	0.04						0.02			
<i>Medicago lupulina</i>		0.13		0.004	0.21	0.83	0.004				0.13		0.004	0.08	0.42			0.04	0.71	0.01	0.15	0.21
<i>Taraxacum officinale</i>		0.02	0.11		0.03	0.22		0.01	0.08			0.05	0.01	0.09	0.23			0.03	0.18	0.13	0.05	0.08
<i>Trifolium agrarium</i>								0.04			0.01		0.004		0.01		0.004	0.04				
<i>Trifolium hybridum</i>		3.13	12.06		0.51	3.10		4.38	14.18	0.08	2.59	7.38		1.63	7.81			1.42	7.00		0.77	11.51
<i>Trifolium pratense</i>																		0.08				
<i>Trifolium sp.</i>	0.37	0.31		0.06	0.92	0.29	0.14	0.08	0.05	0.02	0.15	0.01	0.06	1.34			0.05	0.54	0.01	0.05	0.38	0.01
<i>Veronica officinalis</i>	0.03	0.38	1.51	0.06	1.44	5.06	0.02	0.20	1.72	0.10	0.96	2.23	0.22	1.08	3.59		0.01	0.13	0.97	0.01	0.06	0.80
UNKNOWN ORIGIN GRASS	0.01	0.01	0.00	0.00	0.00	0.00	0.004	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00		0.01	0.00	0.00	0.00	0.00	0.00
unknown grass	0.01	0.01					0.004						0.01				0.01					
UNKNOWN ORIGIN FORB	0.01	0.02	0.01	0.01	0.01		0.03	0.02	0.01	0.03	0.00		0.05	0.01			0.02	0.00	0.02	0.01	0.01	
<i>Hieracium sp.</i>					0.01					0.004							0.004		0.02	0.01		
unknown forb	0.01	0.02	0.01	0.01			0.03	0.02	0.01	0.02			0.05	0.01			0.02			0.004	0.01	
TOTAL PLOT NATIVE VEG CVR	0.63	3.40	12.11	0.69	4.54	12.55	1.65	5.29	11.33	2.84	14.16	22.40	2.50	10.28	21.36		7.77	12.32	23.48	0.93	6.63	13.06
TOTAL PLOT VEG COVER	1.25	7.67	27.66	0.87	7.88	22.49	2.03	10.30	28.94	3.07	18.31	32.28	2.90	14.80	33.75		7.90	14.71	32.58	1.15	8.16	26.22
% NATIVE COVER	50.0%	44.3%	43.8%	79.2%	57.6%	55.8%	81.1%	51.4%	39.1%	92.4%	77.3%	69.4%	86.4%	69.5%	63.3%		98.4%	83.8%	72.1%	81.1%	81.3%	49.8%

Table 5A. Appgar Transit Center Experimental Plots: Statistical comparison of canopy cover between treatments. Table 5A shows cover values of seeded material by treatment. Table 5B shows how treatments are significantly different from each other (90% CI). * = Seeded species.

TREATMENT#	1			2			3			4			5			6			7		
TREATMENT TYPE	XERTEN seed			RUBPAR seed			CALRUB seed			CALRUB seed with forb + SPIBET			CARATH seed with forb + SPIBET			CALRUB plugs			control		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
TOTAL NATIVE TREE	0.18	0.47	2.68	0.20	0.87	2.16	0.33	1.04	2.55	0.22	0.96	1.88	0.31	1.16	2.40	0.35	0.91	3.82	0.38	2.04	3.9
<i>Populus balsamifera</i>	0.13	0.05	0.58	0.18	0.51	0.83	0.17	0.48	0.61	0.18	0.68	0.71	0.26	0.51	0.78	0.30	0.39	1.44	0.31	1.13	1.53
TOTAL NATIVE SHRUB	0.01	0.01	0.03	0.21	1.45	2.96	0.004	0.01	0.07	0.05	0.41	0.31	0.19	0.67	1.86	0.00	0.00	0.04	0.00	0.08	0.32
<i>Rubus parviflorus</i> *	0.01		0.01	0.21	1.45	2.79					0.01			0.01							
<i>Spiraea betulifolia</i> *			0.01		0.01	0.11		0.01	0.05	0.05	0.40	0.31	0.19	0.65	1.79					0.08	0.18
TOTAL NATIVE GRASS	0.11	1.17	3.78	0.05	0.78	3.60	1.08	3.07	5.72	1.01	2.48	2.44	0.28	0.94	3.13	7.29	10.43	16.29	0.18	1.93	4.48
<i>Agrostis scabra</i>			0.05			0.06		0.01	0.14		0.09	0.21		0.27	0.93			0.06		0.21	0.23
<i>Calamagrostis rubescens</i> *		0.07	0.24	0.004	0.10	0.63	1.08	2.70	4.19	1.01	1.63	1.75	0.03	0.03	0.08	7.21	9.54	13.79		0.02	0.01
<i>Carex rossii</i>		0.17	2.17		0.13	1.08			0.50		0.09			0.04	0.34		0.13	1.92		0.08	1.47
TOTAL NATIVE FORB	0.25	1.75	5.14	0.20	1.43	3.61	0.13	1.17	2.53	1.20	10.31	17.17	1.61	7.50	12.50	0.07	0.98	3.11	0.36	2.57	3.96
<i>Achillea millefolium</i> *		0.04	0.04	0.05	0.04	0.03	0.004		0.03	0.95	3.56	3.69	1.53	6.13	11.46		0.04	0.06			0.12
<i>Anaphalis margaritacea</i> *	0.03	0.15	1.25	0.01	0.15	1.00	0.02	0.08	0.37	0.16	2.54	5.95	0.01	0.11	0.63		0.05	0.33	0.01	0.36	0.88
<i>Chamerion angustifolium</i> *	0.08	0.65	1.20	0.12	1.09	1.85	0.12	0.83	1.55	0.09	0.31	0.49	0.15	1.08	1.46	0.06	0.62	1.28	0.31	1.79	1.6
<i>Geum macrophyllum</i> *										0.07	0.68	0.88		0.01							0.04
<i>Solidago canadensis</i> *		0.04					0.004			0.06	0.88	1.88		0.04							
<i>Symphyotrichum laeve</i> *		0.01								0.13	2.12	4.22			0.01		0.01				
<i>Xerophyllum tenax</i> *	0.21	0.61	1.37					0.01								0.004					0.01
TOTAL EXOTIC FORB	0.38	4.03	13.79	0.11	3.12	9.58	0.16	4.74	15.99	0.19	3.85	9.65	0.33	4.25	11.98	0.06	2.35	8.55	0.20	1.48	12.64
<i>Trifolium hybridum</i>		3.13	12.06		0.51	3.10		4.38	14.18	0.08	2.59	7.38		1.63	7.81		1.42	7.00		0.77	11.51

Table 5B. Apgar Transit Center Experimental Plots: Statistical comparison of canopy cover between treatments. Table 5A shows cover values that have significant differences (90% CI) between treatments. Table 5B shows how treatments are significantly different from each other.

TOTAL NATIVE TREE	2008	No significant differences between treatments
	2009	2=3=4=5=6 > 1; 3=4=5=6=7, 7 > 1 and 2
	2010	No significant differences between treatments
<i>Populus balsamifera</i>	2008	No significant differences between treatments
	2009	2=3=4=5=6=7; 1=4, 7 > 1
	2010	No significant differences between treatments
TOTAL NATIVE SHRUB	2008	2=4=5; 2=5 > 1=3=6=7
	2009	2=5; 2 > 4 and 1=3=6=7; 4=5 > 1=3=6=7
	2010	2=5 > 4=7 > 1=3=6
<i>Rubus parviflorus</i>	2008	2 > 1=3=4=5=6=7
	2009	2 > 1=3=4=5=6=7
	2010	2 > 1=2=4=5=6=7
<i>Spiraea betulifolia</i>	2008	4=5; 5 > 1=2=3=6=7
	2009	4=5 > 1=2=3=6=7
	2010	5 > 4 > 1=2=3=6=7 except 4=2=7
TOTAL NATIVE GRASS	2008	3=4 > 1=2=5=7; 6 > 1, 2, 3, 4, 5, 7
	2009	1=4=5=7; 3=4=7; 3 > 1, 2, 5; 4 > 2; 6 > 1, 2, 3, 4, 5, 7
	2010	6 > 1=2=3=7; 6 > 1=2=4=5=7; 3 > 4=5
<i>Agrostis scabra</i>	2008	No significant differences between treatments
	2009	1=2=3=4=6; 5 > 1, 2, 3, 6
	2010	1=2=3=4=6=7; 4=5=7; 5 > 1=2=3=6
<i>Calamagrostis rubescens</i>	2008	3=4 > 1=2=5=7; 6 > 1, 2, 3, 4, 5, 7
	2009	3=4 > 1=2=5=7; 6 > 1, 2, 3, 4, 5, 7
	2010	3 > 4 > 2 > 7=5=1; 1=2=5; 6 > 1, 2, 3, 4, 5, 7
<i>Carex rossii</i>	2008	No significant differences between treatments
	2009	No significant differences between treatments
	2010	2=3=6=7; 5=6
TOTAL NATIVE FORB	2008	4=5 > 1=2=3=6=7
	2009	4=5 > 1=2=3=6=7
	2010	4=5 > 1=2=3=6=7
<i>Achillea millefolium</i>	2008	4=5 > 1=2=3=6=7
	2009	4=5 > 1=2=3=6=7
	2010	5 > 4 > 1=2=3=6=7
<i>Anaphalis margaritacea</i>	2008	4 > 1=2=3=5=6=7
	2009	4 > 1=2=3=5=6=7
	2010	4 > 1=2=3=5=6=7
<i>Chamerion angustifolium</i>	2008	1=2=3=4=5=6; 7 > 1, 4, 6
	2009	1=2=3=5=6; 2=3 > 4; 7 > 4
	2010	No significant differences between treatments
<i>Geum macrophyllum</i>	2008	No significant differences between treatments
	2009	4 > 1=2=3=5=6=7
	2010	4 > 1=2=3=5=6=7
<i>Solidago canadensis</i>	2008	No significant differences between treatments
	2009	4 > 1=2=3=5=6=7
	2010	4 > 1=2=3=5=6=7
<i>Symphyotrichum laeve</i>	2008	4 > 1=2=3=5=6=7
	2009	4 > 1=2=3=5=6=7
	2010	4 > 1=2=3=5=6=7
<i>Xerophyllum tenax</i>	2008	1 > 2=3=4=5=6=7
	2009	1 > 2=3=4=5=6=7
	2010	1 > 2=3=4=5=6=7
TOTAL EXOTIC FORB	2008	No significant differences between treatments
	2009	No significant differences between treatments
	2010	No significant differences between treatments
<i>Trifolium hybridum</i>	2008	No significant differences between treatments
	2009	1=4=5=6=7, 1 > 2; 1=3=4=5=6, 3 > 2 and 7
	2010	
TOTAL EXOTIC GRASS	2008	No significant differences between treatments
	2009	No significant differences between treatments
	2010	No significant differences between treatments

Table 6. Apgar Transit Center Experimental Plots: Density (# plants/0.25m²) of seeded plants, 2008-2010. * = Seeded species. Orange indicates significant difference (90% CI) between treatments. Yellow indicates significant difference (90% CI) between years of same treatment.

TREATMENT #	1			2			3			4			5			6			7		
TREATMENT TYPE	XERTEN seed			RUBPAR seed			CALRUB seed			CALRUB seed with forb			CARATH seed with forb			CALRUB plugs			control		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
NATIVE SHRUB	0	0	0	10.08	6.67	3.92	0	0	0	2.96	7.04	5.58	17.33	13.67	10.58	0	0	0	0	0	0
<i>Rubus parviflorus</i> *				10.08	6.67	3.92															
<i>Spiraea betulifolia</i> *										2.96	7.04	5.58	17.33	13.67	10.58						
NATIVE GRASS	0	0	0	0	0	0	42.67	29.21	19.58	38.00	37.33	18.79	2.46	1.58	2.63	4.00	3.875		0	0	0
<i>Carex sp.</i> (assumed <i>atbrostachya</i> *)										0.04			2.42	1.58	2.63						
<i>Calamagrostis rubescens</i> *							42.67	29.21	19.58	37.96	37.13	18.79	0.04								
CALRUB plugs/microplot																4.00	3.88	3.17			
CALRUB plugs total per macroplot																	32	32			
NATIVE FORB	9.75	8.96	7.67	0	0	0	0	0	0	39.20	54.63	53.81	20.13	21.17	26.00	0	0	0	0	0	0
<i>Achillea millefolium</i> *										14.08	16.71	15.38	19.67	20.25	26.00						
<i>Anaphalis margaritacea</i> *										9.46	16.71	17.88		0.92	-						
<i>Chamerion angustifolium</i> *										0.79	2.13	1.38	0.46								
<i>Geum macrophyllum</i> *										2.54	3.58	3.29									
<i>Solidago canadensis</i> *										3.08	4.21	6.71									
<i>Symphyotrichum laeve</i> *										9.25	11.29	9.17									
<i>Xerophyllum tenax</i> *	9.75	8.96	7.67																		
TOTAL DENSITY OF SEEDED SPECIES	9.75	8.96	7.67	10.08	6.67	3.92	42.67	29.21	19.58	80.17	99.00	78.18	39.92	36.42	39.21				0	0	0.00

Table 7. Apgar Transit Center Experimental Plots: Density (# plants/m²) and percent germination for seeded species, 2008-2010.

Treatment #	1							2							3						
Treatment Type	XERTEN seed							RUBPAR seed							CALRUB seed						
	density			seed rate	density			density			seed rate	density			density			seed rate	density		
	per m ²			per m ²	percent			per m ²			per m ²	percent			per m ²			per m ²	percent		
	2008	2009	2010		2008	2009	2010	2008	2009	2010		2008	2009	2010	2008	2009	2010		2008	2009	2010
NATIVE SHRUB								40.3	26.7	15.7	269	15.0%	9.9%	5.8%							
<i>Rubus parviflorus</i> *								40.3	26.7	15.7	269	15.0%	9.9%	5.8%							
<i>Spiraea betulifolia</i> *																					
NATIVE GRASS															170.7	116.8	78.3	538	31.7%	21.7%	14.6%
<i>Carex sp.</i> (assumed <i>athrostachya</i> *)																					
<i>Calamagrostis rubescens</i> *															170.7	116.8	78.3	538	31.7%	21.7%	14.6%
NATIVE FORB	39.0	35.8	30.7	269	14.5%	13.3%	11.4%														
<i>Achillea millefolium</i> *																					
<i>Anaphalis margaritacea</i> *																					
<i>Chamerion angustifolium</i> *																					
<i>Geum macrophyllum</i> *																					
<i>Solidago canadensis</i> *																					
<i>Symphotrichum laeve</i> *																					
<i>Xerophyllum tenax</i> *	39.0	35.8	30.7	269	14.5%	13.3%	11.4%														
SEED RATE/TRTMNT	269							269							538						

Treatment #	4							5						
Treatment Type	CALRUB seed with forb							CARATH seed with forb						
	density			seed rate	density			density			seed rate	density		
	per m ²			per m ²	percent			per m ²			per m ²	percent		
	2008	2009	2010		2008	2009	2010	2008	2009	2010		2008	2009	2010
NATIVE SHRUB	11.8	28.2	22.3	86	13.8%	32.7%	26.0%	69.3	81.0	42.3	215	32.2%	25.4%	19.7%
<i>Rubus parviflorus</i> *														
<i>Spiraea betulifolia</i> *	11.8	28.2	22.3	86	13.8%	32.7%	26.0%	69.3	54.7	42.3	215	32.2%	25.4%	19.7%
NATIVE GRASS	152.0	148.5	75.2	323	47.0%	46.0%	23.3%	9.9	6.3	10.5	323	3.0%	2.0%	3.3%
<i>Carex sp.</i> (assumed <i>athrostachya</i> *)	0.2							9.7	6.3	10.5	323	3.0%	2.0%	3.3%
<i>Calamagrostis rubescens</i> *	151.8	148.5	75.2	323	47.0%	46.0%	23.3%	0.2						
NATIVE FORB	156.8	218.5	215.2	516	30.4%	42.3%		80.5	84.7	104.0	215	36.6%	37.7%	48.4%
<i>Achillea millefolium</i> *	56.3	66.8	61.5	86	65.5%	77.7%	71.5%	78.7	81.0	104.0	215	36.6%	37.7%	48.4%
<i>Anaphalis margaritacea</i> *	37.8	66.8	71.5	86	44.0%	77.7%	83.2%		3.7					
<i>Chamerion angustifolium</i> *	3.2	8.5	5.5	86	3.7%	9.9%	6.4%	1.8						
<i>Geum macrophyllum</i> *	10.2	14.3	13.2	86	11.8%	16.7%	15.3%							
<i>Solidago canadensis</i> *	12.3	16.8	26.8	86	14.3%	19.6%	31.2%							
<i>Symphotrichum laeve</i> *	37.0	45.2	36.7	86	43.0%	52.5%	42.7%							
<i>Xerophyllum tenax</i> *														
SEED RATE/TRTMNT	925							753						

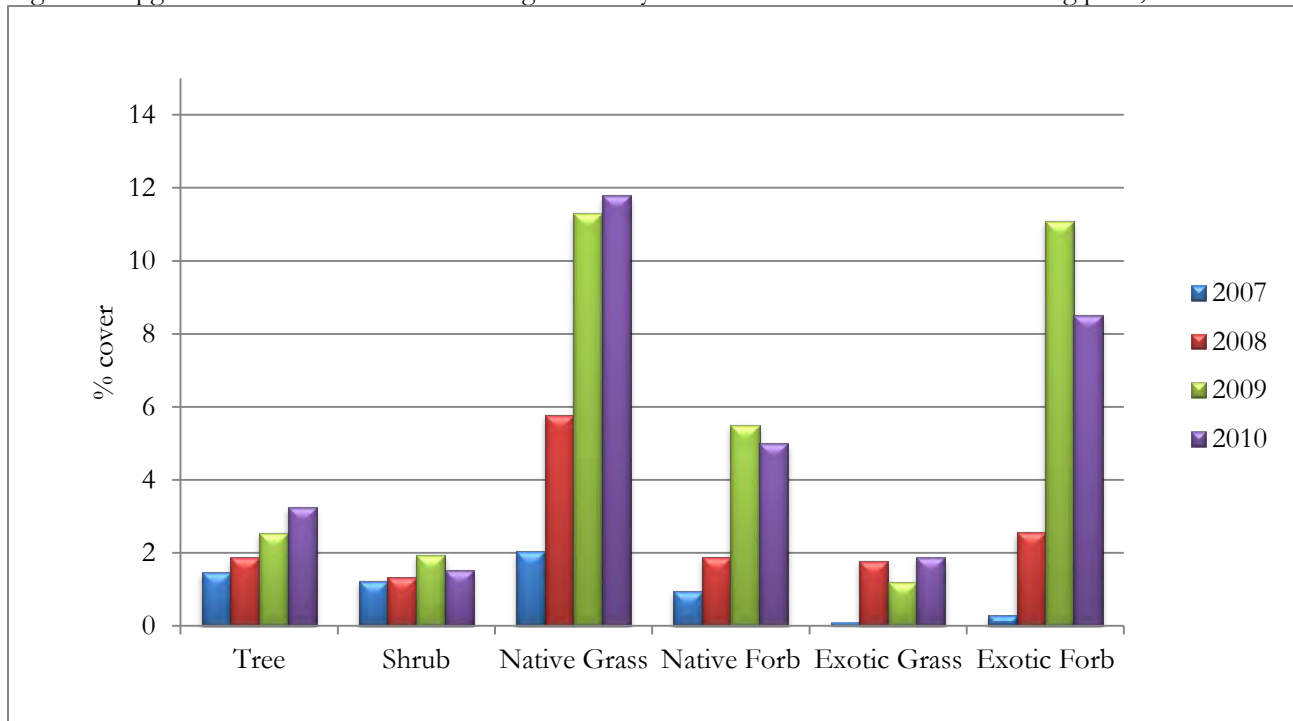
2. *Revegetation Plots Monitored by Ocular Cover*

In August 2010, monitoring plots in and around the ATC parking lot and bike trail were read three years after planting. For each of the 10 plots, ocular canopy cover was estimated for each species to determine success of plant material that was planted and salvaged in 2007 (Table 8). Special note was taken to determine if the material was planted, salvaged, or naturally regenerating to assess the success of each. Some non-native species were pulled, which is documented in the results table.

Overall, the change in total vegetation cover between 2009 and 2010 was slight compared to prior years (Figure 5). This was the trend for all lifeforms in addition to the trend for most individual plots. The collective cover of all plots in 2010 (33%) remained about the same as in 2009 (34%). Native grasses had highest cover of any lifeform (12.0%), followed by exotic forbs (9.0%) and native forbs (5.2%). None of the other lifeforms exceeded 4% cover. Exotic forbs showed the largest change in cover, decreasing from 11.8% cover in 2009 to 9.0% in 2010.

In all, 93 species were observed among all plots in 2010. Of these 93 plants, 13 are new since 2009, 24 established in 2008 and 62 established in 2007. Twenty-six other species have established and then disappeared since 2007. Hence, a net increase 36 species has occurred between 2007 and 2010. Encouragingly, 43 of these 62 new species (69%) are natives and yearly additions of new plants show a similar percentage of natives.

Figure 5. Appar Transit Center: Overall average cover by lifeform derived from 10 monitoring plots, 2007-2010.



2a. *Trees*

Tree cover continued to show little change. Currently, tree cover ranges from 0.4% to 8% depending on the density and size of planted trees. This does not differ much from last year when tree cover ranged from 0.3% to 6%. Half of the plots remained the same in tree cover, while tree cover increased by 1-3% on four plots and decreased by 1% on one plot. Plot 10 had the largest increase in tree cover, increasing from 3% to 6%, due to increases of *Pinus contorta*, *Pseudotsuga menziesii*, and *Populus balsamifera*. Increases of *Pinus contorta* generally accounted for the increases in the remaining plots that increased in tree cover. *Pinus monticola* was the only species observed in 2009 not seen in 2010. All other salvaged trees within monitoring plots seem to be maintaining but not necessarily increasing their cover. Similar to last year, a few salvaged trees in the project appeared less healthy with yellowing needles, however, most trees are generally thriving.

Tree species continue to establish in new areas throughout the project. Naturally regenerating *Pinus contorta*,

Betula papyrifera, *Populus balsamifera*, *Picea engelmannii*, and *Pseudotsuga menziesii* seedlings were observed in several new plots.

2b. Shrubs

Similar to trees and similar to shrub results of last year, most plots did not experience large changes in shrub cover. Currently, the range of shrub cover is 0.5% to 3%, similar to the 0.3% to 4% shrub cover of last year. Six plots have maintained their cover while four plots have decreased in shrub cover by 0.5% to 1%.

In total, there are 19 shrub species that are almost all present with trace cover except for *Symphoricarpos albus* and *Holodiscus discolor* that each have 1% cover on plot 10. Most shrubs have remained with the same cover as last year, except for salvaged *Arctostaphylos uva-ursi* and planted *Symphoricarpos albus* that have had small decreases in certain plots. Of the shrubs used in the 2007 restoration, three species (*Vaccinium myrtillus*, *Shepherdia canadensis* and an unidentified *Ribes*) are no longer present. Also since 2007, naturally regenerating *Rubus ideas* has become established in 6 of the 10 plots. *Vaccinium myrtilloides*, a State of Montana species of concern that inhabited three plots in 2009, was observed in only two plots in 2010, missing from plot 9. The surviving individuals appear to be in good health despite not detectably growing in the past year.

Overall, *Symphoricarpos albus* that was planted as nursery stock consistently has the highest shrub cover throughout the project. Cover of *S. albus* ranges from 0.2% to 1% in most areas, while most other shrubs have less than 1% cover. Unlike the past few years when shrub species were expanding into new areas throughout the project, very few if any new shrubs were observed moving into new plots. Certain shrubs, if anything, are disappearing from plots or the project as a whole. This trend should be monitored in the future.

2c. Native Forbs:

Unlike 2009 when native forb cover increased on all plots throughout the project, native forb cover only increased by 1% to 2% on three plots this year. Three additional plots remained with the same cover as last year, while native forb cover decreased on four plots by 1% to 3%. The result is native forb cover ranging from 3% to 10%, slightly down from the 2% to 13% native forb cover range last year. Native forb cover is the dominant or co-dominant lifeform on three of the plots. In all, 34 native forb species are present among the 10 plots, a net decrease of 1 from 2009 but a substantial net increase of 15 since 2007.

Plots 1, 4, and 6 exhibited the largest decreases in forb cover, decreasing by 2% to 3% since last year. The declines in cover on these plots is due to small decreases of several species, however, there were notable decreases of *Anaphalis margaritacea*, *Epilobium brachycarpum*, *Hieracium albiflorum*, and *Chamerion angustifolium* since last year. This result is interesting in that these were some of the same species last year that showed the biggest increases in cover. Also of note, the 2% increase in native forb cover on plot 7 was due to an increase of *Epilobium brachycarpum* that decreased on several other plots. Overall, six species consistently dominate native forbs with either higher cover or higher constancy: *Anaphalis margaritacea*, *Antennaria howellii*, and *Geum macrophyllum* from nursery stock, as well as *Chamerion angustifolium*, *Hieracium albiflorum*, and *Achillea millefolium* from seed and/or natural regeneration. Most other species have trace cover.

There are fewer new species to the project as a whole but many of the existing forb species are moving to other parts of the project. Several species, although low in cover, expanded the number of plots they inhabit in the past year: *Apocynum androsaemifolium*, *Epilobium brachycarpum* and *Galium triflorum* each colonized two additional plots; 13 other species each colonized one additional plot.

Similar to last year, a few native forb species would not be present within this project without the use of salvaged vegetation mats. While these species are not increasing in cover, they are maintaining their cover since 2008. These forb species include *Maianthemum stellatum*, *Hieracium albiflorum*, *Chimaphila umbellata*, *Melampyrum lineare*, *Viola orbiculata*, *Arnica cordifolia*, and *Xerophyllum tenax*. Several moss and lichen species were also introduced into the revegetation areas through the use of salvage mats. Hopefully, these plants will continue to seed or spread into adjacent areas with less vegetation.

2d. Native grasses:

Like native forbs, native grass cover increased on all plots throughout the project in 2009. This year, however, native grass cover only increased by 1% to 5% on four plots, while cover remained the same on three plots and decreased by 1% to 5% on three plots. Native grass cover currently ranges from 2% to 35%, about the same as

the 2009 native grass cover range of 2% to 40%. Plots 2 and 10 had the biggest increases in native grass cover, increasing 5% this year. Plot 3 had the biggest decrease in native grass cover, decreasing by 5%. In total, there are 18 species of native grasses, down from 19 in 2009 but up from 8 species in 2007. Overall, native grass was the most dominant or co-dominant lifeform on six of the ten plots.

Similar to the last two years, *Elymus glaucus* remained the native grass that had the highest native grass cover where it was present. 2010 cover of this species is similar to cover values of 2009. As observed in other revegetation projects, *E. glaucus* is an effective nurse grass, capable of dramatically increasing in cover the first three years of a restoration project. *Carex rossii* and other *Carex* species, including *Carex pachystachya* and *Carex concinnoides*, also consistently had 0.2% to 5% cover, maintaining similar covers to 2009. While some of this cover was present in salvage mats, most sedge species are naturally regenerating throughout the project, significantly adding to the overall native grass cover of these plots. Other native grasses that offer consistent cover throughout the project include *Danthonia* spp., *Festuca occidentalis*, *Calamagrostis rubescens*, *Agrostis scabra*, and *Bromus carinatus*. It is currently difficult to discern whether cover of *C. rubescens* is due to salvage, seed, nursery stock, or natural regeneration as the plants are getting larger.

In the end, many of the species listed above are the native grass species with the highest and most consistent cover throughout the project. Currently, *Elymus glaucus* from seed (average cover 7.3%), naturally regenerating *Carex rossii* (average cover 1.3%), *Calamagrostis rubescens* from seed, salvage, and nursery stock (average cover 1.2%), and *Festuca occidentalis* from salvage and natural regeneration (average cover 0.7%) are the dominant native grasses on the project with the highest covers. Species with high constancy are *Festuca occidentalis*, present in all 10 plots, *Carex concinnoides*, present in 9 plots, and *Calamagrostis rubescens* and *Carex rossii*, each present in 7 plots. In addition, *Danthonia spicata*, *Carex pachystachya*, *Deschampsia elongata*, and *Agrostis scabra* each had notable cover of 1% to 3% on at least one plot. All other native grass species had trace cover.

Species that have been present within one area of the project are also beginning to establish in other revegetation areas of the project. *Agrostis scabra*, *Carex pachystachya*, *Danthonia spicata*, and *Festuca occidentalis* were observed in 2 additional plots this year and 6 other species were seen in one additional plot. Some of this movement may be due to these species naturally establishing from the seed bank or due to seeding in from other nearby areas.

2e. Exotic forbs:

Unlike last year when exotic forb cover increased in all plots, exotic forb cover in 2010 decreased on five plots, remained the same on four plots, and only notably increased on one plot. Exotic forb cover currently ranges from 1% to 17% cover, down somewhat from exotic forb cover of 1.5% to 21% last year. Similarly, overall average cover of all plots was 9% in 2010 compared to 11.8% cover in 2009. Interestingly, plots 1, 2, 3, 6, and 10 that had the biggest increases in exotic forb cover in 2009, typically increasing 10% to 14%, had the biggest decreases in cover in 2010, typically decreasing 3% to 9%.

Due to hand pulling and herbicide application in this area, several species of exotic forbs decreased in cover from last year. Again, these were some of the same species that just one earlier increased in cover. Overall, *Trifolium* spp., primarily *Trifolium agrarium*, *T. hybridum* and *T. repens*, decreased in cover on half of the plots. *Melilotus alba* and *M. officinalis* also decreased in cover on four plots, disappearing from two plots altogether. Cover of these species typically decreased by 1-9%. In addition, *Veronica officinalis*, a persistent mat-forming weed, decreased on four plots by trace to 3% and *Rumex acetosella* decreased by nearly 5% this year. Despite these decreases, exotic forbs remain the dominant lifeform on six out of ten plots, similar to last year, and the second most common lifeform on one additional plot. Although some of these species are declining in cover, most plots are typically dominated by *Trifolium* spp. (*T. agrarium*, *T. repens*, and *T. hybridum*), *Veronica officinalis*, and *Medicago lupulina*. Hand pulling efforts should continue, as they remain the best option to keep exotic forbs from increasing.

Although 32 exotic forb species were observed in 2010, fortunately each year results in fewer new exotic forb species that naturally recruit to the project area. In terms of noxious weed species, *Cirsium arvense* remains in half of the monitoring plots, while *Chrysanthemum leucanthemum* remains in four plots but they were not found to be spreading. In addition, *Potentilla recta* and a yellow *Hieracium* spp. (assumed noxious) remain each in one plot. *Centaurea maculosa* actually disappeared from two plots, resulting in low cover of this weed species in only one plot. Only *Hieracium aurantiacum* and *Hypericum perforatum* were each found (and pulled) for the first time in one plot this year. In terms of other exotic forb species, only one new species was found this year, specifically *Cerastium fontanum* that was observed in two plots. Other species that are spreading into new areas include *Cirsium vulgare*, *Tragopogon dubius*, and *Convolvulus*

arvensis. Despite decreasing in canopy cover, all ten plots still have low cover of *V. officinalis*, a fairly aggressive exotic forb. This species can be incredibly invasive, even under forest canopy, and should be closely monitored. Active pulling of both noxious weed and other exotic forb species should continue to prevent further increase in cover.

Hand pulling is clearly helping to reduce the incidence of some exotic forb species. Several species are disappearing from the project as a whole or in certain areas. *Amaranthus retroflexus*, *Thlaspi arvense*, *Spergularia rubra*, *Capsella bursa-pastoris*, and *Myosotis micrantha* are gone from all project areas as of 2009, while *Melilotus officinalis*, *Chenopodium album*, *Arenaria serpyllifolia*, *Tanacetum vulgare*, *Polygonum aviculare*, *Galium aparine*, *Digitalis purpurea*, *Madia glomerata*, and *Potentilla norvegica* are gone from all project areas as of 2010. *Melilotus alba* and *Verbascum thapsus* have each disappeared from several plots. Some of these species tend to be present at the onset of disturbance and then naturally decline as other vegetation moves in, although hand pulling these species may have reduced their cover in a quicker time frame.

2f. Exotic grasses:

In keeping with trends from the past two years, most plots have not experienced great changes in exotic grass cover over the last year with the notable exception of one plot. Currently, exotic grass cover ranges from 0% to 11%, up slightly from the 0.1% to 5% exotic grass range last year. In actuality, only two plots have exotic grass cover of 3% and 11% in 2010 while the remaining plots have exotic grass cover equal to or less than 1%. Except on plot 1, native grass cover is currently far higher than exotic grass cover, an excellent sign for the future success of this project.

Plot 1 was the only plot to show a notable increase in exotic grass cover. This increase in cover was due to a dramatic increase of *Agrostis stolonifera* that increased from 3% to 8% cover. *A. stolonifera* still remains the exotic grass with the highest and most consistent cover of all exotic grasses within this project. Clearly hand-pulling this grass, which has been done for the past two years, is preventing it from increasing in certain areas, but *A. stolonifera* remains an aggressive rhizomatous grass that can quickly dominate herbaceous areas. *Elymus repens* and *Poa compressa*, other aggressive grasses, have maintained notable cover on plot 1 as well. More hand-pulling efforts should be employed in this area.

Despite no big increases of exotic grasses on most plots, nine species of exotic grass remain within this project. Besides *A. stolonifera*, other grasses to watch and attempt to control with hand-pulling include *Elymus repens*, *Poa compressa*, *Bromus inermis*, *Phleum pratense*, and *Poa pratensis* where they occur. Hand pulling exotic grasses throughout the project has seemed to keep them in check and should continue in the future on an annual basis. It appears that *Bromus commutatus*, which had such high cover two years ago only to dramatically decrease in cover last year, has remained with low cover this year. It seems that the high cover of this annual grass was merely temporary and it did not reseed itself. It should also be noted that plot 5 currently has no exotic grasses with the disappearance of trace cover of *Poa pratensis*.

2g. Salvage of Vegetation Mats

In general, salvaged mats of vegetation appear to be a good revegetation strategy for several reasons. Plant material that would otherwise be destroyed can be effectively stored and returned to its original habitat along with its native soil. Many of the species salvaged are difficult or impossible to grow in a nursery setting and this method can retain any necessary mycorrhizal relationships that may exist between plants and soil fungi. Additionally, greater initial ground cover can be created, reducing space for invading exotic species to colonize.

Currently, the salvaged vegetation mats are not contributing significant cover to the project as a whole, although there are a few areas where a higher density of mats were replaced and cover of salvaged vegetation is higher. In 2008, there were several species within these mats that died back significantly or disappeared. Some of the larger declines at this time were seen in *Arctostaphylos uva-ursi*, *Carex rossii*, *Festuca occidentalis*, *Fragaria virginiana*, *Hieracium albiflorum*, and *Linnaea borealis*. Similar to last year, most salvaged species are now maintaining their cover. As stated above, it is becoming clear that a few native species would not be present within this project without the use of salvaged vegetation mats. These species include *Vaccinium membranaceum*, *Vaccinium myrtilloides*, *Vaccinium myrtillus*, *Sorbus scopulina*, *Cornus sericeus*, *Linnaea borealis*, *Maianthemum stellatum*, *Hieracium albiflorum*, *Chimaphila umbellata*, *Melampyrum lineare*, *Viola orbiculata*, *Arnica cordifolia*, some *Xerophyllum tenax*, *Carex concinnoides*, and several moss and lichen species. In addition, salvage mats have provided additional cover of *Calamagrostis rubescens*, *Festuca occidentalis*, *Achillea millefolium*, and *Anaphalis margaritacea*. Hopefully, these plants will continue to seed or spread into adjacent areas with less vegetation.

Soils around the Apgar Transit Center project were often severely compacted due to construction machinery, especially within the utility line. This may inhibit germination of seed, although plants within the salvage mats appeared to weather this better. It was noted in plots within the utility line that most of the non-graminoid regeneration was within the salvage mats, with the other exception being conifer seedlings, which seemed to regenerate well everywhere.

The negative side of salvaging vegetation mats is that occasionally non-native species were salvaged along with native species. The most common non-native species found within the mats were *Agrostis stolonifera* and *Veronica officinalis*, both which are considered threats to the project.

D. Conclusions

Listed below are general trends about the status of the Apgar Transit Center revegetation areas:

- Tree cover continued to show little change but is generally showing a small overall increase in cover. Salvaged trees are still doing well in the project after three years with good survival, although a few salvaged trees have yellowing needles. Salvaged trees within monitoring plots seem to be maintaining but not necessarily increasing their cover. Naturally regenerating tree species continue to establish in new areas throughout the project.
- Similar to last year, most plots did not experience large changes in shrub cover. Most plots have maintained their cover or increased by less than 1%. Overall, *Symphoricarpos albus* that was planted as nursery stock consistently has the highest shrub cover throughout the project. Unlike last year, however, very few shrub species appear to be expanding into new areas throughout the project.
- Although there was some concern at the start of this project that the Species of Concern *Vaccinium myrtilloides* would not transplant successfully, several healthy plants remain in two plots. At the same time, it has disappeared from one plot, making long-term monitoring essential before deciding the success of transplanting this rare species. The surviving individuals appear to be in good health despite not detectably growing in the past year.
- Unlike last year when native forb cover increased on all plots, native forb cover only increased on three plots this year by 1-2%. It is now the dominant lifeform on only one plot. Overall, six species consistently dominate native forb cover: *Anaphalis margaritacea*, *Antennaria howellii*, and *Geum macrophyllum* from nursery stock, as well as *Chamerion angustifolium*, *Hieracium albiflorum*, and *Achillea millefolium* from seed and/or natural regeneration.
- Native forb species continue to spread into new areas within the project. The most common species that are spreading throughout the project include: *Apocynum androsaemifolium*, *Epilobium brachycarpum* and *Galium triflorum*. Thirteen other species each colonized into additional plot.
- Native grass cover is following a similar trend to native forb cover. Unlike last year when native grass cover increased on all plots, native grass cover only increased by 1% to 5% on four plots this year. Similar to last year, *Elymus glaucus* remained the native grass that continued to have the highest cover where it was present. Other native grasses that offer consistent cover throughout the project include *Carex rossii*, *Carex pachystachya*, *Carex concinnoides*, *Danthonia* spp., *Festuca occidentalis*, *Calamagrostis rubescens*, *Agrostis scabra*, and *Bromus carinatus*.
- Also like native forbs, species that have been present within the project are beginning to establish in other revegetation areas of the project. *Agrostis scabra*, *Carex pachystachya*, *Danthonia spicata*, and *Festuca occidentalis* were observed in 2 additional plots this year and 6 other species were seen in one additional plot. Some of this movement may be due to these species naturally establishing from the seed bank or due to seeding in from other nearby areas.
- Unlike last year when exotic forb cover increased in all plots, exotic forb cover in 2010 decreased on five plots, remained the same on four plots, and only notably increased on one plot. Hand pulling and weed control efforts appear to be having an impact on exotic forb cover. Despite these decreases, exotic forbs remain the dominant lifeform on six out of ten plots. Dominant species include *Trifolium agrarium*, *T. hybridum* and *T. repens*, *Medicago lupulina*, and *Veronica officinalis*.
- Although 32 exotic forb species were observed in 2010, each year results in fewer new exotic forb species that naturally recruit to the project area. In terms of noxious weed species, *Cirsium arvense* remains in half of the

monitoring plots, while *Chrysanthemum leucanthemum* remains in four plots. *Potentilla recta* and a yellow *Hieracium* spp. (assumed noxious) remain each in one plot. *Centaurea maculosa* actually disappeared from two plots, resulting in low cover of this weed species in only one plot. Only *Hieracium aurantiacum* and *Hypericum perforatum* were each found for the first time in one plot this year. In terms of other exotic forb species, only one new species was found this year, specifically *Cerastium fontanum*. *Cirsium vulgare*, *Tragopogon dubius*, and *Convolvulus arvensis* are spreading into new areas.

- In keeping with trends from the past two years, exotic grass cover has not changed dramatically over the last year with the notable exception of one plot. Only two plots have exotic grass cover of 3% and 11% in 2010 while the remaining plots have exotic grass cover equal to or less than 1%. Except on plot 1, native grass cover is currently far higher than exotic grass cover, an excellent sign for the future success of this project. Any exotic grass increases are due to increases of *Agrostis stolonifera* that remains with the highest and most consistent cover of all exotic grasses within this project.
- The cover of *Bromus commutatus*, present near the retention pond, declined dramatically in 2009 from 2008 (10% to 0.2%), and once again it was present only in trace amounts in 2010. It appears that the high cover of this annual grass was due to initial disturbance and the cover of this grass declines with more established vegetation, particularly *Elymus glaucus* that dramatically increased in cover two years ago. Cover of *E. glaucus* remained especially high in the plots near the retention pond in 2010.
- Overall, the data implies that restoration of the ATC parking area is moving in a positive direction. Although plant cover was about the same in 2010 as 2009, there were no large increases in any exotic species while native species showed no large declines. Again, the stability in exotic cover might be showing the effects of weed pulling. Weed control should continue at least during these early years of restoration while the area is most vulnerable to non-native plant establishment.
- Similar to last year, a few native species would not be present within this project without the use of salvaged vegetation mats. While these species are not increasing in cover, they are maintaining their cover since 2008. These forb species include *Maianthemum stellatum*, *Hieracium albiflorum*, *Chimaphila umbellata*, *Melampyrum lineare*, *Viola orbiculata*, *Arnica cordifolia*, and some *Xerophyllum tenax*. Several moss and lichen species were also introduced into the revegetation areas through the use of salvage mats. It appears that salvage mats are an effective tool to return cover and diversity to a restoration project.
- Plots should be monitored at the following times: 2012 (year 5), 2014 (year 7), and 2017 (year 10).

Table 8. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2010.

		ATC-07-01				ATC-07-02				ATC-07-03				ATC-07-04				ATC-07-05			
Ground Cover		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Basal veg				3	4			3	3			5	5			3	3			5	4
Bare Ground				7	8			20	15			38	30			4	2			15	11
Gravel				1	3			8	8			15	15			5	5			15	15
Litter				87	81			67	72			40	45			81	83			60	61
Moss				2	4			2	2			2	5			6	6			1	1
Rock																0	0			0.2	0.2
Wood													0.2			1	1			8	8
Species	source	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Trees		5	5	6	8	0.2	0.2	0.4	0.4	0	0.2	0.6	0.6	0.2	0.2	0.5	0.5	0.2	0.2	1	1
<i>Larix occidentalis</i>	nursery?	0.2	0.2	0.2	0.2																
<i>Betula papyrifera?</i>	regen				0.2											0.2					
<i>Picea engelmannii</i>	salvage	3	3	3	4														0.2	0.2	0.2
<i>Pinus contorta</i>	salvage?								0.2									0.2	0.2	0.2	0.2
<i>Pinus contorta</i>	regen			0.2	1						0.2	0.2	0.2			0.2	0.2			0.2	0.2
<i>Populus balsamifera</i>	regen	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2			0.2	0.2	0.2	0.2	0.2	1		0.2	0.2	0.2
<i>Populus tremuloides</i>	regen			0.2	0.2																
<i>Pseudotsuga menziesii</i>	salvage	2-	2	2	2								0.2								
<i>Unknown conifer seedlings</i>	regen							0.2				0.2				0.2	0.2		0.2	0.2	0.2
Shrubs		1	1	1	1	0.2	1	1	0.5	0.4	1	0.4	0.6	4	1	1	1	2	1	2	2
<i>Acer glabrum</i>	nursery	0.2	0.2																		
<i>Alnus viridis</i>	nursery	0.2	0.2	0.2																	
<i>Alnus viridis</i>	regen			0.2																	
<i>Amelanchier alnifolia</i>	nursery	0.2																			
<i>Amelanchier alnifolia</i>	regen					0.2															
<i>Arctostaphylos uva-ursi</i>	salvage													3	0.2	0.2	0.2				
<i>Arctostaphylos uva-ursi</i>	nursery			0.2	0.2																
<i>Cornus sericea</i>	salvage																		0.2	0.2	0.2
<i>Holodiscus discolor</i>	nursery	0.2	0.2	0.2	0.2						0.2										
<i>Linnaea borealis</i>	salvage						0.2	0.2	0.2					1+				0.2	0.2	0.2	0.2
<i>Linnaea borealis</i>	regen/seed?														0.2	0.2	0.2				
<i>Paxistima myrsinites</i>	nursery	0.2	0.2				0.2														
<i>Paxistima myrsinites</i>	salvage																	0.2	0.2		
<i>Rubus idaeus</i>	regen			0.2	0.2			0.2			0.2		0.2								
<i>Rubus parviflorus</i>	nursery		0.2		0.2		0.2	0.2	0.2												
<i>Rubus parviflorus</i>	regen/seed?																			0.2	
<i>Salix sp.</i>	nursery?				0.2																
<i>Shepherdia canadensis</i>	nursery	0.2	0.2																		
<i>Spiraea betulifolia</i>	nursery	0.2	0.2																		
<i>Spiraea betulifolia</i>	regen/seed?			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2			0.2	0.2		0.2	0.2	0.2
<i>Spiraea betulifolia</i>	salvage													0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<i>Symphoricarpos albus</i>	nursery	0.2	0.2	0.2	0.2															0.2	
<i>Symphoricarpos albus</i>	regen/seed?																			0.2	
<i>Vaccinium caespitosum?</i>	salvage																	0.2			
<i>Vaccinium caespitosum</i>	regen																			0.2	0.2
<i>Vaccinium membranaceum</i>	regen	0.2		0.2	0.2					0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2				
<i>Vaccinium membranaceum</i>	salvage																	1-	0.2	0.2	0.2
<i>Vaccinium myrtilloides</i>	salvage																	0.2	0.2		0.2

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2010.

		ATC-07-01				ATC-07-02				ATC-07-03				ATC-07-04				ATC-07-05			
		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Native Forbs	TOTAL	1	3+	13	10	0.2	0.2	3	3	0.2	0.2	4	3+	5	5	8	5	1	1	3	3
<i>Achillea millefolium</i>	regen/seed?						0.2	1-	0.2	0.2	0.2	2	1							0.2	0.2
<i>Achillea millefolium</i>	salvage																	0.2	0.2	0.2	0.2
<i>Anaphalis margaritacea</i>	nursery	0.2	1	6	5										0.2	0.2	0.2				
<i>Anaphalis margaritacea</i>	salvage																	0.2			0.2
<i>Anaphalis margaritacea</i>	regen/seed?							0.2	0.2				0.2			0.2	0.2			0.2	0.2
<i>Antennaria howellii</i>	nursery	0.2	0.2	1	1															0.2	0.2
<i>Antennaria howellii</i>	regen/seed?						on edge	0.2	0.2	0.2	0.2	0.2	0.2							0.2	0.2
<i>Antennaria rosea</i>													0.2								
<i>Apocynum andromisaeifolium</i>	regen	0.2	0.2	0.2	0.2						0.2		0.2								
<i>Arabis divaricarpa</i>	regen		0.2	0.2											1.5						
<i>Symphyotrichum laeve</i> v. <i>laeve</i> (<i>Aster laevis</i>)	nursery		0.2	0.2	0.2																
<i>Symphyotrichum laeve</i> v. <i>laeve</i> (<i>Aster laevis</i>)	seeded																			0.2	0.2
<i>Campanula rotundifolia</i>	regen							0.2	0.2												0.2
<i>Chamerion angustifolium</i>	regen/seed?		1.5	2	0.2			0.2	0.2			0.2	0.2		0.2	0.2	0.2			0.2	0.2
<i>Chimaphila umbellata</i>	salvage														0.2	0.2	0.2	0.2	0.2	0.2	0.2
<i>Clintonia uniflora</i>	regen/seed?																		0.2		
<i>Conyza canadensis</i>	regen		0.2	0.2	0.2								0.2				0.2				
<i>Epilobium brachycarpum</i> (thin lvs)	regen		0.2	1	0.2										2	3	0.2				
<i>Epilobium brachycarpum</i> (wider lvs)	regen			0.2	0.2												0.2				
<i>Fragaria virginiana</i>	salvage													2+	0.2	1	1-				
<i>Fragaria virginiana</i>	regen/seed?											0.2	0.2								
<i>Galium boreale</i>	regen			0.2	0.2																
<i>Galium triflorum</i>	salvage																				0.2
<i>Geranium bicknellii</i>	regen/seed?	0.2	0.2	0.2											0.2	0.2			0.2		
<i>Geum macrophyllum</i>	nursery	0.2	0.2	0.2	0.2																
<i>Geum macrophyllum</i>	regen/seed?							0.2	0.2			0.2	0.2								
<i>Gnaphalium macounii</i>	regen			0.2	0.2		0.2	0.2								0.2			0.2P		
<i>Hieracium albiflorum</i>	regen		0.2	0.2	0.2	0.2	0.2	0.2	0.2		0.2	0.2	0.2							0.2	0.2
<i>Hieracium albiflorum</i>	salvage													3	1	2	1	0.2	0.2	0.2	0.2
<i>Hieracium</i> sp. (yellow)	regen															0.2					
<i>Lathyrus ochroleucus</i>	regen		0.2	0.2	0.2				0.2												
<i>Lupinus sericeus</i>	regen											0.2	0.2								
<i>Maianthemum stellatum</i>	regen/seed?			0.2	0.2			0.2	0.2	0.2	0.2	0.2	0.2		0.2	0.2	0.2		0.2	0.2	0.2
<i>Melampyrum lineare</i>	salvage															0.2	0.2	0.2	0.2	0.2	0.2
<i>Osmorhiza berteroi</i>	regen																0.2			0.2	0.2
<i>Penstemon confertus</i>	nursery	0.2	0.2	0.2	0.2		0.2													0.2	
<i>Penstemon lyallii?</i>	nursery	0.2																			
<i>Penstemon</i> spp.	nursery	0.2	0.2																		
<i>Pteridium aquilinum</i>	nursery	0.2	0.2	0.2	0.2		0.2														
<i>Ranunculus</i> sp.	regen			0.2																	
<i>Solidago canadensis</i>	seeded				0.2		0.2	0.2	0.2		0.2	0.2	0.2							0.2	
<i>Viola adunca?</i>	regen									0.2											
<i>Viola orbiculata</i>	salvage						0.2	0.2			0.2	0.2		0.2		0.2		0.2	0.2	0.2	0.2
<i>Viola orbiculata</i>	regen																			0.2	0.2
<i>Xerophyllum tenax</i>	nursery?	0.2	0.2																		
<i>Xerophyllum tenax</i>	seeded														0.2	0.2	0.2			0.2	0.2
<i>Xerophyllum tenax</i>	salvage																	0.2	0.2	0.2	0.2
<i>Xerophyllum tenax</i>	regen					0.2															
unknown forb	regen				0.2												0.2		0.2		

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2010.

		ATC-07-01				ATC-07-02				ATC-07-03				ATC-07-04				ATC-07-05			
		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Native Grasses	TOTAL	0.5	2	9	9	3	15	25	30	5	25	40	35	8	4	9	8	1	1+	2	2
<i>Agrostis scabra</i>	nursery		0.2	0.2	0.2		0.2						0.2								
<i>Bromus carinatus</i>	seeded																			0.2	0.2
<i>Calamagrostis rubescens</i>	nursery	0.2	0.2	0.2	0.2		0.2														
<i>Calamagrostis rubescens</i>	seeded																			0.2	0.2
<i>Calamagrostis rubescens</i>	salvage													1+	1	1	1-	0.2	0.2	0.2	0.2
<i>Calamagrostis stricta</i>	regen																0.2				
<i>Carex athrostachya</i>	nursery			0.2	0.2																
<i>Carex concinnoides</i>	salvage		0.2	0.2	0.2		0.2	0.2	0.2					3	1	1+	1-		0.2	0.2	0.2
<i>Carex pachystachya</i>	regen		0.2						0.2												
<i>Carex pachystachya</i>	nursery			2	2																
<i>Carex rossii</i>	regen		0.2	3	3										0.2	2	1+		0.2		
<i>Carex</i> spp.	salvage													0.2				0.2	0.2	0.2	0.2
<i>Carex</i> spp.	regen						0.2	0.2	0.2			0.2	0.2								
<i>Danthonia intermedia?</i>	seeded?									0.2							0.2				
<i>Danthonia spicata?</i>	?		0.2	2+	2							0.2								0.2	0.2
<i>Elymus glaucus</i>	seeded					3	15	25	30	5	25	40	35						0.2	0.2	0.2
<i>Elymus glaucus</i>	salvage													0.2							
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>	?	0.2																			
<i>Festuca idahoensis</i>	regen			0.2																	
<i>Festuca occidentalis</i>	salvage		0.2											3	1	1	0.2	0.2	0.2	0.2	0.2
<i>Festuca occidentalis</i>	regen/seed?			1	1				0.2				0.2			4+	4				
<i>Hordeum jubatum</i>	regen?				0.2						0.2				0.2	0.2	0.2				
<i>Oryzopsis asperifolia</i>	regen		0.2		0.2							0.2							0.2	0.2	0.2
<i>Poa</i> spp.	?	0.2																			
<i>Trisetum cernuum</i>																			0.2		
<i>Trisetum canescens</i>																0.2				0.2	0.2
unknown	?					0.2					0.2			0.2				0.2	airy sheath)		
Exotic Forbs	TOTAL	0.2	5	18	13	0.2	1	11	5	0.2	3	12	3	1	2	9	10	0.2	0.4	1	1
<i>Amaranthus retroflexus</i>	regen		0.2												0.2						
<i>Arenaria serpyllifolia</i>	regen		0.2	0.2																	
<i>Artemisia absinthium</i>	regen		0.2	0.2	0.2																
<i>Centaurea maculosa</i>	regen			0.2																	
<i>Chenopodium album</i>	regen		0.2												0.2						
<i>Chrysanthemum leucanthemum</i>	regen		0.2P		0.2															0.2	0.2
<i>Cerastium fontanum</i>	regen				0.2				0.2												
<i>Cirsium arvense</i>	regen	0.2	0.2P	0.2	0.2				0.2												
<i>Cirsium vulgare</i>	regen	0.2	0.2	0.2	0.2												0.2				
<i>Convolvulus arvensis</i>	regen			0.2	0.2																
<i>Erodium cicutarium</i>	regen									0.2				0.2	0.2	0.2					
<i>Filago arvensis</i> / <i>Gnaphalium palustre</i>	regen		0.2	0.2	0.2				0.2					0.2	0.2	0.2	0.2		0.2		
<i>Galium aparine</i>	regen		0.2	0.2															0.2	0.2	
<i>Lactuca serriola</i>	regen		0.2	0.2	0.2		0.2									0.2	0.2		0.2		
<i>Madia glomerata</i>	regen														0.2	0.2					
<i>Medicago lupulina</i>	regen		1	7	2										0.2	2-	3				
<i>Melilotus alba</i>	regen			1	0.2																
<i>Melilotus officinalis</i>	regen															0.2					

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2010.

		ATC-07-01				ATC-07-02				ATC-07-03				ATC-07-04				ATC-07-05			
Exotic forbs, con'd		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
<i>Melilotus</i> spp.	regen		0.2	0.2																	
<i>Plantago major</i>	regen	0.2	0.2P	0.2	0.2																
<i>Potentilla argentea</i>	regen		0.2	0.2	0.2										0.2	0.2	0.2				
<i>Potentilla norvegica</i>	regen			0.2																	
<i>Prunella vulgaris</i>	regen													0.2							
<i>Taraxacum officinale</i>	regen		0.2	0.2	0.2			0.2	0.2							0.2		0.2			
<i>Thlaspi arevense</i>	regen														0.2						
<i>Tragopogon dubius</i>	regen		0.2	0.2											0.2						
<i>Trifolium agrarium</i>	regen		1	1	0.2										0.2		0.2				
<i>Trifolium</i> spp. (<i>hybridum</i> , <i>repens</i> + <i>pratense</i>)	regen	0.2	3			0.2	1	10	4	0.2	3	12		1	1	5+		0.2	0.2	1-	
<i>Trifolium hybridum</i>	regen			5	7								3				6				1
<i>Trifolium pratense</i>	regen			0.2	0.2				0.2								0.2				
<i>Trifolium repens</i>	regen			1																	
<i>Verbascum thapsus</i>	regen	0.2	0.2	0.2																	
<i>Veronica officinalis</i>	regen		0.2	1	1		0.2	1-	0.2			0.2	0.2		0.2	1	0.2		0.2	0.2	0.2
<i>Veronica serpyllifolia</i>	regen		0.2	0.2	0.2								0.2		0.2	0.2	0.2				
<i>Verbena bracteata</i>	regen															0.2	0.2				
unknown	regen	0.2												0.2							
unknown mustard (ascending pods)	regen															0.2					
Exotic Grasses	TOTAL	0.2	4	5	11	0	1	0.2	0.4	0	10	0.4	0.5	0	0.2	0.5	0.4	0.2	0.2	0.2	0
<i>Agrostis stolonifera</i>	salvage		2	3	8		0.2	0.2	0.2		0.2				0.2			0.2	0.2P		
<i>Agrostis stolonifera</i>	regen												0.2			0.2	0.2				
<i>Bromus commutatus</i>	regen						1		0.2		10	0.2	0.2								
<i>Bromus inermis</i>	regen		0.2	0.2	0.2																
<i>Dactylis glomerata</i>	regen	0.2	0.2																		
<i>Elymus repens</i>	regen		0.2	1	2												0.2				
<i>Phleum pratense</i>	regen		0.2	0.2	0.2																
<i>Poa annua</i>	regen		0.2												0.2	0.2					
<i>Poa compressa</i>	regen	0.2	1	1	1							0.2	0.2			0.2					
<i>Poa pratensis</i>	regen	0.2	0.2		0.2													0.2		0.2	
<i>Triticum aestivum</i>	?						0.2								0.2			0.2	0.2		
<i>Annual Brome</i>				0.2																	

P= pulled

*= likely mis-ID: BROCOM

2009: BROCOM in 07-03, read in Sept all gone and dried up found one old dried plant in entire plot

Plot 1: in 2007, ELYTVT likely ELYREP

Plot 5: seeded grasses coming up throughout plot (ELYGLA, CALRUB?). Most other regen. is within salvage mats, most likely due to soil compaction.

Plot 5: in 2007: PICENG = mis-ID?

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2010.

		ATC-07-06				ATC-07-07				ATC-07-08				ATC-07-09				ATC-07-10			
Ground Cover		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Basal veg				3	3			5	5			2	2			2	2			3	3
Bare Ground				10	2			20	10			1	1			5	2			25	10
Gravel				5	4			10	10			10	10			5	5			5	5
Litter				81	90			64	74			80	79			70	72			67	81
Moss				1	1			0.2	0.2			1	2			2	3			0	1
Rock				0	0			1	1			3	3			1	1			0.2	0.2
Wood				0	0			0	0.2			3	3			15	15			0	0
Species		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Trees		3	3	3	5	2	3	4	5	2	3	4	3	1	1	3	3	1	3	3	6
<i>Abies lasiocarpa</i>	salvage	1	1	1	1													1	1.5	0.2	0.5
<i>Betula papyrifera</i>	regen				0.2							0.2									0.1
<i>Larix occidentalis</i>	nursery?	0.5	0.25	0.25	0.2	0.2	0.2	0.2	0.2									0.2	0.5	1	1
<i>Picea engelmannii</i>	salvage					1	2	2	2								0.1				
<i>Pinus contorta</i>	nursery	0.2	0.2	0.2	1	0.5	1	1	1+	0.5	1							0.2	0.2	0.2	0.6
<i>Pinus contorta</i>	salvage?									0.5		1	1-								
<i>Pinus contorta</i>	regen			0.2	1			0.2	1			0.2	0.2			0.2	0.2			1	1.5
<i>Pinus monticola</i>	salvage									0.2	0.2	0.2									
<i>Populus balsamifera</i>	regen				0.2	0.1	0.1	0.1	0.2		0.1	0.2	0.2		0.1	0.5	0.3	0.1	0.1	0.1	1-
<i>Populus balsamifera</i>	salvage											0.2	0.2	0.1	0.1	0.1	0.3				
<i>Populus tremuloides</i>								0.1				0.2				0.1	0.1				
<i>Pseudotsuga menziesii</i>	nursery																	0.1	0.1	0.2	1-
<i>Pseudotsuga menziesii</i>	regen											0.2					0.1				
<i>Tsuga heterophylla</i>	salvage	1	1	1	1					1	1.5	1.5	1	1	1	2	2				
Unknown conifer seedlings	regen		0.1				0.1	0.1				0.2	0.2			0.2			0.1	0.1	
unknown - opposite leaved	regen																				
Shrubs		1	2	2	2	2	2	3	2	0.5	2	4	3	0.2	0.2	2	0.2	1	2	3	3
<i>Acer glabrum</i>	nursery	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2									0.1	0.1	0.1	
<i>Alnus viridis</i>	nursery/regen?					0.1	0.1	0.2	0.2			0.2				0.1				0.1	
<i>Amelanchier alnifolia</i>	nursery	0.1	0.1	0.2	0.2													0.2	0.2	0.2	0.5
<i>Amelanchier alnifolia</i>	regen											0.2									
<i>Arctostaphylos uva-ursi</i>	salvage											0.5	1-	0.5							
<i>Arctostaphylos uva-ursi</i>	nursery	0.1	0.1	0.2	0.2																
<i>Cornus sericea</i>	nursery					0.2	0.2	0.2	0.2												
<i>Holodiscus discolor</i>	nursery					0.2	0.2	0.2	0.2									0.1	0.1	1-	1-
<i>Linnaea borealis</i>	regen									0.1	0.1	0.5	0.5		0.1	0.1	0.1				
<i>Mahonia repens</i>	nursery	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.2												0.1
<i>Paxistima myrsinites</i>	nursery	0.1	0.1	0.1														0.1	0.1	0.1	0.1
<i>Ribes</i> spp.?	nursery	0.1				0.1															
<i>Rosa</i> spp.	seeded?	0.1								0.1 (<i>Sorbus</i> ?)	occ	0.1	0.2								
<i>Rubus idaeus</i>	regen		0.1	0.2	0.2		0.1	0.2	0.2		0.1	0.2	0.2						0.1	0.1	0.1
<i>Rubus parviflorus</i>	nursery		0.1	0.2	0.2	0.1	0.1	0.2	0.2									0.2	0.2	0.1	0.5
<i>Rubus parviflorus</i>	salvage										0.1	0.2	0.2								
<i>Rubus parviflorus</i>	seeded											0.2	0.2			0.2					
<i>Salix</i> sp.					0.2														0.1		0.1
<i>Sorbus scopulina</i>	salvage										0.1	0.2	0.2								
<i>Spiraea betulifolia</i>	nursery	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2									0.2	0.2	0.1	0.2
<i>Spiraea betulifolia</i>	seeded									0.1	0.1	0.5	0.2	0.1	0.1	0.1	0.1				
<i>Spiraea betulifolia</i>	salvage														0.1	0.2	0.1				
<i>Symphoricarpos albus</i>	nursery	0.2	0.5	0.2	0.2	0.5	0.5	1-	0.2		0.5	0.5	0.2					0.2	0.5	1	1
<i>Symphoricarpos albus</i>	seeded															0.2	0.1				
<i>Vaccinium membranaceum</i>	regen									0.1	0.2	0.1	0.5								
<i>Vaccinium membranaceum</i>	salvage													0.1	0.1	0.2					
<i>Vaccinium myrtilloides</i>	salvage									0.2	0.1	0.2	0.2	0.2	0.1	1-					
<i>Vaccinium myrtillus</i>	salvage													0.1	0.1	0.1					
<i>Vaccinium scoparium</i>	regen																	0.1			

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2010.

		ATC-07-06				ATC-07-07				ATC-07-08				ATC-07-09				ATC-07-10			
		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Native Forbs		0.5	4	9	7	0.5	1	2	4	0.5	1	3	4	0.1	0.5	2	3	0.5	2	8	7
<i>Achillea millefolium</i>	regen							0.2	0.2	0.1	0.1	0.2	0.2								0.1
<i>Achillea millefolium</i>	seeded														0.1	0.2	0.3				
<i>Achillea millefolium</i>	salvage															0.2	0.3				
<i>Adenocaulon bicolor</i>													0.2								
<i>Allium cernuum</i>	regen																				0.1
<i>Anaphalis margaritacea</i>	nursery	0.1	1	5	5	0.2	0.2	0.2	0.2									0.1	1	3	3
<i>Anaphalis margaritacea</i>	seeded															0.2	0.3				
<i>Anaphalis margaritacea</i>	salvage											0.2	0.2								
<i>Antennaria boveellii</i>	nursery	0.1	0.1	0.2	0.2														0.1	0.5	0.5
<i>Antennaria boveellii</i>	seeded							0.2							0.1	0.1	0.1				
<i>Antennaria rosea?</i>	regen/seed?			0.2	0.2																
<i>Apocynum androsaemifolium</i>	regen						0.1	0.1	0.2			0.1	0.2			0.1	0.1	0.1	0.1	0.1	0.5
<i>Arabis divaricarpa?</i>	regen											0.1							0.1		
<i>Aralia nudicaulis</i>	regen											0.1	0.2								
<i>Arnica cordifolia</i>	nursery	0.1	0.1																		
<i>Arnica cordifolia</i>	salvage				0.2							0.1	0.2	0.2							
<i>Symphyotrichum laeve</i> var. <i>laeve</i> (<i>Aster laevis</i>)	nursery	0.1	0.1	0.2	0.2							0.1	0.2	0.2				0.1	0.1	0.5	0.5
<i>Symphyotrichum laeve</i> var. <i>laeve</i> (<i>Aster laevis</i>)	seeded							0.2								0.2	0.5				
<i>Aster</i> spp.	nursery																	0.1			
<i>Campanula rotundifolia</i>	regen		0.1	0.2	0.2			0.1		0.1	0.1	0.2	0.2			0.1	0.1				
<i>Cerastium arvense</i>	regen																			1?	
<i>Chamerion angustifolium</i>	regen/seed?		2	2	0.2		0.1	0.2	0.2			0.1	0.2	0.2			0.2	0.1		0.1	0.1
<i>Chimaphila umbellata</i>	salvage									0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1				
<i>Conyza canadensis</i>	regen		0.1	0.2			0.1	0.1	0.2							0.1			0.1	0.2	0.1
<i>Dracopcephalum parviflorum</i>	regen											0.1									
<i>Dryas drummondii</i>	nursery		0.1	0.2														0.1	0.1	0.5	0.1
<i>Epilobium brachycarpum</i>	regen		0.1	0.2	0.2		0.1	0.1	2				0.2						0.1	0.1	0.5
<i>Epilobium brachycarpum</i> (wider lvs)	regen			0.2	0.2				0.2				0.2								
<i>Fragaria vesca</i>	nursery					0.1															
<i>Fragaria virginiana</i>	nursery					0.1	0.1	0.2	0.2												
<i>Fragaria virginiana</i>	regen							0.2	0.2												
<i>Galium boreale</i>	regen			0.2	0.2																
<i>Galium triflorum</i>	regen												0.2								
<i>Geranium bicknellii</i>	regen		0.1				0.1	0.2				0.1	0.2						0.1		
<i>Geum aleppicum</i>	nursery				0.2			0.1												1-	
<i>Geum macrophyllum</i>	nursery	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2									0.2	0.2		1
<i>Geum macrophyllum</i>	seeded															0.1	0.1				
<i>Gnaphalium macounii</i>	regen		0.1	0.2			0.1	0.1	0.2			0.1	0.2		0.1	0.1	0.1		0.1	1-	0.1
<i>Hieracium albiflorum</i>	regen		0.1	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2			0.2	0.3		0.1	0.1	0.2
<i>Hieracium albiflorum</i>	salvage													0.1	0.1	0.2	0.3				
<i>Maianthemum stellatum</i>	regen						0.1						0.2								
<i>Melampyrum lineare</i>	salvage								0.2			0.1	0.1	0.2							
<i>Penstemon albertinus</i>	nursery	0.1	0.1																		
<i>Penstemon confertus</i>	nursery	0.2	0.2	0.2	0.2		0.1					0.1						0.1	0.1	0.5	0.5
<i>Penstemon confertus</i>	regen								0.2								0.1				
<i>Polemonium pulcherrimum</i>	regen												0.2	0.2							
<i>Sagina saginoides</i>	regen		0.1																0.1	0.1	0.1
<i>Solidago canadensis</i>	regen/seed?		0.1	0.2	0.2										0.1	0.2	0.1		0.1	0.1	0.1
<i>Veronica peregrina</i>	regen		0.1	0.2																	
<i>Viola orbiculata</i>	salvage		0.1							0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1				
<i>Viola orbiculata</i>	regen							0.1												0.1	
<i>Xerophyllum tenax</i>	nursery?	0.1	0.1															0.1			
<i>Xerophyllum tenax</i>	seeded														0.1 (ID?)	0.2	0.2				
<i>Xerophyllum tenax</i>	salvage									0.1	0.1	1-	1+		0.1	0.2	0.2				
<i>Xerophyllum tenax</i>	regen									0.1	0.1	0.2	0.2		0.1			0.1	0.1	0.1	
<i>unknown forb</i>	regen								0.2			0.1	0.2	0.2							

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2010.

		ATC-07-06				ATC-07-07				ATC-07-08				ATC-07-09				ATC-07-10			
		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Native Grasses		0.2	0.5	5	4	2	4	5	5	0.2	0.3	2	3	0.2	1	6	7	0.2	4	10	15
<i>Agrostis scabra</i>	nursery						0.1	0.2	0.2				0.2			0.2		0.1	0.1	1+	2.5
<i>Bromus carinatus</i>	regen/seed?														0.1?	0.2	0.3		0.1	0.5	
<i>Calamagrostis rubescens</i>	nursery	0.1	0.1	0.2														0.1	1	1+	1.5
<i>Calamagrostis rubescens</i>	seeded										0.1				0.1	0.5	0.5				
<i>Calamagrostis rubescens</i>	salvage									0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.5				
<i>Calamagrostis rubescens</i>	regen					2	3	3+	4-			0.5	0.2								
<i>Carex athrostachya</i>	nursery?			0.2	0.2																
<i>Carex concinnoides</i>	salvage		0.1	0.2			0.1	0.2	0.2			0.2	0.2		0.1	0.2	0.1		0.1	1	1
<i>Carex concinnoides</i>	regen			0.2	0.2			0.5	0.2			0.2	0.2								
<i>Carex (deweyana?)</i>	regen			0.2			0.1														
<i>Carex pachystachya</i>																					0.2
<i>Carex rossii</i>	regen		0.1	1+	1		0.1	1-	1-			1-	2-				0.3		1	4	5
<i>Carex</i> spp.	nursery	0.1				0.1	0.1											0.1	0.1		
<i>Carex</i> spp.	salvage													0.1							
<i>Carex</i> spp.	regen/seed?				0.2					0.1	0.1					0.2					
<i>Danthonia intermedia?</i>	seeded?																		0.1	1	
<i>Danthonia intermedia</i>	nursery	0.1					0.1	0.2													
<i>Danthonia spicata?</i>	?			2	2				0.2							0.2	0.2				1.5
<i>Deschampsia elongata?</i>	nursery								0.2									0.1	1	0.2	2.5
<i>Elymus glaucus</i>	seeded														0.5	4+	5		0.1	0.1	0.2
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>	?		0.1	0.2	0.2																
<i>Festuca occidentalis</i>	salvage									0.1	0.1			0.1							
<i>Festuca occidentalis</i>	regen/seed?		0.1	0.7	0.2		0.1	0.4	0.2			0.2	0.2		0.1	0.5	0.5		0.1	1+	0.1
<i>Oryzopsis asperifolia</i>	regen										0.1	0.1									
<i>Panicum capillare</i>	regen																		0.1		
<i>Poa interior</i>								0.1													
<i>Poa</i> spp.	?		0.1																		
<i>Trisetum canescens</i>													0.2								
<i>Trisetum cernuum</i>																0.2	0.1				
unknown	?	0.1												0.1	0.1			0.1	0.1		
Exotic Forbs		0.2	7	17	9	0.5	3	15	15	0.2	0.3	1	2	0.1	0.1	7	10	0.1	4	20	17
<i>Arenaria serpyllifolia</i>	regen						0.1	0.1	0.2												
<i>Artemisia absinthium</i>	regen		0.1 P				0.1	0.1	0.2												
<i>Capsella bursa-pastoris</i>	regen																		0.1		
<i>Centaurea maculosa</i>	regen			0.2	0.2		0.1 P	0.2 P													
<i>Cerastium fontanum</i>	regen		0.1	0.2																	
<i>Chenopodium album</i>	regen		0.5	0.5			0.1	0.2											0.1		
<i>Chrysanthemum leucanthemum</i>	regen					0.1 P	.1 (some P)	0.5	1+									0.1 P	0.1 P	0.1	0.1
<i>Cirsium arvense</i>	regen		0.1 P	0.2	0.2						0.1	0.2	0.5						0.1	0.5	0.2
<i>Cirsium vulgare</i>	regen						0.1	0.1	0.2		0.1 P	0.2	0.2						0.1	0.1	0.1
<i>Cirsium</i> sp.	regen			0.2	0.2																
<i>Convolvulus arvensis</i>	regen				0.2																
<i>Digitalis purpurea</i>	regen			0.1																	
<i>Erodium cicutarium</i>	regen																		0.1	0.5	0.1
<i>Filago arvensis</i>	regen		0.1	0.2	0.2			0.5	0.5			0.2	0.2			0.1	0.1			0.1	0.1
<i>Galium aparine</i>	regen							0.1				0.2							0.1		
<i>Hieracium aurantiacum</i>	regen																				0.1P

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2010.

		ATC-07-06				ATC-07-07				ATC-07-08				ATC-07-09				ATC-07-10			
Exotic forbs con'd		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
<i>Hieracium floribundum?</i>	regen		0.1 P																		
<i>Hieracium</i> sp. (nativity?)	regen							0.1					0.2								
<i>Hieracium</i> sp. (white, glab, hairy marg)	regen			0.2																	
<i>Hypericum perforatum</i>	regen								0.2												
<i>Lactuca serriola</i>	regen		0.1	0.2	0.2		0.1	0.2	0.2											0.1	0.1
<i>Madia glomerata</i>	regen						0.1	0.2	0.2												
<i>Medicago lupulina</i>	regen	0.1 P	1	3	2	0.2	1	3	6			0.2	0.2			0.2	0.2		0.1	1	3
<i>Melilotus alba</i>	regen			3	0.2			1										0.1	0.1	0.1	0.2P
<i>Melilotus officinalis</i>	regen			0.2				0.2												0.1	
<i>Melilotus</i> spp.	regen	0.1 P	1				0.2		0.2												
<i>Myosotis micrantha</i>	regen		0.1																		
<i>Plantago major</i>	regen						0.1	0.1	0.2									0.1	0.1	0.1	0.1
<i>Polygonum aviculare</i>	regen							0.1											0.1		
<i>Polygonum convolvulus</i>	regen		0.1 P	0.2	0.2																
<i>Potentilla argentea</i>	regen		0.1		0.2			0.2	0.2												
<i>Potentilla recta</i>	regen						0.2 (P 5)	0.1 (P)	0.2												
<i>Prunella vulgaris</i>	regen		0.1	0.1	0.2																
<i>Rumex acetosella</i>	regen																		0.1	5	0.3
<i>Spergularia rubra</i>	regen							0.1											1		
<i>Tanacetum vulgare</i>	regen		0.1 P					0.2													
<i>Taraxacum officinale</i>	regen			0.2	0.2							0.2	0.2			0.2	0.1				
<i>Tragopogon dubius</i>	regen			0.2	0.2			0.1	0.2								0.1				
<i>Trifolium agrarium</i>	regen			0.5	0.2		0.5	1	0.2			0.2	0.2			0.2	0.1			0.5	0.5
<i>Trifolium pratense</i>	regen							0.2	0.2								0.1				0.2
<i>Trifolium</i> spp.	regen		3	3+	2		0.2	6	4	0.1	0.1	0.2	0.2	0.1	0.1	6	10	0.1	1.5	12	11
<i>Verbascum thapsus</i>	regen		0.1	0.2		0.1 P	0.1 P		0.2		0.1	0.2					0.1P		0.1	0.1	0.1
<i>Veronica officinalis</i>	regen	0.1 P	0.5	5	3		0.1	1-	1		0.1	0.5	0.2	0.1 P	0.1	1	1		0.1	1+	1
<i>Veronica serpyllifolia</i>	regen						0.1	0.2		0.1 P			0.2						0.1	0.1	0.1
unknown exotic forb	regen								0.2												
Exotic Grasses		0.1	0.1	0.2	0.5	0.1	0.1	0.5	1	0.2	0.2	0.5	1	0.2	1	4	3	0	1	0.5	1
<i>Agrostis stolonifera</i>	salvage		0.1		0.2		0.1	0.2	0.5	0.2	0.2	0.5	1-	0.2	1	2	2		0.5	0.5	0.5
<i>Agrostis stolonifera</i>	regen			0.2	0.2			0.2	0.5							0.5	0.5				
<i>Bromus secalinus?</i>	regen								0.2												
<i>Dactylis glomerata</i>	regen										0.1										
<i>Festuca arundinacea</i>	regen															1					
<i>Phleum pratense</i>	regen	0.1 P			0.2	0.1					0.1 P			0.1							0.1
<i>Phleum pratense</i>	salvage								0.2					0.1					0.1		
<i>Poa annua</i>	regen																		0.1		
<i>Poa compressa</i>	regen		0.1	0.1	0.2		0.1	0.2	0.2						0.1						0.1
<i>Poa pratensis</i>	regen	0.1																	0.1	0.1	0.5
Re-green	?							0.1				0.1		0.1	0.1						

P= pulled

*= likely mis-ID: BROCOM

Plot 9: in 2008: uncertain of ID of grass seedlings. Lots look like ELYGLA, but some have hairy sheath. Looks like XERTEN is coming up from seed.

Table 9. Apgar Transit Center: Seeded Species for Plot Areas and Their Seed Rates

*Plots 1, 6 and 7 were mulched with fine bark, but not seeded

*Plots 4, 8 and 10 were on the edge of a seeding unit and may or may not have received seed

*The bike path seed mix may have been administered in some of the nearby plots

	A		C		D	
	Bike Path		Retention Pond		DW, lot, water line	
			Plots 2 and 3		Plots 5, 9, (4, 8, 10?)	
	38,674 ft ²		13,000 ft ²		33,979 ft ²	
	g	seeds/m ²	g	seeds/m ²	g	seeds/m ²
<i>Achillea millefolium</i>			11.6	57.21	72.6	136.98
<i>Adenocaulon bicolor</i>	25.98g	5.79				
<i>Anaphalis margaritacea</i>					15.81g	90.54
<i>Antennaria bonellii</i>	2g	7.63			8g	34.73
<i>Antennaria</i> spp.					9g	unk
<i>Aralia nudicaulis</i>	12.8g	0.63				
<i>Arnica cordifolia</i>	35.9g	7.39				
<i>Aster laevis</i>					138.1g	137.89
<i>Aster</i> spp.					4.28g	unk
<i>Bromus carinatus</i>					1379g	80.38
<i>Calamagrostis rubescens</i>	186g	177.15			638g	691.61
<i>Carex</i> / forb mix			100g	unk		
<i>Carex athrostachya</i>	450g	614.96	50g	203.27	292g	454.18
<i>Carex pachystachya</i>	1500g	unk			405g	unk
<i>Carex</i> spp.			1.7g	unk		
<i>Chamerion angustifolium</i>					19.39g	92.25
<i>Clintonia uniflora</i>	20.29g	unk				
<i>Cornus canadensis</i>	5.42g	0.23				
<i>Deschampsia elongata</i>	1.5g	1.66				
<i>Dryas drummondii</i>					3g	1.90
<i>Elymus glaucus</i>			650.68g	160.01	463g	43.56
<i>Festuca occidentalis</i>	250g	53.37				
<i>Fragaria virginiana</i>	8.69g	4.95				
<i>Geranium bickenellii</i>	1.15g	unk				
<i>Geum macrophyllum</i>			29.64g	41.03	82.32g	43.60
<i>Heracleum sphondylium</i>	106.6g	3.95			345g?	14.54
<i>Iliamna rivularis</i>					26.4g	2.40
<i>Linnaea borealis</i>	0.11g	unk				
<i>Maianthemum stellatum</i>	8.17g	unk				
<i>Mimulus</i> spp.	0.72g	9.42				
<i>Penstemon confertus</i>			4.04g	19.75	22.3g	41.71
<i>Penstemon ellipticus</i>					17g	24.80
<i>Rosa acicularis</i>					55.89g	1.93
<i>Rubus parviflorus</i>	30g	5.49			92.7g	19.29
<i>Sambucus racemosa</i>					26.14g	4.48
<i>Solidago canadensis</i>			6.48g	71.92	47g	199.57
<i>Spiraea betulifolia</i>	1.6g	1.18	9g	19.72	5.83g	4.89
<i>Symphoricarpos albus</i>					39.78g	2.12
<i>Tiarella trifoliata</i>	6g	4.86				
<i>Trisetum spicatum</i>					56.97g	47.32
<i>Xerophyllum tenax</i>					1181g	173.59

Seed Unit E: no seed rates are available for this area, only a species list of seeded species.

Cells marked unk are due to the fact that there is no information on seeds/g for this species.

III. GOING-TO-THE-SUN ROAD: PHASE VI MONITORING

A. BACKGROUND AND PURPOSE

In July 2007, an 8 to 10-year rehabilitation project for the Going to the Sun Road (GTSR) was initiated, funded by Federal Highway dollars. Phase VI of the project, including the roadside from West Tunnel to Haystack Creek, began in 2007 and continued into 2008. Construction during this phase included installation of retaining walls, culverts and drains, as well as base stabilization. Additionally, a day-use and vista area was created across from the “Road Camp” area on the south side of the road. Elevation for this phase of the GTSR Rehabilitation Project ranges from approximately 4,400 feet to 5,230 feet.

A species list was created for this segment of road in 2007 which directed seed collection. Disturbance created from construction of this phase was revegetated in June 2010. Five roadside sites or turnouts, estimated at 18,732 ft², in phase VI were planted, seeded, and provided with fencing to deter trampling. Several of these sites had significant plant material and were only lightly seeded with a forb, shrub, and grass mix (Table 11). Others had less planted material and were seeded more heavily with the same seed mix. In all turnout areas that were seeded, the soil was scarified and seeds were hand raked into the ground. All roadside edges that were disturbed throughout phase VI, totaling at 87,120 ft², were then hydroseeded with the same seed mix.

B. METHODS

Monitoring plots were established in September 2010 at all five sites that were planted with nursery stock (Figure 6). At this time, seed was not yet germinating so no plots were created in areas that were seeded alone. Additional sites may be added in the future if deemed necessary. Plots are not permanently marked and size and shape of plots were determined by site parameters (Table 10). Most plots were located behind wood fencing and varied in width.

Plots were evaluated using Level II protocol. All plants within plots were identified to species and given ocular cover estimates.

Table 10. GTSR-Phase VI: Plot Dimensions and Locations.

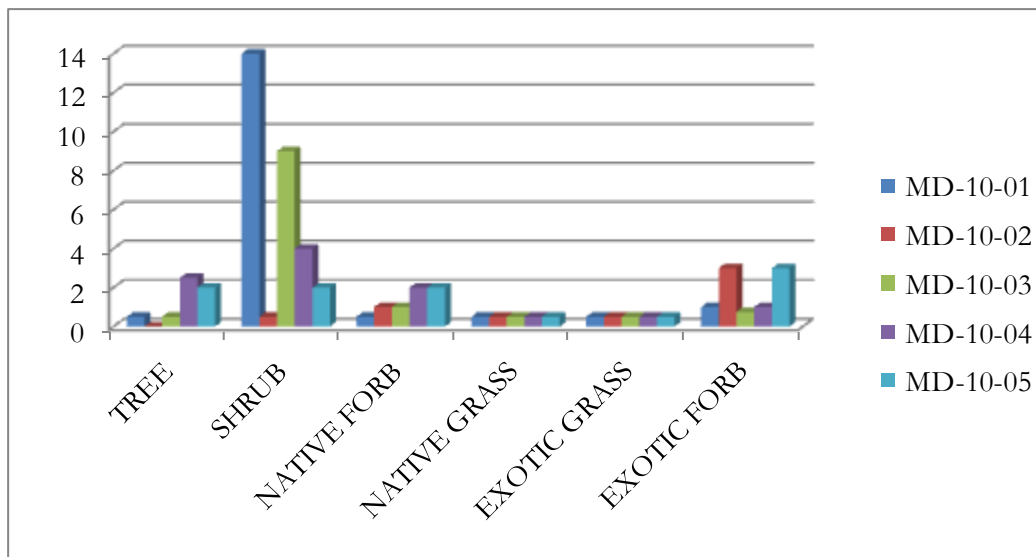
Plot Number	Plot dimensions	UTM N	UTM E
MD-10-01	24 m x 2 m	5403348	295945
MD-10-02	35 m x 3 m	5402887	296917
MD-10-03	50 m x 2 m	5402469	297398
MD-10-04	25 m x 4 m	5402249	297553
MD-10-05	18 m x 3 m	5402096	297673

C. RESULTS

Since these areas were recently revegetated, results reflect an immediate post-planting condition. Covers of native species depict a baseline of abundances of planted material. A minimal amount of natural native plant species were also present at this time from adjacent undisturbed vegetation. Exotic species had begun to invade, however, given that there was an abundance of open disturbed soil and seeded species had not yet germinated. Only *Capsella bursa-pastoris* and *Verbascum thapsus* were present with greater than trace cover. Weeds were pulled, when possible, during monitoring to enhance success of seeded and planted species.

In most plots, shrubs were the dominant life form, particularly in plot MD-10-01 where they contributed 14% cover (Table 12, Figure 7). All plots contained 6 to 10 species of shrubs. The relative abundance of shrubs is expected to change over time as seeded material germinates and develops, however.

Figure 7. GTSR-Phase VI: Percent Ocular Cover of Lifeforms for All Plots, 2010.



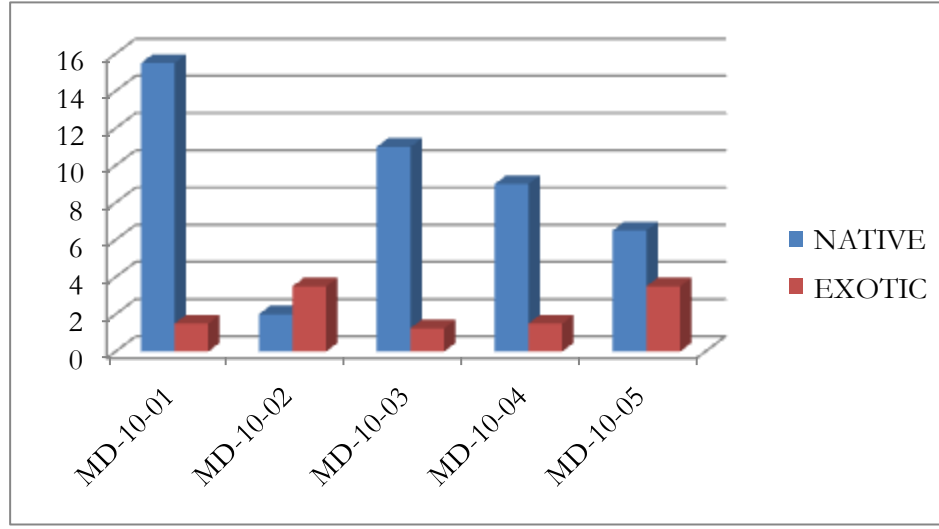
Shrubs can produce abundant, relatively rapid cover, which should aid in outcompeting exotic species. *Arctostaphylos uva-ursi*, *Cornus sericea* and *Salix* species were most common across plots.

Trees were present in four of the five plots, and while they do not provide much cover yet, trees may serve the same function as shrubs as they mature. Five species of trees were found across all plots with each plot containing from 0 to 3 species (Table 12). *Populus balsamifera* was the most commonly planted tree, a result based on site analysis data where it was found to be the most abundant tree in phase VI (Asebrook and Hintz 2007). *P. balsamifera* is also a very fast growing species, helping to further gain quick ground cover.

All plots were planted with a variety of native forbs. Between 9 and 19 species were present in all plots, most with trace cover. Only *Fragaria virginiana* and *Achillea millefolium* were present with 1% cover in one plot. Native grasses were less abundant. Only three species were present across plots and no plot contained more than trace cover of native grass.

Exotic grass cover was low with no more than trace cover in any plot. No plot contains more than 3 species of exotic grass. Unfortunately, a wide diversity of exotic forbs was present within the project. Between 7 and 23 exotic forb species were found in each plot. As stated above, however, only two species had more than trace cover. Many of the exotic forbs found within the project typically do not persist once other vegetation becomes established. Species in the mustard family, such as *Capsella bursa-pastoris*, and in the pea family, such as *Medicago lupulina*, *Trifolium agrarium* and *Trifolium hybridum*, have been found to decrease in cover over time in other revegetation projects. Of more concern, however, are the noxious weed species that were present throughout the area. *Centaurea stoebe* (*Centaurea maculosa*), *Cirsium arvense*, *Cynoglossum officinale*, *Hypericum perforatum* and *Leucanthemum vulgare*, all Montana Priority 2B Noxious Weeds, were all found in at least one plot with several found in two or three plots. All weeds were pulled at the time of monitoring when feasible. Native species have greater cover than exotic species, with the exception of plot 2 (Figure 8) where overall vegetative cover is just over 5%. With this low native cover, the spread of weeds across this project should be closely monitored.

Figure 8. GTSR-Phase VI: Comparison of Total Native vs. Exotic Cover by Plot, 2010



D. CONCLUSIONS AND RECOMMENDATIONS

Baseline data collected in 2010 reflect immediate post-planting covers. Subsequent data will reveal success of seeded species and survival of planted material. Post-planting results show shrub cover to be most prominent with other lifeforms fairly inconsequential at this early date. Frequent weeding of exotic species is recommended to enhance native species survival. Herbicide application should also continue in this area to reduce noxious weeds. Plots should be read again in 2011 (year 1), 2012 (year 2), 2013 (year 3), 2015 (year 5) and 2020 (year 10).

Figure 6. GTSR-Phase VI: Location of Plots

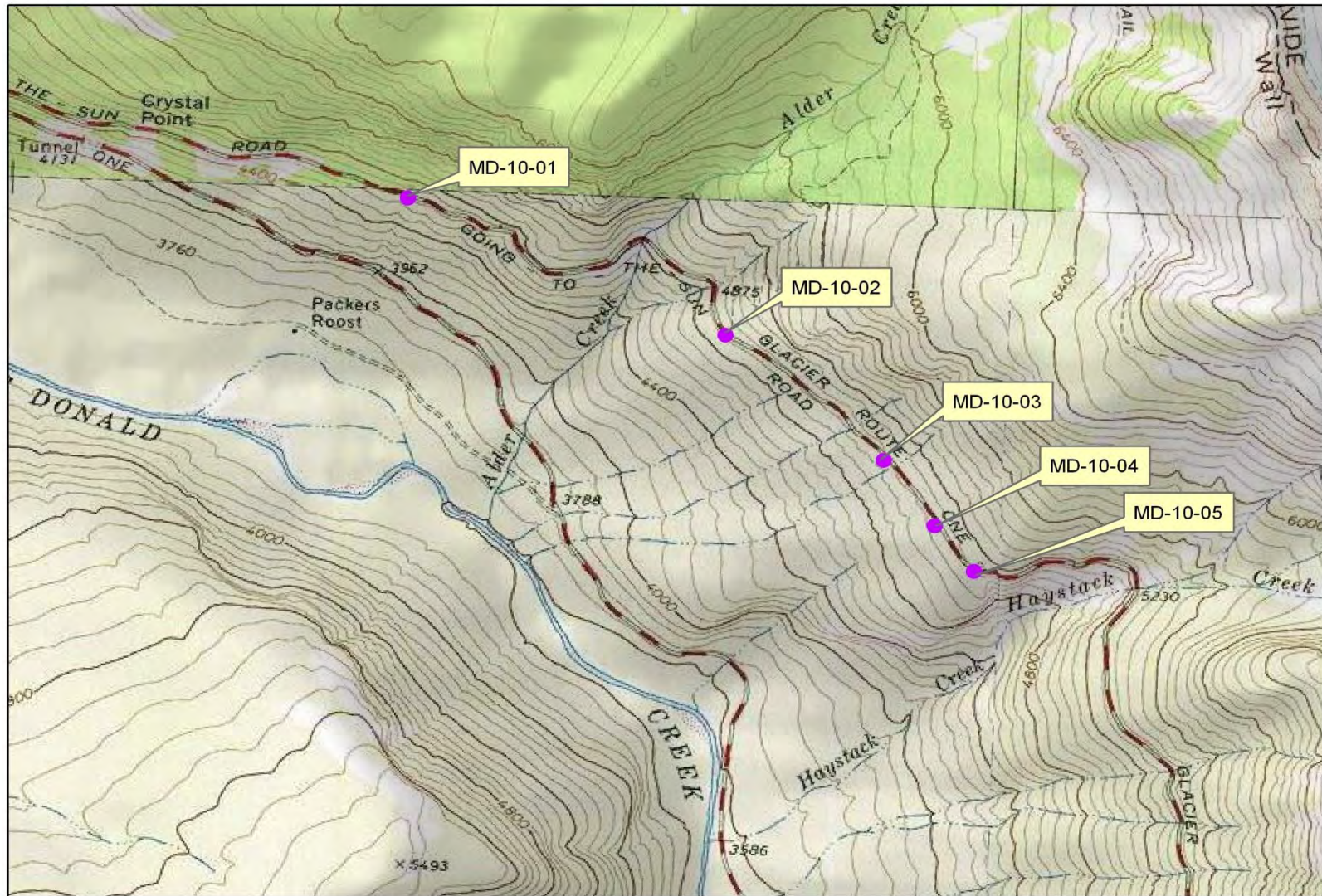


Table 11. GTSR-Phase VI: List of seeded species and their seed rates

Species	Grams of seeds	Seeds/ft ²	Acc. #
Forbs/Shrubs			
<i>Achillea millefolium</i>	73g	5 seeds/ft ²	9054522, 9054562, 9057899, 9076137
<i>Chamerion angustifolium</i>	28g	5 seeds/ft ²	9087363, 9082171
<i>Eurybia conspicua</i>	138g	5 seeds/ft ²	9081946, 9087433
<i>Fragaria spp.</i>	1.2g	trace/ft ²	09-002
<i>Geum macrophyllum</i>	261g	5 seeds/ft ²	9087654
<i>Monarda fistulosa</i>	6.11g	0.2 seeds/ft ²	9088010, 9088080
<i>Penstemon confertus</i>	39.0g	4 seeds/ft ²	9057993
<i>Penstemon hyallii</i>	29.78g	0.3 seeds/ft ²	9063300, 9057994
<i>Solidago canadensis</i>	32.5g	5 seeds/ft ²	9081611
<i>Spiraea betulifolia</i>	26.8g	0.8 seeds/ft ²	9078402
Grass/Carex:			
<i>Carex pachystachya</i>	532g	seed weight estimated at 4900 seeds/g 30 seeds/ft ²	9078645
<i>Carex rossii</i>	119g	seed weight estimated at 2500 seeds/g 3.41 seeds/ft ²	9088095
<i>Elymus glaucus</i>	5866g	20 seeds/ft ²	9087927
<i>Elymus trachycaulus</i>	5462g	20 seeds/ft ²	cultivar Revenue
<i>Bromus marginatus</i>	9469g	20 seeds/ft ²	cultivar Garnet
<i>Festuca occidentalis</i>	1136g	10 seeds/ft ²	cultivar

Table 12: GTSR-Phase VI: Ocular Canopy Cover of all Species by Plot, 2010.

Species:	MD-10-01		MD-10-02		MD-10-03		MD-10-04		MD-10-05	
	planted?	2010	planted?	2010	planted?	2010	planted?	2010	planted?	2010
TREE		T		0		T		2+		2
<i>Abies lasiocarpa</i>	p							T		
<i>Betula papyrifera</i>			p			T				
<i>Picea engelmannii</i>										2
<i>Populus balsamifera</i>	p	T	p			T		2		
<i>Pseudotsuga menziesii</i>	p							T		
SHRUB		14		T		9		4		2
<i>Acer glabrum</i>		T+					p			T
<i>Alnus viridis</i>						T				
<i>Amelanchier alnifolia</i>		T					p			
<i>Arctostaphylos uva-ursi</i>	p	2-	p	T	p	3-	p			
<i>Cornus sericea</i>	p	5	p			3	p	1	p	1
<i>Mahonia repens</i>	p		p	T	p	T				T
<i>Paxistima myrsinites</i>	p		p			T				T
<i>Prunus virginiana</i>	p		p			T				
<i>Ribes viscosissimum</i>		T		T	p		p			
<i>Rosa woodsii</i> (+ other <i>Rosa</i> sp?)	p		p			2			p	T+
<i>Rubus idaeus</i>		T+		T		T	p	T		
<i>Rubus parviflorus</i>		T+	p			T	p	T		
<i>Salix</i> sp. (mostly <i>S. scouleriana</i>)	p	5					p	2-		
<i>Sambucus racemosa</i>				T						T
<i>Spiraea betulifolia</i>	p	T	p	T	p	T+	p	T	p	T
<i>Symphoricarpos albus</i>		1	p					T+		T
NATIVE FORB		T		1		1		2		2
<i>Achillea millefolium</i>		T		T		T		T+		1-
<i>Anaphalis margaritacea</i>				T						
<i>Antennaria bonellii</i>	p		p	T	p	T			p	T
<i>Aquilegia flavescens</i>										T
<i>Artemisia ludoviciana</i>				T				T		
<i>Aster</i> sp.	p	T								
<i>Cardamine pensylvanica</i>				T		T		T		
<i>Castilleja miniata</i>		T								
<i>Chamerion angustifolium</i>		T				T				T
<i>Cirsium hookerianum</i>								T		
<i>Epilobium brachycarpum</i> (wide leaves)								T		
<i>Epilobium</i> sp.				T				T		
<i>Fragaria vesca</i>				T	p	T	p	T		
<i>Fragaria virginiana</i>	p	T		T	p	T	p	1		T
<i>Geranium bicknellii</i>				T						
<i>Geum macrophyllum</i>		T		T		T		T		
<i>Gnaphalium macounii</i>				T						
<i>Illecebrum rivularis</i>	p		p	T	p		p	T	p	T
<i>Maianthemum stellatum</i>		T					p			
<i>Monarda fistulosa</i>				T						
<i>Penstemon albertinus</i>				T						
<i>Penstemon confertus</i>	p	T	p	T	p	T	p	T	p	T
<i>Penstemon ellipticus</i>				T						
<i>Penstemon lyallii</i>	p	T			p	T	p	T		
<i>Phacelia hastata</i>				T		T		T		
<i>Plagiobothrys scouleri</i>		T								
<i>Solidago canadensis</i>	p	T	p	T		T		T	p	
<i>Symphotrichum laeve</i> (<i>Aster laevis</i>)	p	T	p	T	p	T		T		T
<i>Urtica dioica</i>						T				T
<i>Viola</i> spp.								T		

Table 12, con'd: GTSR-Phase VI: Ocular Canopy Cover of all Species by Plot, 2010.

<i>Species:</i>	MD-10-01	MD-10-02	MD-10-03	MD-10-04	MD-10-05
	2010	2010	2010	2010	2010
NATIVE GRASS	T	T	T	T	T
<i>Bromus carinatus</i>	T	T	T	T	
<i>Carex</i> sp.		T		T	T
<i>Elymus trachycaulus</i> (v. <i>trachycaulus</i> ?)	T				
<i>unknown grass</i>	T		T	T	T
EXOTIC GRASS	T	T	T	T	T
<i>Elymus repens</i>			T		
<i>Panicum capillare</i>		T (P)			
<i>Phleum pratense</i>				T	
<i>Poa annua</i>			T		T
<i>Poa compressa</i>	T	T			
<i>Poa pratensis</i>				T	
<i>unknown grass</i>				T	T
EXOTIC FORB	1	3	T+	1	3
<i>Amaranthus graecizans</i>				T (P)	
<i>Arenaria serpyllifolia</i>		T			T (P)
<i>Capsella bursa-pastoris</i>	T	T (P)	T	T (P)	2-
<i>Centaurea stoebe</i> (<i>Centaurea maculosa</i>)		T			
<i>Chaenorrhinum minus</i>		T			
<i>Chenopodium album</i>			T (P)	T (P)	T (P)
<i>Chenopodium</i> sp.		T	T (P)		
<i>Cirsium arvense</i>		T	T		T (P)
<i>Cirsium vulgare</i>		T			T
<i>Cynoglossum officinale</i>		T	T	T (P)	T (P)
<i>Descurainia sophia</i>				T (P)	T (P)
<i>Erodium cicutarium</i>		T	T (P)		
<i>Filago arvensis</i>					T (P)
<i>Gnaphalium palustre</i>				T	
<i>Hypericum perforatum</i>	T (P)	T (P)			
<i>Lactuca serriola</i>				T (P)	T (P)
<i>Lamium amplexicaule</i>				T (P)	T (P)
<i>Leucanthemum vulgare</i>				T (P)	
<i>Medicago lupulina</i>	T (P)	T (P)		T (P)	T (P)
<i>Melilotus officinalis</i>	T+ (P)				
<i>Melilotus</i> sp.		T (P)			
<i>Myosotis arvensis</i>		T			
<i>Plantago major</i>				T	
<i>Polygonum aviculare</i>		T (P)	T (P)	T (P)	T (P)
<i>Polygonum convolvulus</i>		T (P)		T (P)	T (P)
<i>Potentilla norvegica</i>		T			
<i>Prunella vulgaris</i>				T	
<i>Rumex</i> sp.		T	T		T (P)
<i>Silene latifolia</i>				T	
<i>Sisymbrium altissimum</i>		T (P)		T (P)	T+ (P)
<i>Taraxacum officinale</i>	T (P)		T		T (P)
<i>Thlaspi arvense</i>		T		T (P)	T (P)
<i>Tragopogon dubius</i>		T			
<i>Trifolium agrarium</i>	T (P)	T			
<i>Trifolium hybridum</i>				T	
<i>Verbascum thapsus</i>	T (P)	2	T	T (P)	T (P)
<i>Veronica arvensis</i>			T		
<i>Veronica serpyllifolia</i>		T		T	

of exotic forb species

7

23

11

20

18

(P) = Pulled some or all

red text = noxious weed species

IV. GOING-TO-THE-SUN ROAD SPECIES LISTS

A. BACKGROUND AND PURPOSE

Much of the Going-to-the-Sun Road (GTSR) is now over 75 years old and is in need of extensive reconstruction in order to preserve its safety and natural heritage. In July 2007, an 8 to 10-year rehabilitation project for the GTSR was initiated, funded largely by Federal Highway dollars. Additional federal stimulus money has accelerated work on this project, lending urgency to creating revegetation plans for many sections of the road. Most recently, the project received \$27.6 million in federal stimulus money for two phases of alpine work in 2010 including phase VIII, from Big Bend to Logan Pass, and phase XI from Logan Pass to Siyeh Bend (Figure 9). Additional work is slated to take place on phase VII between Avalanche Creek and West Tunnel during the shoulder seasons of 2010 when motorized traffic is restricted.

The purpose of this report is to document pre-disturbance plant data prior to construction in order to guide the selection of plant material for revegetation.

B. METHODS

Five construction phases of the GTSR were surveyed in 2010 (Table 13). As many turnouts and adjacent roadsides as possible were visited within each phase. Roadsides within a quarter mile of each turnout were also surveyed. All tree, shrub, forb, grass and weed species were recorded at each site. Cover for each species was rated high (H), medium (M) or low (L) and averaged across each phase or ecological section of road, whichever was smaller.

Ecological vegetation breaks were noted and separate lists were created for each zone. In phase VIII, from Big Bend to Logan Pass, an ecological vegetation break occurs between Triple Arches and Logan Pass. Above Triple Arches, alpine vegetation dominates and the alpine list should be consulted when planning for seed collection for that zone. Within phase XI, wetter and drier zones exist, although a single species list has been created for this phase. Individual plants within the species list have been denoted as either wetter or drier, but many can tolerate conditions and have no notation. Specialized wetter or drier seed prescriptions could be created from this list if desired. Phase XII, from below Siyeh Bend to Rising Sun, is a very long stretch and therefore four species lists have been created for this section. This phase has been split into a subalpine section, with both wet and dry areas, as well as a lower elevation section with both wet and dry areas.

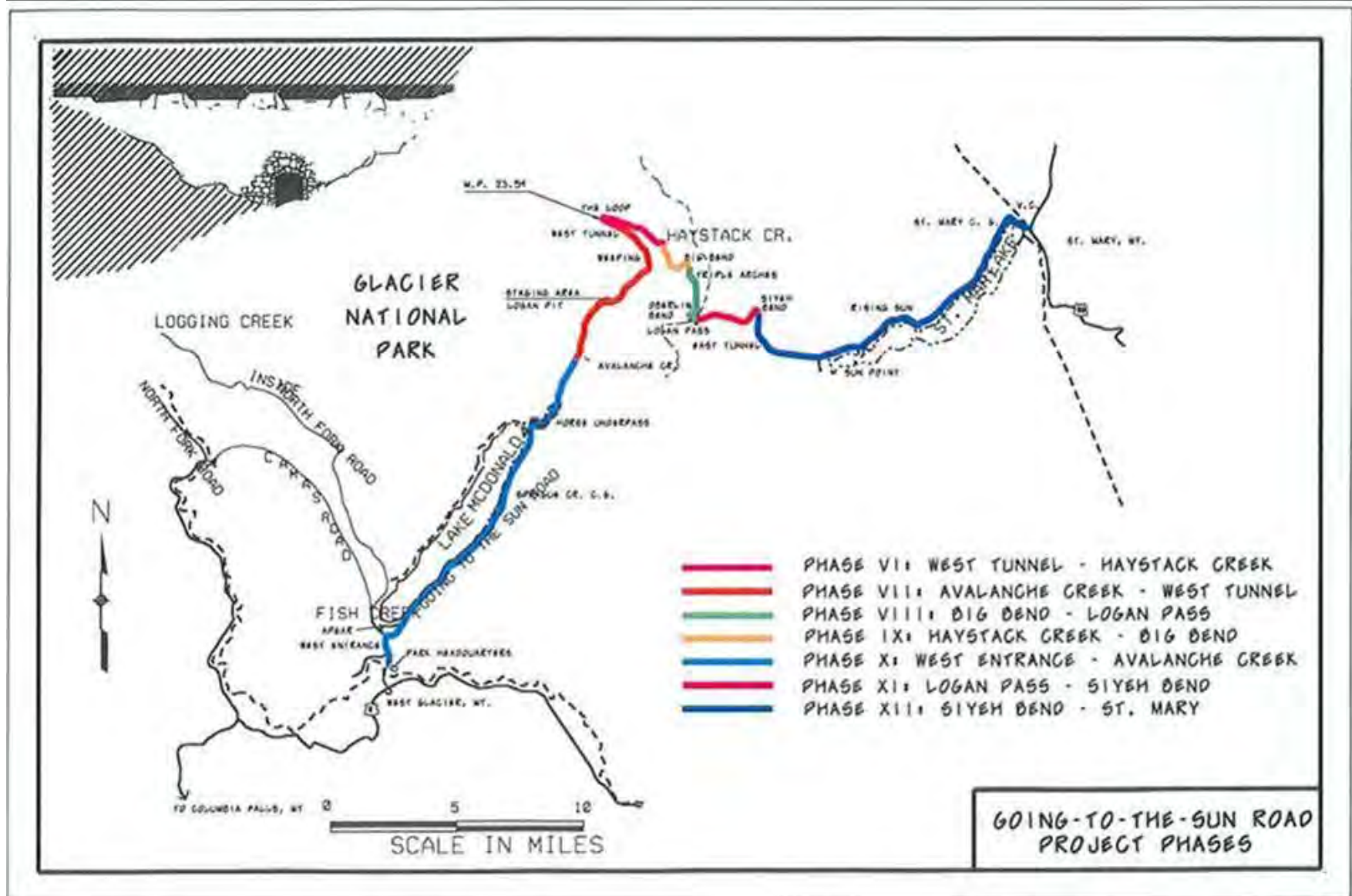
Table 13. GTSR: phases and dates of monitoring

Phase	Start of phase	End of phase	Dates surveyed	End of Construction	Reveg date	Acres disturbed
VII	Avalanche Creek	West Tunnel	8/26/2010	Summer 2011	Fall 2011?	~7
VIII	Big Bend	Logan Pass	8/24-25/10, 9/7/10	Fall 2011	Fall 2011?	~1.5
IX	Haystack Creek	Big Bend	7/29/10, 8/24/10	Fall 2012	Fall 2012?	~1.5
XI	Logan Pass	Siyeh Bend	7/14-15/10, 8/24/10	August, 2011	Fall 2011	2
XII	Siyeh Bend	St. Mary	8/23/2010			

C. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Complete species lists by lifeform follow. Exotic species are also listed, most of which were isolated to the road shoulder. Species in blue are plants that were generally relatively abundant and are recommended species for revegetation.

Figure 9. Going-to-the-Sun Road Project Phase Map



1. PHASE VII: Avalanche Creek to West Tunnel

A site analysis was completed for phase VII of the GTSR in 2004. Five 20m x 5m or 10m x 2.5m plots were placed in areas representing different habitats and/or plant associations. Ocular percent cover of each species present was then recorded in each plot. The resulting recommended species list was utilized for preliminary seed collection. An additional survey took place along phase VII in August 2010 to survey a broader range along this stretch of road and to further refine the seed collection list. Construction of this road section is scheduled to start in the fall of 2010 and end in the summer of 2011 with revegetation potentially taking place as soon as the fall of 2011.

Phase VII is shrubby and rich in species diversity. Several low to medium stature shrubs have been recommended (Table 14), although vegetation height restrictions in road corridors may prohibit the planting of shrubs. Many or all of these areas are regularly mowed and do not lend themselves to harboring woody material. However, areas behind turnouts are often revegetated with taller woody species and virtually any species on the overall list that is available for revegetation would be suitable for such areas unless visual height restrictions are desired.

The majority of forb and grass species recommended for revegetation can be used in dry or mesic conditions (Figure 10). A few species, however, are adapted to a much moister regime and likely will not thrive in a general roadside seed mix. *Angelica arguta* and *Heracleum sphondylium* are particularly common species in wetter areas, and if used, should specifically be planted or seeded in wetter sections along the road. Other species labeled as “wetter” or “wet” could be planted or seeded in these areas as well (Figure 10).

Exotic species are numerous in phase VII, many with medium or high covers. Herbicide application has been regularly practiced along this stretch of road and will likely need to continue after restoration. Forb species in the Aster family may need to be limited in revegetation prescriptions, since they are usually most affected by herbicides. Several species of noxious weeds are common along this road corridor, including *Chrysanthemum leucanthemum* and *Centaurea maculosa*. Perhaps most worrisome is *Hypericum perforatum*, which has increased greatly in this area in the last few years and can be difficult to control. Unfortunately, exotic grasses are also quite common in some areas of this road phase. Currently, the park does not have an effective method to control weedy grasses. They can be quite aggressive and often undermine revegetation efforts. Any removal of exotic grasses prior to restoration would likely aid in the success of revegetation efforts.

Figure 10. GTSR-Phase VII: Avalanche Creek to West Tunnel planting zones

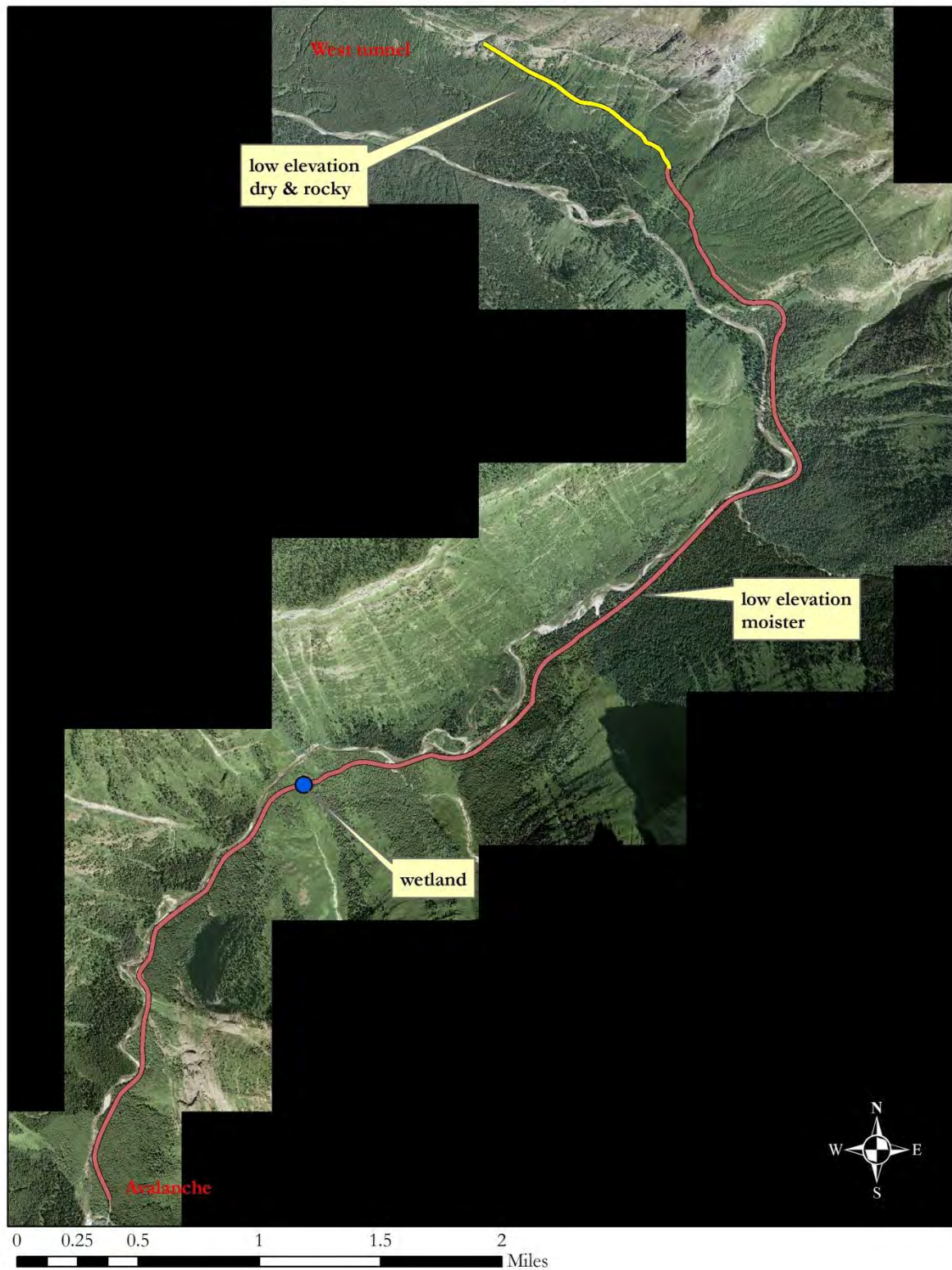


Table 14: GTSR-Phase VII (Avalanche to West Tunnel): Species List and Abundance (recommended species in blue)

Abundance: L=low M=moderate H=high

TREE		SHRUB		NATIVE FORB		NATIVE FORB, con'd	
<i>Abies lasiocarpa</i>	L	<i>Acer glabrum</i>	M	<i>Achillea millefolium</i>	L/M	<i>Gymnocarpium disjunctum</i>	L/M
<i>Betula papyrifera</i>	L	<i>Alnus incana</i>	L	<i>Adenocaulon bicolor</i>	M/H	<i>Gymnocarpium dryopteris</i>	L
<i>Picea engelmannii</i>	L	<i>Alnus viridis</i>	L	<i>Allium cernuum</i> (dry)	L	<i>Heracleum sphondylium</i> (wetter)	L/M
<i>Populus balsamifera</i>	M	<i>Amelanchier alnifolia</i>	L	<i>Anaphalis margaritacea</i> (dry)	M	<i>Heuchera cylindrica</i>	L
<i>Pseudotsuga menziesii</i>	L	<i>Cornus sericea</i>	M	<i>Aneome multifida</i>	L	<i>Hieracium albiflorum</i>	L
<i>Thuja plicata</i>	L	<i>Crataegus douglasii</i>	L	<i>Angelica arguta</i> (wetter)	M	<i>Maianthemum racemosum</i>	L/M
<i>Tsuga heterophylla</i>	L	<i>Dasiphora floribunda</i>	L	<i>Antennaria howellii</i>	L	<i>Maianthemum stellatum</i>	L/M
		<i>Holodiscus discolor</i>	L	<i>Apocynum androsaemifolium</i>	L	<i>Monarda fistulosa</i> (dry)	L
		<i>Juniperus communis</i>	L	<i>Aquilegia flavescens</i> (wetter)	L	<i>Orthilia secunda</i>	L
		<i>Linnaea borealis</i>	L	<i>Aralia nudicanlis</i>	L/M	<i>Osmorhiza berteroi</i>	L/M
		<i>Lonicera involucrata</i>	L	<i>Arnica amplexicaulis</i>	L	<i>Penstemon hyallii</i> (dry, higher elevation)	L
		<i>Menziesia ferruginea</i>	L	<i>Artemisia ludoviciana</i> (dry)	L	<i>Phacelia hastata</i> (dry)	L
		<i>Oplopanax horridus</i>	L	<i>Artemisia michauxiana</i> (dry)	L	<i>Platanthera hyperborea</i>	L
		<i>Paxistima myrsinites</i>	L	<i>Athyrium filix-femina</i> (wetter)	L/M	<i>Potentilla gracilis</i>	L
		<i>Rhamnus alnifolia</i>	L	<i>Botrychium virginianum</i>	L	<i>Prosartes hookeri</i>	L
		<i>Ribes hudsonianum</i>	L	<i>Campanula rotundifolia</i>	L	<i>Pteridium aquilinum</i>	L
		<i>Ribes inerme</i>	L	<i>Canadanthus modestus</i> (<i>Aster modestus</i>)	L	<i>Sanicula marilandica</i>	L
		<i>Ribes lacustre</i>	L	<i>Castilleja miniata</i>	L/M	<i>Sedum lanceolatum</i>	L
		<i>Rosa woodsii</i>	L	<i>Chamerion angustifolium</i> (both)	L	<i>Senecio pauperculus</i> / <i>Senecio pseudolaurens</i>	L
		<i>Rubus idaeus</i>	L/M	<i>Circaea alpina</i>	L	<i>Solanum dulcamara</i>	L
		<i>Rubus parviflorus</i>	L/M	<i>Clematis occidentalis</i>	L	<i>Solidago canadensis</i>	M/H
		<i>Salix</i> sp.	L	<i>Clintonia uniflora</i>	L	<i>Streptopus amplexifolius</i>	L
		<i>Sambucus racemosa</i>	L	<i>Crepis runcinata</i>	L	<i>Symphyotrichum foliaceum</i> var. <i>foliaceum</i> (<i>Aster foliaceus</i>)	L
		<i>Shepherdia canadensis</i>	L	<i>Dryopteris filix-mas</i>	L	<i>Symphyotrichum laeve</i> (<i>Aster laevis</i>)	M/H
		<i>Sorbus scopulina</i>	L	<i>Equisetum arvense</i>	L	<i>Thalictrum occidentale</i>	L
		<i>Spiraea betulifolia</i>	L	<i>Eurybia conspicua</i> (<i>Aster conspicuus</i>)	L	<i>Tiarella trifoliata</i>	L/M
		<i>Symphoricarpos albus</i>	M	<i>Fragaria vesca</i>	M	<i>Trillium ovatum</i>	L
				<i>Fragaria virginiana</i>	L	<i>Urtica dioica</i> (wet)	L
				<i>Galium boreale</i>	L	<i>Veratrum viride</i> (wetter)	L
				<i>Galium triflorum</i>	L	<i>Viola canadensis</i> / <i>Viola glabella</i>	L
				<i>Geum macrophyllum</i>	L/M	<i>Viola orbiculata</i>	L
				<i>Goodyera oblongifolia</i>	L		

Table 14, con'd: GTSR-Phase VII (Avalanche to West Tunnel): Species List and Abundance (recommended species in blue)

Abundance: L=low M=moderate H=high

NATIVE GRASS		EXOTIC FORB		EXOTIC GRASS	
<i>Bromus carinatus</i>	L	<i>Arctium minus</i>	L	<i>Agrostis stolonifera</i>	M
<i>Bromus vulgaris</i>	L	<i>Centaurea maculosa</i>	L	<i>Avena sativa</i>	L
<i>Calamagrostis canadensis</i>	L/M	<i>Cerastium fontanum</i>	L	<i>Bromus inermis</i>	H
<i>Carex deweyana</i>	L	<i>Chaemorbinum minus</i>	L	<i>Dactylis glomerata</i>	M
<i>Carex mertensii</i> (wetter)	L	<i>Chrysanthemum leucanthemum</i>	M	<i>Elymus repens</i>	L/M
<i>Carex microptera</i>	L	<i>Cirsium arvense</i>	L	<i>Phalaris arundinacea</i>	L
<i>Carex pachystachya</i>	L	<i>Cirsium vulgare</i>	L	<i>Phleum pratense</i>	M
<i>Carex rossii</i>	L	<i>Cynoglossum officinale</i>	L	<i>Poa compressa</i>	M
<i>Elymus glaucus</i>	M	<i>Descurainia sophia</i>	L	<i>Poa pratensis</i>	M/H
<i>Elymus trachycaulus</i>	L	<i>Hypericum perforatum</i>	L/M	<i>Setaria glauca</i>	L
<i>Festuca subulata</i>	L	<i>Lactuca serriola</i>	L		
<i>Glyceria elata</i> (wet)	L	<i>Linaria vulgaris</i>	M		
<i>Hordeum jubatum</i>	L	<i>Medicago lupulina</i>	L		
<i>Melica smithii</i>	L	<i>Melilotus alba</i>	L/M		
<i>Poa interior</i>	L	<i>Melilotus officinale</i>	M		
<i>Poa palustris</i>	L	<i>Plantago lanceolata</i>	L		
<i>Poa secunda</i>	L	<i>Plantago major</i>	M		
<i>Trisetum canescens</i>	L	<i>Polygonum aviculare</i>	L		
		<i>Prunella vulgaris</i>	M		
		<i>Silene cucubalus</i>	L		
		<i>Silene latifolia</i>	L		
		<i>Taraxacum officinale</i>	M		
		<i>Thlaspi arvense</i>	L		
		<i>Trifolium agrarium</i>	L/M		
		<i>Trifolium hybridum</i>	L		
		<i>Trifolium pratense</i>	L		
		<i>Verbana bracteata</i>	L		
		<i>Verbascum thapsus</i>	L		
		<i>Veronica officinalis</i>	L		
		<i>Veronica serpyllifolia</i>	L		

2. PHASE VIII: Triple Arches to Logan Pass (Alpine Section)

Construction on this section of the GTSR took place this season and is slated to end in fall of 2011. This project phase may be revegetated as soon as the fall of 2011. Previous studies have contributed to compilation of a comprehensive revegetation list for this area, in addition to roadside surveys completed this year. The Logan Pass and Oberlin Bend areas of the GTSR underwent reconstruction during the summer of 1995. In preparation for this, thirteen site analyses in more widespread habitat types were conducted by Vanderbilt and Potter in 1993. Results from these site analyses were utilized in preparation of the species list for revegetation.

No trees or tall shrubs have been recommended for revegetation simply because of height restrictions on roadsides. In the event that some turnouts will accommodate taller plant material, any tree or shrub species listed would be appropriate.

It should be noted that many species listed on the compiled alpine list have specific ecological niches. Several of these species are commonly found in moist alpine turf, which is probably moister than a typical roadside would be. Several of these plants tend to grow in higher elevation areas where snow persists late into the season and thus require higher moisture regimes. Species such as *Salix arctica*, *Phyllodoce glanduliflora*, *P. empetriformis*, *Ranunculus eschscholtzii*, *Senecio cymbalaroides*, *Carex nigricans*, *Deschampsia atropurpurea* and *Luzula hitchcockii* are within such community types. If moist alpine turf areas with late snow melt are slated to be revegetated, then species labeled as “late snow” may be appropriate, although these habitats are fragile and likely difficult to recreate. Other species on the list tend to grow in montane to alpine seep areas. Plants that grow in these wet areas have wide elevational amplitudes and include *Alnus viridis*, *Cornus sericea*, *Allium schoenoprasum*, *Aquilegia flavescens*, *Mimulus lewisii*, *Parnassia fimbriata* and *Juncus drummondii*. Additionally, several species are most commonly found in moist meadows and likely would not thrive in a drier roadside environment. These species grow at a variety of elevations and include *Heracleum sphondylium*, *Senecio triangularis* and *Veratrum viride*. Moist meadow species that typically occur in the subalpine zone may also require higher moisture regimes than roadsides, including *Anemone occidentalis*, *Erigeron caespitosus*, *E. speciosus*, *E. peregrinus*, *Gentiana calycosa*, *Hypericum formosum*, *Mitella breveri*, *Veronica wormskjoldii* and *Carex haydeniana*. Several of these species have been successful in previous alpine revegetation projects, however, and should not be discounted. Most of the subalpine moist meadow species listed above are recommended for revegetation in this area unless it is known to be extremely dry and rocky (Figure 11). Plants denoted as “dry” on the list are appropriate for such areas. Species labeled as “wet” or “late snow” are generally not recommended for general roadside revegetation.

A few non-native species were found along the alpine section of phase VIII, usually with low covers (Table 15). Care should be given to revegetate in a manner that reduces open area for weed species invasion. Glacier National Park has very little weed invasion in alpine areas, but it has been increasing in recent years, presumably due in part to construction activities.

Table 15 lists plant species found in the alpine section of the GTSR from Triple Arches to Logan Pass. The first approximately one mile of this stretch is bordered by a steep rock face to the east and a steep drop-off to the west and is largely unvegetated (Figure 11). Therefore revegetation efforts likely will not need to occur until just prior to (north of) Oberlin Bend.

Plants in blue text are recommended species for revegetation; they have done well in previous subalpine restoration projects. Species labeled as (dry) are present only in dry, stony, low vegetation areas and could be used on roadsides (Figure 11). Species labeled as (both) are present in subalpine turf and dry stony openings and could be used on roadsides. Species labeled as (wet or late snow) are present in moist seep areas or in late snowmelt areas and are typically not recommended for roadside revegetation. Species that have no label are present in common subalpine habitats and can be used on roadsides.

Figure 11. GTSR-Phase VIII: Big Bend to Logan Pass (alpine and lower elevation sections) planting zones

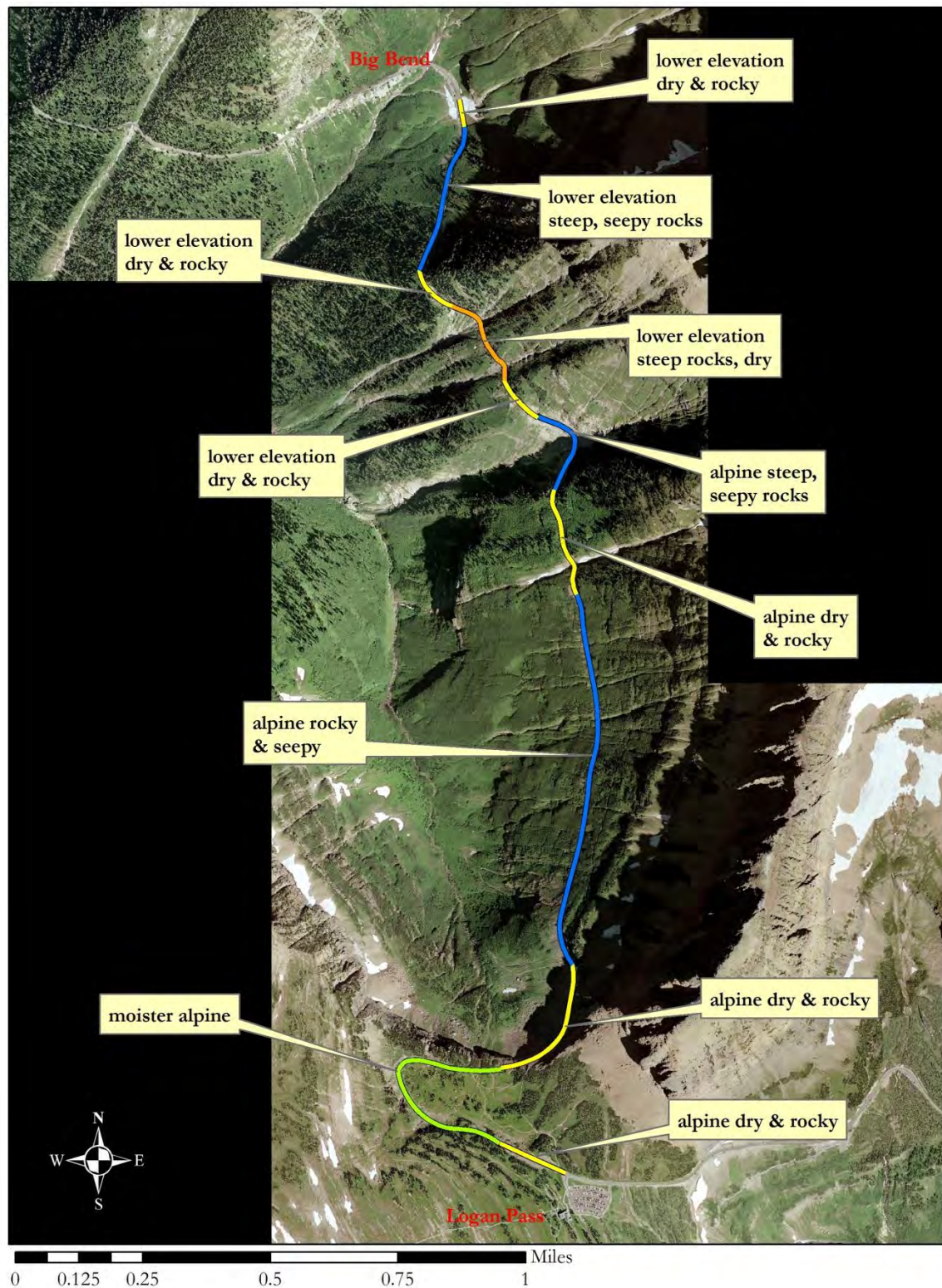


Table 15: GTSR-Phase VIII (Alpine Section - Triple Arches to Logan Pass): Species List (recommended species in blue)

TREE	SHRUB	NATIVE FORB	NATIVE FORB, con't
<i>Abies lasiocarpa</i>	<i>Alnus viridus</i> (wet)	<i>Achillea millefolium</i>	<i>Mimulus lewisii</i> (late snow or wet)
<i>Picea engelmannii</i>	<i>Cornus sericea</i> (wet)	<i>Agoseris aurantiaca</i>	<i>Mitella breweri</i>
<i>Populus balsamifera</i>	<i>Dasiphora floribunda</i>	<i>Allium cernuum</i> (dry)	<i>Osmorhiza</i> sp.
	<i>Lonicera involucrata</i>	<i>Allium schoenoprasum</i> (wet)	<i>Oxyria digyna</i>
	<i>Menziesia ferruginea</i>	<i>Anaphalis margaritacea</i> (dry)	<i>Parnassia fimbriata</i> (wet)
	<i>Phyllodoce glanduliflora/ empetriformis</i> (late snow)	<i>Anemone occidentalis</i>	<i>Pedicularis bracteosa</i>
	<i>Ribes lacustre</i>	<i>Antennaria alpina</i>	<i>Pedicularis contorta</i>
	<i>Rubus parviflorus</i>	<i>Antennaria umbrinella</i>	<i>Penstemon ellipticus</i> (dry)
	<i>Salix commutata</i>	<i>Arenaria capillaris</i>	<i>Penstemon hyallii</i> (dry)
	<i>Salix arctica</i> (late snow)	<i>Aquilegia flavescens</i> (wet)	<i>Phacelia hastata</i> (dry)
	<i>Salix vestita</i>	<i>Arnica diversifolia</i> (both)	<i>Phacelia hyallii</i> (dry)
	<i>Shepherdia canadensis</i>	<i>Arnica mollis</i> (both)	<i>Polemonium pulcherrimum</i>
	<i>Sorbus scopulina</i>	<i>Artemisia michauxiana</i> (dry)	<i>Potentilla divesifolia</i>
	<i>Vaccinium membranaceum</i>	<i>Astragalus bourgouvii</i>	<i>Ranunculus eschscholtzii</i> (late snow)
	<i>Vaccinium scoparium</i>	<i>Campanula rotundifolia</i> (dry)	<i>Ranunculus uncinatus</i>
		<i>Castilleja mineata</i> (both)	<i>Sagina saginoides</i>
		<i>Castilleja rhexifolia</i>	<i>Saxifraga hyallii</i>
		<i>Chamerion angustifolium</i> (both)	<i>Sedum lanceolatum</i>
		<i>Cirsium hookerianum</i> (dry)	<i>Senecio cymbalarioides</i> (late snow)
		<i>Epilobium anagallidifolium</i>	<i>Senecio triangularis</i> (both)
		<i>Erigeron caespitosus</i>	<i>Sibbaldia procumbens</i>
		<i>Erigeron compositus</i>	<i>Silene acaulis</i>
		<i>Erigeron speciosus</i> (both)	<i>Solidago canadensis</i>
		<i>Erigeron peregrinus</i> (both)	<i>Solidago multiradiata</i>
		<i>Fragaria virginiana</i>	<i>Symphyotrichum laeve</i>
		<i>Gaillardia aristata</i> (dry)	<i>Thalictrum occidentale</i>
		<i>Galium boreale</i> (dry)	<i>Valeriana sitchensis</i> (both)
		<i>Gentiana calycosa</i>	<i>Veratrum viride</i> (wetter)
		<i>Hedysarum sulphurescens</i>	<i>Veronica wormsleyi</i>
		<i>Heracleum sphondylium</i> (wetter)	<i>Xerophyllum tenax</i>
		<i>Heuchera cylindrica</i> (dry)	<i>Zigadenus elegans</i> (both)
		<i>Hypericum formosum</i>	

Table 15, con'd: GTSR-Phase VIII (Alpine Section - Triple Arches to Logan Pass): Species List (recommended species in blue)

NATIVE GRASS	EXOTIC FORB	EXOTIC GRASS
<i>Agrostis thurberiana</i>	<i>Medicago lupulina</i>	<i>Agrostis stolonifera</i>
<i>Bromus carinatus</i>	<i>Melilotus spp.</i>	<i>Poa annua</i>
<i>Carex haydeniana</i> (wetter)	<i>Rumex crispus</i>	<i>Poa compressa</i>
<i>Carex nigricans</i> (late snow)	<i>Taraxacum officinale</i>	
<i>Carex paysonis</i>	<i>Trifolium agrarium</i>	
<i>Carex phaeocephala</i>	<i>Trifolium repens</i>	
<i>Carex podocarpa</i> (wet)		
<i>Carex preslii</i>		
<i>Deschampsia atropurpurea</i> (late snow)		
<i>Elymus glaucus</i>		
<i>Elymus trachycaulus</i>		
<i>Juncus castaneus</i> (wet)		
<i>Juncus drummondii</i> (wet)		
<i>Luzula hitchcockii</i> (late snow)		
<i>Phleum alpinum</i>		
<i>Poa alpina</i>		
<i>Poa arctica</i>		
<i>Poa interior</i>		
<i>Poa glauca</i>		
<i>Poa secunda ssp. gracillima</i>		
<i>Poa stenantha</i>		
<i>Pseudoroegneria spicata</i> (dry)		
<i>Trisetum spicatum</i>		

3. PHASE VIII: Big Bend to Triple Arches (Lower Elevation Section)

Construction also took place in the lower elevation section of phase VIII this season with completion scheduled for the fall of 2011. Revegetation may occur on this section as soon as the fall of 2011 as well.

Once again, no tree species were recommended for this section of road due to height constraints. Three shrub species of relatively low stature are recommended, however, as long as this complies with roadside regulations. *Dasiphora floribunda*, *Rubus parviflorus* and *Symphoricarpos albus* were all present with relatively low covers and also lend themselves well to revegetation projects. Most species listed as “dry” or “both” on the recommended list (Table 16) should work well as roadside revegetation species. A few of the wetter species may be problematic in drier road edge regimes, especially *Angelica arguta*, *Heracleum sphondylium* and *Senecio triangularis*. Perhaps a wet-site seed prescription comprised of these three species as well as other species on the list with a designation of “wet”, “wetter” or “both” could be utilized in areas along the road with a moister regime.

Exotic species were more abundant along this lower elevation section of road. The lower elevation sections of road are likely more difficult to protect from invasive weeds and seed rates may need to be adjusted to exclude exotic species more readily.

Table 16 lists all species found in the survey of the lower elevation section of project phase VIII of the GTSR. Plants in blue text are recommended species for revegetation; they have done well in previous subalpine restoration projects. Species labeled as (dry) are present only in dry, stony, low vegetation areas and could be used on roadsides (Figure 11). Species labeled as (both) are present in subalpine turf and dry stony openings and could be used on roadsides. Species labeled as (wet or late snow) are present in moist seep areas or in late snowmelt areas and are typically not recommended for roadside revegetation. Species that have no label are present in common subalpine habitats and can be used on roadsides.

Table 16. GTSR-Phase VIII (Lower Elevation Section - Big Bend to Triple Arches): Species List and Abundance (recommended species in blue)
Abundance: L=low M=moderate H=high

TREE		SHRUB		NATIVE FORB		NATIVE GRASS	
<i>Abies lasiocarpa</i>	M	<i>Alnus viridus</i>	L/M	<i>Achillea millefolium</i>	L	<i>Bromus carinatus</i>	L/M
<i>Populus balsamifera</i>	L	<i>Dasiphora floribunda</i>	L	<i>Agoseris aurantiaca</i>	L	<i>Bromus pumpehianus</i>	L
<i>Populus tremuloides</i>	L	<i>Lonicera utabensis</i>	L	<i>Allium cernuum</i> (dry)	L	<i>Deschampsia caespitosa</i> (wetter)	L
<i>Pseudotsuga menziesii</i>	M	<i>Ribes lacustre</i>	L	<i>Allium schoenoprasum</i> (wet)	L	<i>Elymus smithii</i>	L
		<i>Rubus idaeus</i>	L	<i>Anaphalis margaritacea</i> (dry)	L/M	<i>Elymus glaucus</i>	L/M
		<i>Rubus parviflorus</i>	L/M	<i>Angelica arguta</i> (wetter)	L/M	<i>Elymus trachycaulus</i>	L/M
		<i>Sambucus racemosa</i>	L	<i>Aquilegia flavescens</i> (wet)	L	<i>Melica smithii</i> (wetter)	L
		<i>Sorbus scopulina</i>	L	<i>Arnica diversifolia</i> (both)	M	<i>Poa glauca</i>	L
		<i>Symphoricarpos albus</i>	L	<i>Artemisia michauxiana</i> (dry)	M	<i>Poa interior</i>	L
				<i>Campanula rotundifolia</i> (dry)	L	<i>Poa palustris</i>	L
				<i>Castilleja miniata</i> (both)	M/H	<i>Poa secunda</i>	L/M
				<i>Chamerion angustifolium</i> (both)	L/M	<i>Pseudoroegneria spicata</i> (dry)	M
				<i>Cheilanthes gracillima</i>	L	<i>Stipa nelsonii</i>	L
				<i>Cirsium bookerianum</i> (dry)	L	<i>Trisetum spicatum</i>	L
				<i>Cystopteris fragilis</i>	L		
				<i>Epilobium brachycarpum</i>	L		
				<i>Fragaria virginiana</i>	L/M		
				<i>Gaillardia aristata</i> (dry)	L/M		
				<i>Hedysarum sulphurescens</i> (dry)	L/M		
				<i>Heracleum sphondylium</i> (wetter)	L/M		
				<i>Heuchera cylindrica</i> (dry)	L		
				<i>Lomatium dissectum</i>	L		
				<i>Nothocalais cuspidata</i>	L		
				<i>Penstemon ellipticus</i>	L/M		
				<i>Penstemon hyalii</i> (dry)	M/H		
				<i>Phacelia hastata</i> (dry)	L		
				<i>Polygonum douglasii</i> ssp. <i>douglasii</i>	L		
				<i>Sedum lanceolatum</i>	L		
				<i>Senecio triangularis</i> (wetter)	M/H		
				<i>Solidago canadensis</i>	L/M		
				<i>Solidago multiradiata</i>	L		
				<i>Symphyotrichum laeve</i>	M/H		
				<i>Thalictrum occidentale</i>	L/M		
				<i>Veratrum viride</i>	L		
				<i>Viola canadensis</i>	L		
				<i>Viola glabella</i>	L		

Table 16, con'd. GTSR-Phase VIII (Lower Elevation Section - Big Bend to Triple Arches): Species List and Abundance. Abundance: L=low M=moderate H=high

EXOTIC FORB		EXOTIC GRASS	
<i>Melilotus officinale</i>	H	<i>Bromus inermis</i>	L
<i>Plantago major</i>	L	<i>Elymus repens</i>	L/M
<i>Rumex crispus</i>	L	<i>Phleum pratensis</i>	L/M
<i>Taraxacum officinale</i>	L	<i>Poa compressa</i>	L
<i>Trifolium hybridum</i>	L	<i>Poa pratensis</i>	L

4. Phase IX: Haystack Creek to Big Bend

Construction on this phase of the GTSR has not yet begun but it is scheduled to end in the fall of 2012. Revegetation may take place in the fall of 2012.

Surveys revealed that vegetation along phase IX does not change significantly in terms of plants adapted to specific elevation zones. Most species in this phase are most commonly found in the montane zone and thus there is no need for separate seed prescriptions for different elevations within this phase. There are wetter and drier sections within phase IX, however, and two seed prescriptions are recommended for revegetation of wet versus dry areas (Table 17; Figure 12).

If shrubs are desired in wet areas, some species listed on the species list that are not highlighted as recommended revegetation species may still be appropriate. *Alnus viridis* and *Salix bebbiana* are particularly adapted for wet areas. Again, if height restrictions are not in order, any listed shrub species would be appropriate for this road stretch with consideration given to moisture regime. The lower profile shrub species highlighted are more suitable in areas where woody material is appropriate but where height is a concern.

Most of the recommended species are known to be fairly successful roadside revegetation species and most are adapted to fairly dry conditions, common on roadsides (Table 17). The exceptions are *Heracleum sphondylium*, *Senecio triangularis*, *Carex mertensii* and *Calamagrostis canadensis* which tend to prefer wetter conditions. These species, together with any other suitable revegetation species on the list labeled as “wet”, “moist” or “wetter”, are recommended for a wet seed mix. This wet seed mix may not be required as the only true wet areas along this stretch of road occur near Big Bend at the Weeping Wall where restoration efforts may be minimal (Figure 12).

Weed species are consistent throughout this project phase and many exotic grasses have fairly substantial covers in areas. *Cirsium arvense*, a noxious weed, and *Melilotus officinalis* were also common. *Hypericum perforatum*, another noxious species, was less common but needs to be monitored as it becomes more common higher in elevation, especially along the GTSR.

Figure 12. GTSR-Phase IX: Haystack Creek to Big Bend planting zones

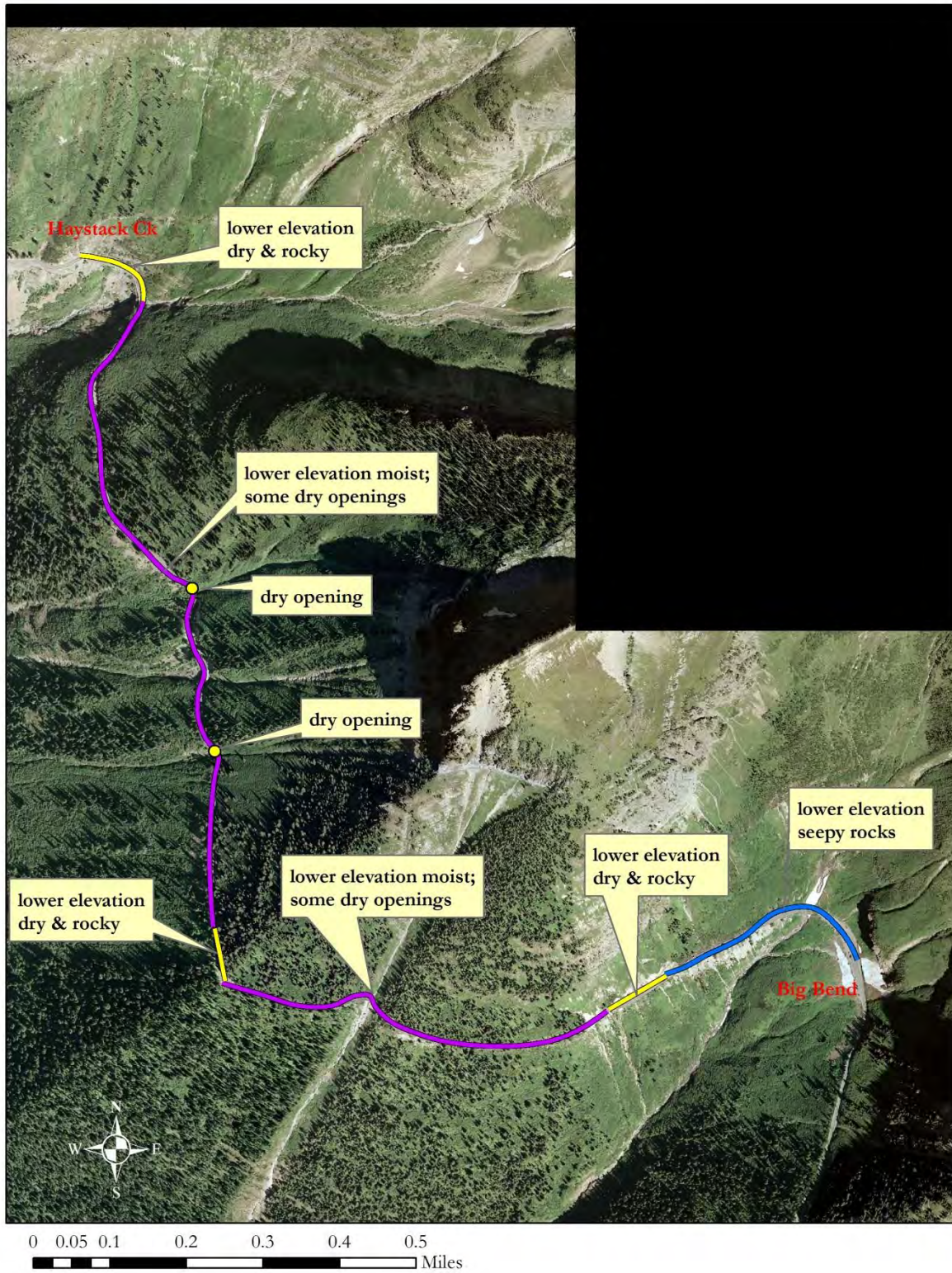


Table 17: GTSR Phase-IX (Haystack Creek to Big Bend): Species List and Abundance (recommended species in blue).

TREE		SHRUB		NATIVE FORB		NATIVE FORB, con'd	
<i>Abies lasiocarpa</i>	L	<i>Acer glabrum</i>	L	<i>Achillea millefolium</i>	L/M	<i>Geum macrophyllum</i>	L
<i>Picea engelmannii</i>	L	<i>Alnus viridus</i>	L	<i>Agoseris aurantiaca</i>	L	<i>Hackelia micrantha</i>	L
<i>Populus balsamifera</i>	M	<i>Amelanchier alnifolia</i>	L	<i>Allium cernuum</i> (dry)	L	<i>Hedysarum sulphurescens</i>	L
<i>Pseudotsuga menziesii</i>	L	<i>Dasiphora floribunda</i>	L/M	<i>Allium schoenoprasum</i> (wetter)	L/M	<i>Heracleum sphondylium</i> (wetter)	L/M
		<i>Lonicera utabensis</i>	L	<i>Anaphalis margaritaea</i> (dry)	L	<i>Heuchera cylindrica</i>	L
		<i>Paxistima myrsinites</i>	L	<i>Anemone multifida</i>	L	<i>Hypericum formosum</i>	L
		<i>Ribes inerme</i>	L	<i>Angelica arguta</i> (wetter)	L	<i>Lomatium dissectum</i> (dry)	L
		<i>Ribes lacustre</i>	L	<i>Aquilegia flavescens</i> (wetter)	L	<i>Oxyria digyna</i>	L
		<i>Rubus idaeus</i>	L	<i>Arnica diversifolia</i> (both)	M	<i>Parnassia fimbriata</i>	L
		<i>Rubus parviflora</i>	M	<i>Artemisia ludoviciana</i> (dry)	L/M	<i>Penstemon albertinus</i> (dry)	L
		<i>Salix bebbiana</i>	L	<i>Artemisia michauxiana</i> (dry)	L	<i>Penstemon lyallii</i> (dry)	H
		<i>Salix sp.</i>	L	<i>Athyrium filix-femina</i> (wetter)	L	<i>Phacelia hastata</i> (dry)	L
		<i>Sambucus racemosa</i>	L	<i>Balsamorhiza sagittata</i> (dry)	L	<i>Plantanthera dilatata</i> (wetter)	L
		<i>Shepherdia canadensis</i>	L	<i>Campanula rotundifolia</i> (dry)	L	<i>Polystichum lonchitis</i> (wetter)	L
		<i>Sorbus scopulina</i>	L	<i>Castilleja mineata</i> (both)	M	<i>Potentilla glandulosa</i>	L
		<i>Spiraea betulifolia</i> (lower)	L	<i>Chamerion angustifolium</i> (both)	L/M	<i>Sedum lanceolatum</i>	L
		<i>Spiraea densiflora</i> (higher)	L	<i>Circaea alpina</i> (wetter)	L	<i>Senecio pseudolaurens</i>	L
		<i>Symphoricarpos albus</i>	L	<i>Cirsium hookerianum</i> (dry)	L	<i>Senecio triangularis</i> (wetter)	M
				<i>Cystopteris fragilis</i>	L	<i>Solidago canadensis</i>	M/H
				<i>Epilobium anagallidifolium</i>	L	<i>Symphyotrichum laeve</i>	M/H
				<i>Epilobium bracycarpum</i>	L	<i>Thalictrum occidentale</i> (moist)	L
				<i>Equisetum arvense</i>	L	<i>Urtica dioica</i> (wetter)	L
				<i>Eurybia conspicua</i> (<i>Aster conspicuus</i>)	L	<i>Valeriana sitchensis</i> (both)	L/M
				<i>Fragaria vesca</i>	L	<i>Veratrum viride</i> (wetter)	L
				<i>Fragaria virginiana</i>	M	<i>Xerophyllum tenax</i>	L
				<i>Galium boreale</i>	L	<i>Zigadenus elegans</i> (both)	L
				<i>Galium triflorum</i>	L		

Abundance: L=low M=moderate H=high

Table 17, con'd: GTSR-Phase IX (Haystack Creek to Big Bend): Species List and Abundance (recommended species in blue).

Abundance: L=low M=moderate H=high

NATIVE GRASS		EXOTIC FORB		EXOTIC GRASS	
<i>Agrostis exarata</i>	L	<i>Cerastium fontanum</i>	L	<i>Agrostis stolonifera</i>	M
<i>Agrostis scabra</i>	L	<i>Cirsium arvense</i>	M	<i>Bromus inermis</i>	L
<i>Bromus carinatus</i>	L	<i>Cirsium vulgare</i>	L	<i>Dactylis glomerata</i>	L
<i>Calamagrostis canadensis</i> (wetter)	L	<i>Descurania sophia</i>	L	<i>Elymus repens</i>	L
<i>Carex deveyana</i>	L	<i>Hypericum perforatum</i>	L	<i>Phleum pratense</i>	M
<i>Carex flava</i> (wet)	L	<i>Lucentibemum vulgare</i>	L	<i>Poa compressa</i>	M
<i>Carex geyeri</i>	M	<i>Medicago lupulina</i>	L	<i>Poa pratensis</i>	M
<i>Carex lenticularis</i> (wet)	L	<i>Melilotus officinalis</i>	M		
<i>Carex mertensii</i> (wet)	L/M	<i>Plantago major</i>	L		
<i>Carex preslii</i>	M	<i>Prunella vulgaris</i>	L		
<i>Carex scirpoidea</i> (moist)	L	<i>Rumex crispus</i>	L		
<i>Elymus glaucus</i>	L/M	<i>Taraxacum officinale</i>	L		
<i>Elymus trachycaulus</i>	L/M	<i>Tragopogon dubius</i>	L		
<i>Glyceria elata</i> (wet)	L	<i>Verbascum thapsus</i>	L		
<i>Juncus ensifolius</i>	L				
<i>Phleum alpinum</i>	L				
<i>Poa alpina</i>	L				
<i>Poa glauca</i>	L				
<i>Poa interior</i>	L				
<i>Poa palustris</i>	L				
<i>Poa secunda</i>	L				
<i>Pseudoroegneria spicata</i> (dry)	L				
<i>Stipa nelsonii</i>	L				
<i>Trisetum spicatum</i>	L				

5. Phase XI: Logan Pass to Siyeh Bend

Phase XI was under construction during the field season of 2010 and is scheduled to be completed in August of 2011. It will be ready for revegetation in the fall of 2011.

This section of road encompasses mostly alpine and subalpine species. The 2010 survey, in combination with previous site analyses done by Vanderbilt and Potter in 1993, provided for a comprehensive species list (Table 18). Although there are several species of tree and taller shrub along this stretch, they are not recommended for revegetation due to height.

Shorter shrub species may be appropriate for this area, depending on revegetation strategy, and several have been recommended (Table 18). A wide variety of native forb and grass species were observed along this road corridor with many species suitable for revegetation.

As in phase VIII, several species found in this area are specialized to grow in late snow-melt microhabitats. Generally, these are not recommended for roadside revegetation unless a very specific habitat was to be recreated. Several other species are designated as preferring “wet” habitats. These species would be appropriate to mix together into a seed prescription for wetter areas along the roadside (Figure 13).

Weed species were not present with high cover in this area, although several species were found along this corridor. Once again, care should be taken to seed at appropriate rates to exclude exotic species as well as possible.

Table 18 lists all species found in the survey of project phase XI of the GTSR. Plants in italics are species present from previous (1993) surveys in the Oberlin Bend and Logan Pass area. Plants in blue text are recommended species for revegetation; they have done well in previous subalpine restoration projects. Species labeled as “dry” are present only in dry stony, low vegetation areas and could be used on roadsides (Figure 13). Species labeled as “both” are present in subalpine turf and dry stony openings and could be used on roadsides. Species labeled as “moist”, “wet” or “late snow” are present in moist seep areas or in late snowmelt areas and are typically not recommended for roadside revegetation. Species that have no label are present in common subalpine habitats and can be used on roadsides.

Figure 13. GTSR Phase XI: Logan Pass to Siyeh Bend planting zones

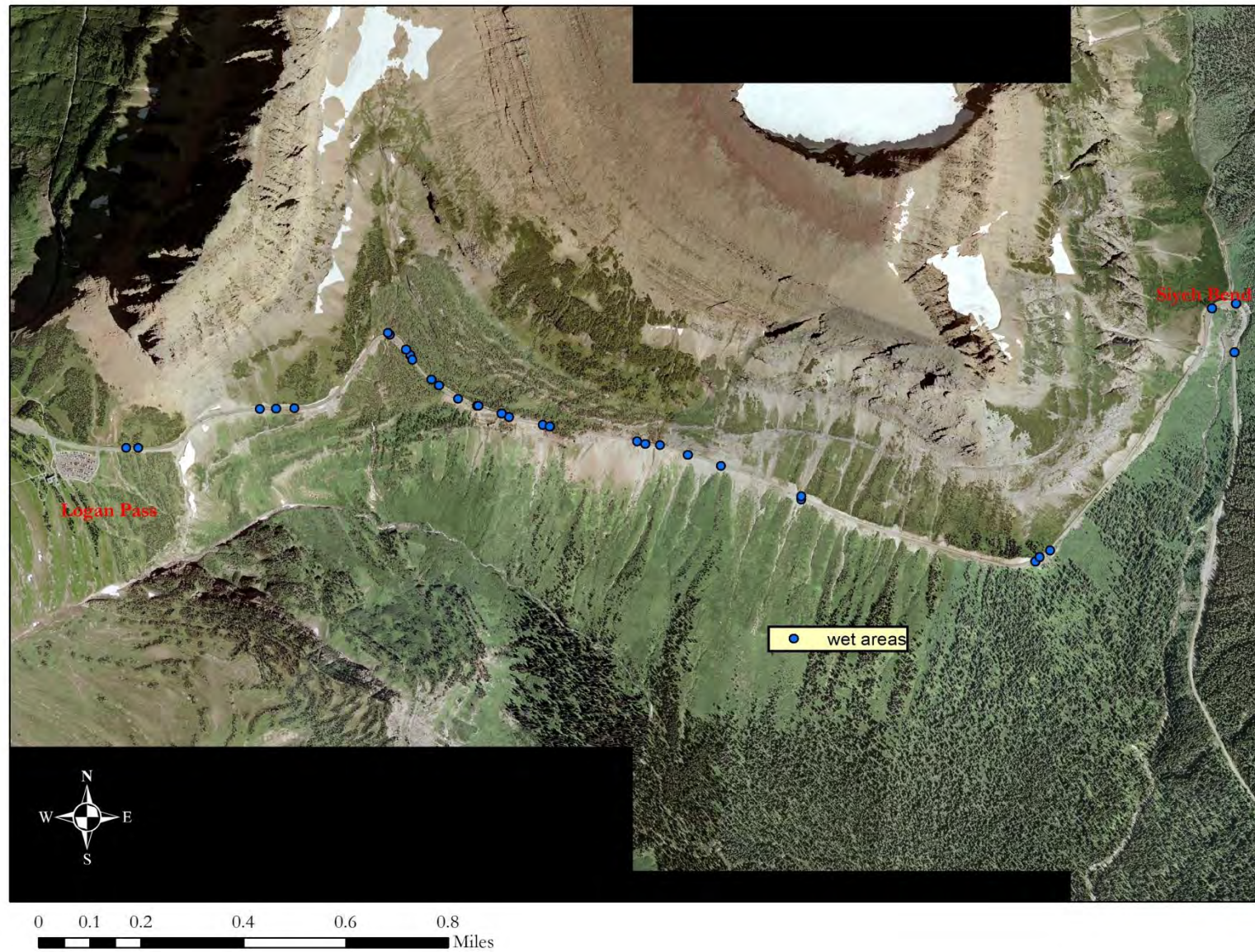


Table 18. GTSR-Phase XI (Logan Pass to Siyeh Bend): Species List and Abundance (recommended species in blue; plants from 1993 survey in *italics*).
Abundance: L=low M=moderate H=high

TREE		SHRUB		NATIVE FORB		NATIVE FORB, con't	
Abies lasiocarpa	L	Alnus viridus	L	Achillea millefolium	M	Mitella pentandra	L
Picea engelmannii	L	Dasiphora floribunda	M	Allium cernuum	L/M	Oxyria digyna	L
Pinus albicaulis	L	Juniper communis	L	Allium schoenoprasum (wet)	L	Pedicularis bracteosa	L
Populus balsamifera	L	Lonicera involucrata	L	Anaphalis margaritacea	L	Pedicularis contorta	L
		<i>Menziesia ferruginea</i>		<i>Anemone occidentalis</i> (moist)	L	Pedicularis groenlandica	L
		<i>Phyllodoce empetriformis</i> (late snow)		<i>Anemone tetonensis</i>	L	Penstemon albertinus	L/M
		<i>Phyllodoce glanduliflora</i> (late snow)		<i>Angelica arguta</i> (wet)	L	Penstemon confertus	L
		Ribes lacustre	L	Antennaria alpina	L	Penstemon ellipticus	M/H
		Ribes inerme	L	Antennaria umbrinella	L	Penstemon lyallii (dry)	L
		Rubus idaeus	L	<i>Antennaria rosea</i>	L	Phacelia hastata (dry)	L
		Rubus parviflorus	M	<i>Arenaria capillaris</i>		Phacelia lyallii (dry)	L
		Spiraea betulifolia	L	<i>Astragalus bourgouvi</i>		Phacelia sericea	L
		Salix arctica	L	Aquilegia flavescens (wet)	L	Polemonium pulcherrimum	L
		Salix bebbiana	L	Arabis nuttallii	L	Potentilla glandulosa	L
		Salix sitchensis	L	Arnica diversifolia	L/M	Potentilla diversifolia	L
		Sambus racemosa	L	<i>Arnica mollis</i>	L	Potentilla gracilis	L
		Sorbus scopulina	L	<i>Artemisia michauxiana</i> (dry)	L	<i>Ranunculus uncinatus</i>	
		Sorbus sitchensis	L	Botrychium lunaria	L	<i>Ranunculus eschscholtzii</i> (late snow)	?
		<i>Vaccinium membranaceum</i>		Calochortus apiculatus	L	<i>Sagina saginoides</i>	
		<i>Vaccinium scoparium</i>		Castilleja mineata/rhexifolia	L/M	Sedum lanceolatum	L
				Chamerion angustifolium	L/M	Sedum roseum	L
				Clematis occidentalis	L	Senecio canus	L
				Cirsium hookerianum	L	Senecio cymbalaria	
				Equisetum arvense	L	Senecio megacephalus (dry)	L
				Epilobium anagallidifolium	L	Senecio triangularis (moist)	L/M
				Erigeron compositus	L	Sibbaldia procumbens	L
				Erigeron peregrinus	L	Silene acaulis	L
				Eriogonum umbellatum	L	<i>Solidago multiradiata</i>	
				Erythronium glandiflora (late snow)	L	Symphyotrichum laeve	M/H
				Fragaria virginiana	M	Thalictrum occidentale	L
				Galium boreale	L	Tofieldia occidentalis	L
				Gentianella amarella	L	Trollius laxus (wet)	L
				<i>Gentiana calycosa</i> (late snow)		Urtica dioica (wet)	L
				Hackelia micrantha	L	Valeriana sitchensis	L
				Hedysarum sulphurescens	L	Veratrum viride	L
				<i>Heracleum sphondylium</i> (moist)	M	Veronica wormskjoldii	L
				Hypericum formosum	L	Viola adunca	L
				Heuchera cylindrica	L	Viola glabella	L
				Linum lewisii	L	Xerophyllum tenax	L
				Lomatium dissectum	L	Zigadenus elegans	L
				<i>Mimulus lewisii</i> (wet)		Zigadenus venenosus	L

Table 18, con't. GTSR-Phase XI (Logan Pass to Siyeh Bend): Species List and Abundance

NATIVE GRASS		EXOTIC FORB		EXOTIC GRASS	
<i>Agrostis thurberiana</i>		<i>Leucanthemum vulgare</i>	L	<i>Agrostis stolonifera</i>	L
<i>Bromus carinatus</i>		<i>Rumex crispus</i>	L	<i>Bromus inermis</i>	L
<i>Carex geyeri</i>	L	<i>Taraxacum officinale</i>	L/M	<i>Dactylis glomerata</i>	L
<i>Carex haydeniana</i>	L	<i>Linaria vulgaris</i>	L	<i>Phleum pratense</i>	L
<i>Carex hoodii</i>		<i>Medicago lupulina</i>		<i>Poa annua</i>	
<i>Carex nigricans</i> (late snow)		<i>Melilotus spp.</i>		<i>Poa compressa</i>	L
<i>Carex paysonis</i>		<i>Rumex crispus</i>		<i>Poa pratensis</i>	L
<i>Carex phaeocephala</i>	L	<i>Taraxacum officinale</i>			
<i>Carex rossii</i>	L	<i>Trifolium agrarium</i>			
<i>Deschampsia atropurpurea</i> (late snow)		<i>Trifolium repens</i>			
<i>Elymus glaucus</i>	L				
<i>Elymus trachycaulus</i>	H				
<i>Festuca idahoensis</i> (lower)	L				
<i>Festuca saximontana</i>	L				
<i>Juncus drummondii</i> (wet)					
<i>Luzula hitchcockii</i> (late snow)					
<i>Phleum alpinum</i>	L				
<i>Poa alpina</i>	L				
<i>Poa glauca</i>	L				
<i>Poa interior</i>	L				
<i>Poa secunda</i> ssp. <i>gracillima</i>	L/M				
<i>Trisetum spicatum</i>	L				

6. Phase XII: Siyeh Bend to Rising Sun

Phase XII is not scheduled for construction until after 2012. The 2010 survey of this phase was completed to begin development of a future seed collection list. Since this is a long section of road, spanning an elevational gradient, four separate plant lists have been created. Although phase XII spans over nine miles, only the upper (western-most) 0.65 miles contains subalpine vegetation. Below the end of Siyeh Bend, where the road turns to the southeast, vegetation is relatively constant. Both the upper and lower elevation segments of this phase are comprised of wetter and drier areas and therefore two species lists have been created for each elevational segment (Tables 19-22; Figure 14).

The upper segment of road is contained within the hairpin section known as Siyeh Bend. Within this segment, mostly along the eastern road edge, seep areas are prolific. These areas may be difficult to revegetate as many of the species that grow in seep areas are delicate and difficult to grow. If seep areas require revegetation, then plants on the higher elevation wet species list labeled “wet” or “wetter” would be most appropriate to seed or plant, depending on feasibility (Table 19). Seep areas tend to be moss-dominated and consist of low-growing plants. Most of the plants labeled as “wet” or “wetter” are taller-growing, so this should be kept in mind if it is desired to maintain the character of these mossy seeps. Many species on the higher elevation wet list were located along the road edge and are appropriate for drier conditions. *Achillea millefolium*, *Hedysarum sulphurescens*, *Symphytotrichum laeve*, *Elymus trachycaulus*, *Poa alpina* and *Trisetum spicatum* as well as most weed species were primarily found on road edges. Any native species not labeled as “wet” or “wetter” would be appropriate for revegetating road edges. Most of the western edge of the upper road segment consists of drier conditions and the dry species list should be consulted for this area (Table 20).

The lower elevation section of phase XII consists of a mix of dry and wetter areas (Figure 14). Much of the lower elevation section is composed of a diverse mix of mesic species, many of which are adapted to wetter conditions (Table 21). Dry areas are less abundant along the lower section of phase XII but species composition is different enough to warrant a separate species list (Table 22). If possible, two separate seed prescriptions are recommended for the lower elevation stretch for wetter and drier areas.

It should be noted that several species found in the wetter sections actually prefer drier conditions. These plants are labeled with “dry” following the species name. *Juniperus communis*, *Prunus virginiana*, *Anaphalis margaritacea*, *Penstemon hyalli*, and *Elymus trachycaulus* are particularly suited for drier conditions. Other species are found in wetter conditions. *Angelica arguta*, *Aquilegia flavescens*, *Equisetum hyemale*, *Heracleum sphondylium*, *Juncus ensifolius*, *Juncus alpinoarticulatus*, *Carex mertensii* and *Calamagrostis canadensis* are adapted for fairly wet regimes and may not be suitable roadside revegetation species. However, many of these would be good candidates for a wet mix, if needed. The remaining species on the wetter species list are adapted for mesic, or intermediate, soil conditions.

Almost all species from the lower elevation drier list would be suitable for roadside habitats, although not all have been proven to be successful revegetation species. A few species have been recommended that have not previously been widely used for revegetation. *Carex geyeri* (elk sedge) is a common species in this area that would provide good cover with a relatively low growth-form. Given that roadside areas are typically mowed, low-profile species are advantageous. Elk sedge may prove to be a challenging species from which to collect abundant seed as it produces few (1-3) perigynia per spike and the seed heads disappear rapidly after production. It does provide significant cover in areas, however, and would provide a good transition to surrounding native vegetation.

Lower elevation areas along phase XII contained a high diversity and abundance of weed species. It is recommended to seed at a fairly high rate in these areas to outcompete any non-native seed sources that persist in the seed bank or drift in from surrounding areas. Weed control prior to revegetation may also be necessary.

Figure 14. GTSR Phase XII: Siyeh Bend to Rising Sun planting zones

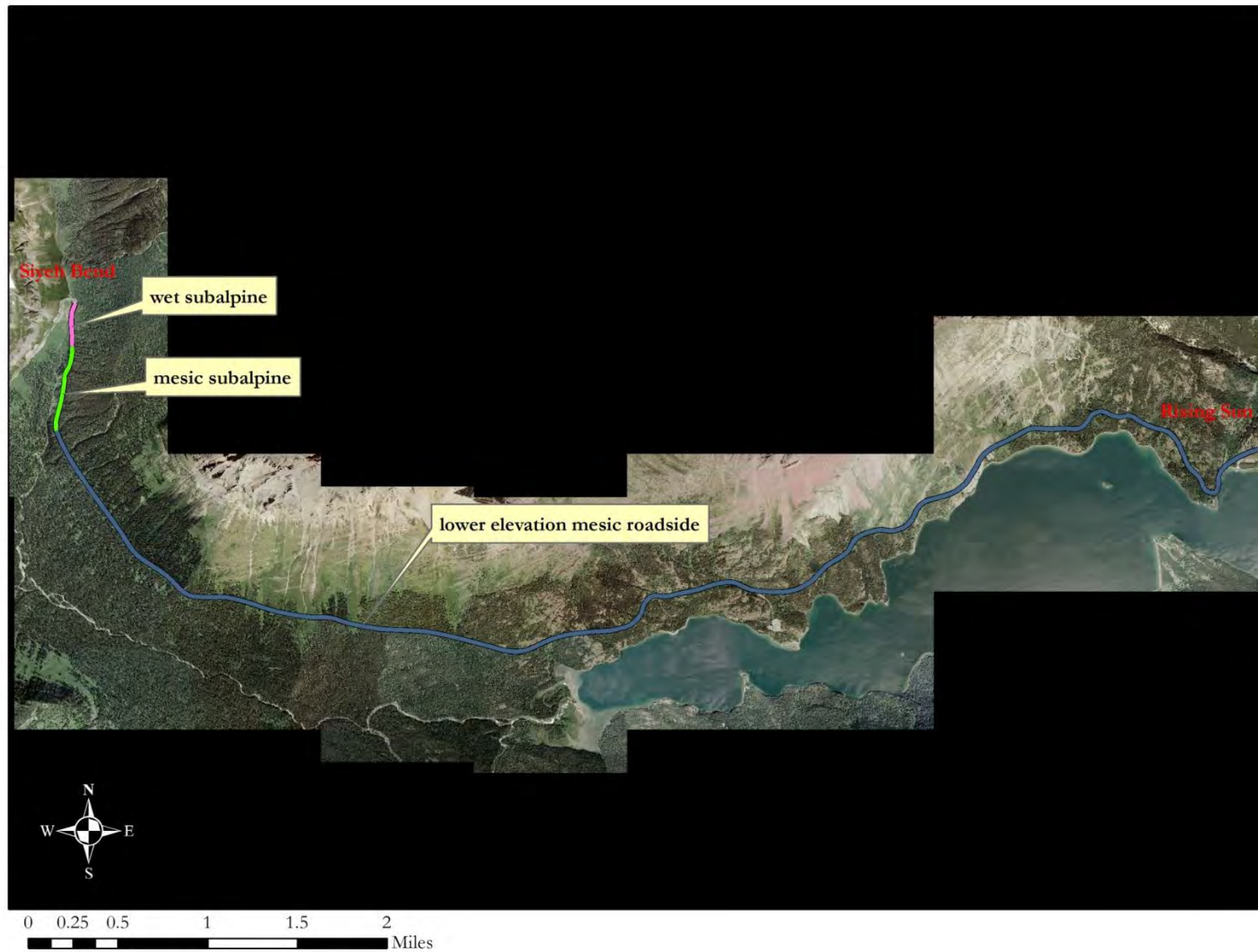


Table 19. GTSR-Phase XII (Siyeh Bend High Elevation Wetter Areas): Species List and Abundance (recommended species in blue).

TREE	SHRUB	NATIVE FORB	NATIVE GRASS	EXOTIC FORB	EXOTIC GRASS
<i>Picea engelmannii</i>	<i>Dasiphora floribunda</i>	<i>Achillea millefolium</i>	<i>Agrostis scabra</i>	<i>Plantago major</i>	<i>Agrostis stolonifera</i>
	<i>Salix commutata</i> (wet)	<i>Arnica mollis</i>	<i>Calamagrostis canadensis</i> (wetter)	<i>Taraxacum officinale</i>	<i>Bromus inermis</i>
	<i>Salix sitchensis</i> (wet)	<i>Castilleja mineata</i>	<i>Carex mertensii</i> (wet)		<i>Poa compressa</i>
		<i>Equisetum arvense</i>	<i>Elymus trachycaulus</i>		
		<i>Hedysarum sulphurescens</i>	<i>Juncus alpinoarticulatus</i> (wet)		
		<i>Parnassia fimbriata</i> (wet)	<i>Juncus ensifolius</i> (wet)		
		<i>Penstemon ellipticus</i>	<i>Poa alpina</i>		
		<i>Rhinanthus crista-galli</i>	<i>Trisetum spicatum</i>		
		<i>Senecio pseudoreus</i>			
		<i>Senecio traingularis</i> (wetter)			
		<i>Symphotrichum laeve</i>			

Table 20. GTSR-Phase XII (Siyeh Bend High Elevation Dry Road Edge Areas): Species List and Abundance (recommended species in blue).

SHRUB	NATIVE FORB	NATIVE GRASS	EXOTIC FORB	EXOTIC GRASS
<i>Dasiphora floribunda</i>	<i>Achillea millefolium</i>	<i>Agrostis scabra</i>	<i>Chrysanthemum leucanthemum</i>	<i>Bromus inermis</i>
	<i>Anaphalis margaritacea</i>	<i>Elymus glaucus</i>	<i>Plantago lanceolata</i>	<i>Poa compressa</i>
	<i>Arnica mollis</i>	<i>Elymus trachycaulus</i>	<i>Plantago major</i>	
	<i>Chamerion angustifolium</i>	<i>Phleum alpinum</i>	<i>Prunella vulgaris</i>	
	<i>Erigeron compositus</i>	<i>Poa alpina</i>	<i>Taraxacum officinale</i>	
	<i>Gentiana amarella</i>	<i>Poa interior</i>	<i>Trifolium hybridum</i>	
	<i>Penstemon ellipticus</i>	<i>Trisetum spicatum</i>		
	<i>Penstemon lyallii</i>			
	<i>Phacelia hastata</i>			
	<i>Polemonium pulcherrimum</i>			
	<i>Symphotrichum laeve</i>			

Table 21. GTSR-Phase XII (Lower Elevation Mesic Road Areas): Species List and Abundance (recommended species in blue).

TREE	SHRUB	NATIVE FORB	NATIVE FORB, con'd	NATIVE GRASS	EXOTIC FORB	EXOTIC GRASS
<i>Populus balsamifera</i>	<i>Symphoricarpos albus</i>	<i>Achillea millefolium</i>	<i>Iliamna rivularis</i>	<i>Juncus ensifolius</i> (wet)	<i>Taraxacum officinale</i>	<i>Poa compressa</i>
	<i>Ribes lacustre</i>	<i>Anaphalis margaritacea</i> (dry)	<i>Lomatium triternatum</i>	<i>Juncus alpinoarticulatus</i> (wet)	<i>Plantago major</i>	<i>Agrostis stolonifera</i>
	<i>Arctostaphylos uva-ursi</i>	<i>Angelica arguta</i> (wetter)	<i>Maianthemum racemosum</i>	<i>Carex mertensii</i> (wet)		<i>Bromus inermis</i>
	<i>Acer glabrum</i>	<i>Antennaria</i> sp.	<i>Maianthemum stellatum</i>	<i>Elymus trachycaulus</i> (dry)		
	<i>Ribes inerme</i>	<i>Aquilegia flavescens</i> (wetter)	<i>Osmorhiza berteroi</i>	<i>Poa alpina</i>		
	<i>Spiraea betulifolia</i>	<i>Arnica cordifolia</i>	<i>Oxytropis borealis</i>	<i>Agrostis scabra</i>		
	<i>Rubus parviflorus</i>	<i>Astragalus americanus</i>	<i>Oxytropis campestris</i>	<i>Trisetum spicatum</i>		
	<i>Sorbus scopulina</i>	<i>Athyrium filix-femina</i> (moist)	<i>Pedicularis bracteosa</i>	<i>Calamagrostis canadensis</i> (wetter)		
	<i>Alnus incana</i>	<i>Campanula rotundifolia</i>	<i>Penstemon confertus</i>			
	<i>Cornus sericea</i>	<i>Cerastium arvense</i>	<i>Penstemon hyalli</i> (dry)			
	<i>Paxistima myrsinites</i>	<i>Chamerion angustifolium</i>	<i>Platanthera</i> sp.			
	<i>Juniperus communis</i> (dry)	<i>Cirsium bookerianum</i>	<i>Polemonium pulcherrimum</i>			
	<i>Prunus virginiana</i>	<i>Cryptogramma acrostichoides</i>	<i>Potentilla arguta</i>			
	<i>Rosa woodsii</i>	<i>Cystopteris fragilis</i>	<i>Potentilla gracilis</i>			
	<i>Sambucus racemosa</i>	<i>Equisetum arvense</i> (moist)	<i>Pteridium aquilinum</i>			
	<i>Shepherdia canadensis</i>	<i>Equisetum hymale</i> (wetter)	<i>Pyrola asarifolia</i>			
		<i>Eurybia conspicua</i> (<i>Aster conspicuus</i>)	<i>Senecio pseudolaureus</i>			
		<i>Fragaria virginiana</i>	<i>Solidago canadensis</i>			
		<i>Galium boreale</i>	<i>Symphyotrichum foliaceum</i> v. <i>foliaceum</i> (<i>A. foliaceus</i>)			
		<i>Galium triflorum</i>	<i>Symphyotrichum laeve</i> (<i>Aster laevis</i>)			
		<i>Gentiana amarella</i>	<i>Thalictrum occidentale</i>			
		<i>Geum macrophyllum</i>	<i>Urtica dioica</i> (wet)			
		<i>Heracleum sphondylium</i> (wetter)	<i>Viola canadensis</i> / <i>Viola glabella</i>			
		<i>Heuchera cylindrica</i>	<i>Xerophyllum tenax</i>			

Table 22. GTSR-Phase XII (Lower Elevation Dry Areas): Species List and Abundance (recommended species in blue).

SHRUB	NATIVE FORB	NATIVE FORB, con'd	NATIVE GRASS	EXOTIC FORB	EXOTIC GRASS
<i>Acer glabrum</i>	<i>Achillea millefolium</i>	<i>Lomatium disjunctum</i>	<i>Achnatherum nelsonii (Stipa nelsonii)</i>	<i>Alyssum alyssoides</i>	<i>Agropyron cristatum</i>
<i>Amelanchier alnifolia</i>	<i>Agoseris glauca</i>	<i>Lomatium triternatum</i>	<i>Bromus carinatus</i>	<i>Arenaria serpyllifolia</i>	<i>Agrostis stolonifera</i>
<i>Arctostaphylos uva-ursi</i>	<i>Allium cernuum</i>	<i>Lupinus sericea</i>	<i>Carex athrostachya</i>	<i>Centaurea maculosa</i>	<i>Bromus inermis</i>
<i>Ceanothus velutinus</i>	<i>Anaphalis margaritaea</i>	<i>Maianthemum racemosum</i>	<i>Carex geyeri</i>	<i>Erodium cicutarium</i>	<i>Bromus tectorum</i>
<i>Cornus sericea</i>	<i>Aneome multifida</i>	<i>Maianthemum stellatum</i>	<i>Carex pachystachya</i>	<i>Linaria vulgaris</i>	<i>Dactylis glomerata</i>
<i>Dasiphora floribunda</i>	<i>Antennaria howellii</i>	<i>Microsteris gracilis</i>	<i>Danthonia intermedia</i>	<i>Medicago lupulina</i>	<i>Elymus repens</i>
<i>Holodiscus discolor</i>	<i>Antennaria rosea</i>	<i>Monarda fistulosa</i>	<i>Elymus glaucus</i>	<i>Melilotus alba</i>	<i>Phleum pratense</i>
<i>Juniperus communis</i>	<i>Apocynum androsaemifolium</i>	<i>Osmorhiza berteroi</i>	<i>Elymus trachycaulus</i>	<i>Melilotus officinale</i>	<i>Poa compressa</i>
<i>Mabonia repens</i>	<i>Artemisia ludoviciana</i>	<i>Oxytropis</i> sp.	<i>Festuca idahoensis</i>	<i>Prunella vulgaris</i>	<i>Poa pratensis</i>
<i>Paxistima myrsinites</i>	<i>Artemisia michauxiana</i>	<i>Packera cana (Senecio canus)</i>	<i>Poa palustris</i>	<i>Rumex crispus</i>	
<i>Prunus virginiana</i>	<i>Astragalus</i> sp.	<i>Penstemon albertinus</i>	<i>Pseudoroegneria spicata</i>	<i>Silene latifolia</i>	
<i>Ribes lacustre</i>	<i>Campanula rotundifolia</i>	<i>Penstemon confertus</i>		<i>Taraxacum officinale</i>	
<i>Rosa woodsii</i>	<i>Castilleja mineata</i>	<i>Penstemon hyalli</i>		<i>Tragopogon dubius</i>	
<i>Rubus idaeus</i>	<i>Cerastium arvense</i>	<i>Phacelia hastata</i>		<i>Verbascum thapsis</i>	
<i>Rubus parviflorus</i>	<i>Chamerion angustifolium</i>	<i>Platanthera</i> sp.			
<i>Shepherdia canadensis</i>	<i>Collomia linearis</i>	<i>Polemonium pulcherrimum</i>			
<i>Spiraea betulifolia</i>	<i>Epilobium brachycarpum</i>	<i>Polygonum douglasii</i> ssp. <i>douglasii</i>			
<i>Symphoricarpos albus</i>	<i>Erigeron compositus</i>	<i>Potentilla arguta</i>			
	<i>Erigeron speciosus</i>	<i>Potentilla gracilis</i>			
	<i>Eriogonum umbellatum</i>	<i>Potentilla hippiana</i>			
	<i>Eurybia conspicua (Aster conspicuus)</i>	<i>Saxifraga bronchialis</i>			
	<i>Fragaria virginiana</i>	<i>Sedum lanceolatum</i>			
	<i>Gaillardia aristata</i>	<i>Senecio pseudolaureus</i>			
	<i>Galium boreale</i>	<i>Solidago canadensis</i>			
	<i>Geranium viscosissimum</i>	<i>Symphyotrichum campestre (Aster campestriis)</i>			
	<i>Geum triflorum (upslope from road)</i>	<i>Symphyotrichum foliaceum</i> var. <i>foliaceum (A. foliacens)</i>			
	<i>Goodyera oblongifolia</i>	<i>Symphyotrichum laeve (Aster laevis)</i>			
	<i>Hedysarum sulphureum</i>	<i>Thalictrum occidentale</i>			
	<i>Heterotheca villosa (above road)</i>	<i>Viola adunca</i>			
	<i>Heuchera cylindrica</i>	<i>Woodsia</i> sp.			
	<i>Lithospermum ruderae</i>				

V. WEST ENTRANCE STATION

A. BACKGROUND AND PURPOSE

The West Entrance Station is the primary entrance to Glacier National Park from the west side and receives heavy use during the summer months. The existing entrance station and approach lanes are often insufficient to handle traffic volumes during peak summer months, which often causes lengthy vehicle backups. Construction of the Going-to-the-Sun Road, which is an on-going 10-year project, brings increased vehicular traffic through the entrance, further contributing to congestion at the entrance.

In the fall of 2008, a new approach lane was added to the West Entrance Station, starting at the Headquarters turn-off and continuing to the east of the existing road. An expedited entrance lane for employees and concessionaires was added in an attempt to expedite traffic flow. Additional developments in the area include enhancing the utility line to the station and replacing the existing vault toilet with an accessible restroom, storage, and break room for entrance station staff. Disturbance to native vegetation spanned approximately 20-30 feet out from the pre-existing asphalt. A 2007 survey revealed that this area contained a *Pinus contorta* / *Clintonia uniflora*-*Xerophyllum tenax* Forest (lodgepole pine/queencup beadlily –beargrass), *Larix occidentalis* / *Vaccinium membranaceum* / *Xerophyllum tenax* Forest (Western larch/black huckleberry/beargrass), and a *Pseudotsuga menziesii* / *Calamagrostis rubescens* Forest (Douglas-fir/pinegrass).

In the spring of 2008, prior to construction, the revegetation crew salvaged plants from the disturbance corridor and stored them in containers in the nursery over the summer, where they were watered and cared for. Since the construction area contained a Montana Natural Heritage Program Species of Concern, *Vaccinium myrtilloides* (Velvetleaf Blueberry; G5, S1), this species was specifically targeted for salvage. Numerous other native plants were also extracted from the disturbance corridor and stored, including difficult to grow species such as black huckleberry (*Vaccinium membranaceum*), dwarf huckleberry (*Vaccinium caespitosum*) and grouse whortleberry (*Vaccinium scoparium*). Individual plants were mostly salvaged, but some mats of vegetation containing several species of vascular plants and mosses were extracted as well. Salvaged material was planted in the disturbance area adjacent to the entrance station in the fall of 2008. This area was also hand seeded after planting (see Table 24 for seed prescription). Additionally, the disturbed road corridor south of the planting site was mechanically hydroseeded in the fall of 2008.

In 2009, an employee room and restroom were constructed on the west side of the entrance station, on the opposite side of the road from the monitoring plots. During construction, the exit lane was closed. To accommodate incoming and outgoing traffic, much of which consisted of large construction vehicles, a new bypass lane needed to be temporarily created. The bypass lane needed to be tall enough for construction vehicles, and thus could not utilize existing lanes with an overhead restriction. This new lane traversed some of the 2008 revegetation area. Plant material was subsequently salvaged again from this area, including many *Vaccinium myrtilloides* shrubs included in monitoring plots.

B. METHODS

Two salvage monitoring plots were installed in October 2008 and two hydroseed monitoring plots were installed in September 2009 (Figure 15). Plots of different sizes were installed to encompass most of the planted material in this narrow road corridor. Of the salvage monitoring plots, plot 1 measured 2m x 12m and plot 2 measured 3m x 17m. Of the hydroseed plots, plot 1 measured 2m x 12m and plot 2 measured 4m x 12m. GPS points were recorded at the upper left and lower right corners of each plot and permanent plot markers (12" nails) were placed at all four corners of each salvage plot and in the upper left and lower right corners of the hydroseeded plots.

Level II monitoring for revegetation plots included ocular estimates of canopy cover for all native and exotic species within the plot, as well as estimates of ground cover. Photographs were taken of each plot at each monitoring event. All *Vaccinium myrtilloides* plants in each salvage plot were flagged with a pin flag and tagged with a pre-numbered metal tag, so that survival of individual plants could be monitored. Tags were slightly buried in the soil so as to be less visible in this high traffic area. Additionally, three photomonitoring sites were established in 2009 to document progress of hydroseeding throughout the project (Table 23).

In August 2010, the two salvage monitoring plots were monitored, two years after planting and seeding. The two hydroseed plots were read in September 2010, two years after seeding. Ocular covers of all species in all plots were recorded (Tables 26 and 27). Originally, special note was taken to determine if plant material was salvaged or naturally occurring to assess the success of each in the salvage plots. However, by 2010, it was difficult to impossible to distinguish the origin of many of the plants, and thus categories were often merged. *Vaccinium myrtilloides* in the salvage plots were assessed for health, and height and width were measured. Photomonitoring took place in September 2010.

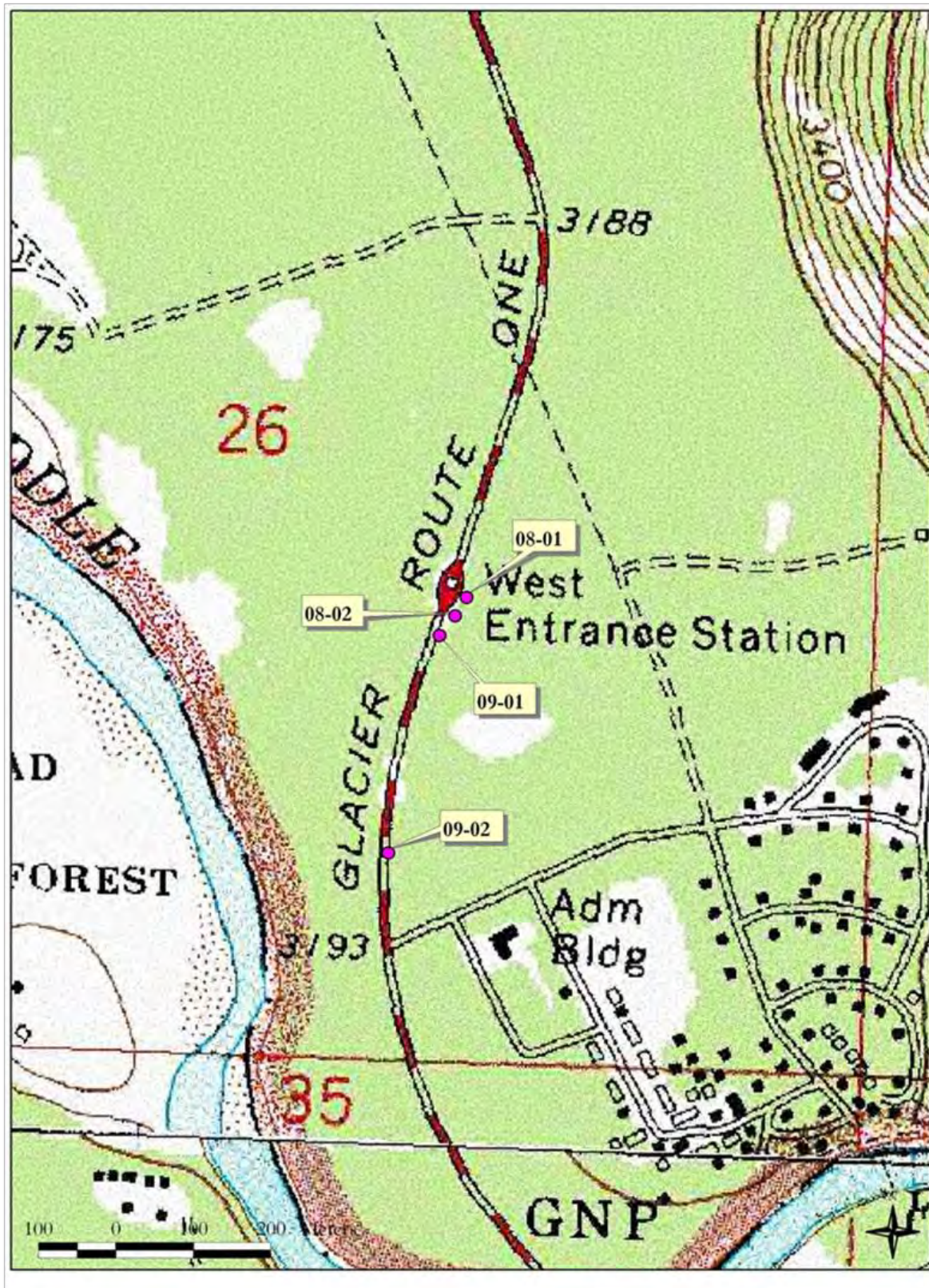
Table 23. West Entrance Station: Photomonitoring Sites.

Site #	Photo	Description	Purpose
1	1: north	From Speed Limit 25 sign	to document downhill slope with hydroseed
	2: south		
2	1: south	From Overheight Vehicles sign	to document upslope and narrow ditch with hydroseed
	2: north		
3	1: north	From Right Lane Employees Only	to document planted beargrass salvage success
	2: south		to document hydroseed success

Table 24. West Entrance Station: Seed Prescription, Fall 2008. (Approx. 3 acre)

Forbs/Shrubs	Collection #	Grams of seed	Seeds/ft ²
<i>Achillea millefolium</i>	03-110, 02-135	11.2 g, 10.6 g	3 seed/ ft ²
<i>Aquilegia flavescens</i>	98-175	30.30 g	0.16 seed/ ft ² .
<i>Anaphalis margaritacea</i>	05-136, 9087364	30.55 g, 0.5 g	4 seed/ ft ²
<i>Antennaria</i> sp.	9087370	14 g	1.5 seed/ ft ²
<i>Arnica cordifolia</i>	05-022, 07-003	4.9 g, 40 g	0.16 seed/ ft ²
<i>Aster laevis</i>	03-118, 02-512	1 g, 86.46 g	2.1 seed/ ft ²
<i>Symphyotrichum laeve</i>	9081447	70 g	1.63 seed/ ft ²
<i>Aster</i> sp.	9087432	5 g	0.11 seed/ ft ²
<i>Campanula rotundifolia</i>	04-189	0.35 g	0.06 seed/ ft ²
<i>Eurybia conspicua</i>	9087433	300 g	6.9 seed/ ft ²
<i>Geum macrophyllum</i>	9087654	600 g	7.7 seed/ ft ²
<i>Heracleum maximum</i>	95-205	23.7 g	0.02 - old seed
<i>Iliamna rivularis</i>	06-089	600 g	1.3 seed/ ft ²
<i>Penstemon confertus</i>	06-090	21.66 g	0.97 seed/ ft ²
<i>Potentilla gracilis</i>	03-091	107 g	3 seed/ ft ²
<i>Rubus parviflorus</i>	07-041, 06-038	23.48 g, 25 g	17 seed/ ft ²
<i>Solidago canadensis</i>	04-192, 03-090	14 g, 88 g	10.5 seed/ ft ²
<i>Spiraea betulifolia</i>	9082154	5 g	0.10 seed/ ft ²
<i>Xerophyllum tenax</i>	03-029	269 g	0.98 seed/ ft ²
Grasses			
<i>Bromus carinatus</i>	9087805	655 g	1.3 seed/ ft ²
<i>Bromus marginatus</i>	9054510	49 g	0.10 seed/ ft ²
<i>Bromus vulgaris</i>	07-017	314 g	0.58 seed/ ft ²
<i>Calamagrostis rubescens</i>	00-022, 00-021	400 g, 550 g	42.4 seed/ ft ²
<i>Carex athrostachya</i>	04-297, 9081443	368 g, 704 g	40.27 seed/ ft ²
<i>Carex deweyana</i>	05-074, 02-513	17 g, 44 g	0.10 seed/ ft ²
<i>Carex douglasii/ deweyana</i>	9078646, 01-523	122 g, 33 g	0.30 seed/ ft ²
<i>Carex pachystachya</i>	03-513, 66-869 (2000), 9078645	291 g, 200 g, 1360 g	25.75 seed/ ft ²
<i>Elymus glaucus</i>	06-053	156.41 g	0.35 seed/ ft ²

Figure 15: West Entrance Station: Location of Revegetation Monitoring Plots.

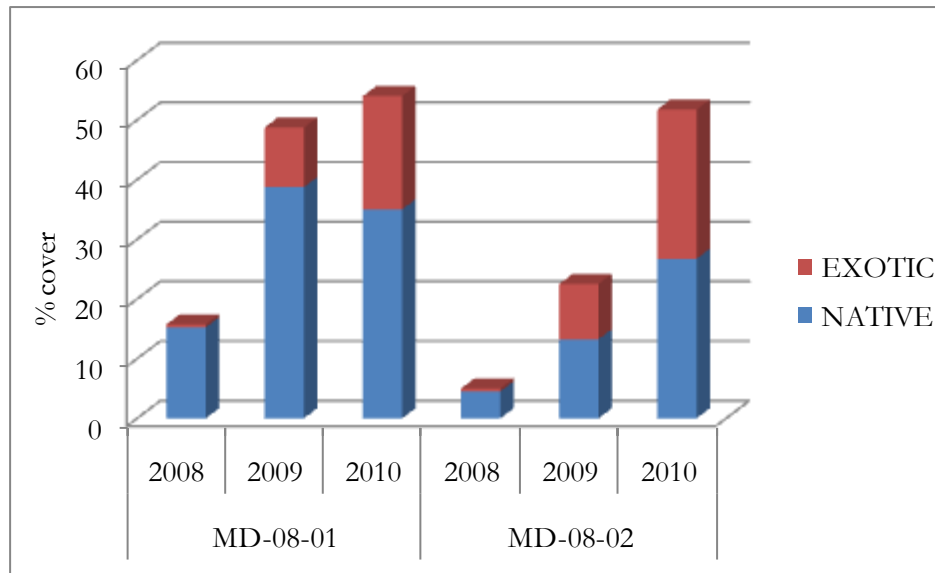


C. RESULTS

1. Salvage Plots

Overall cover has increased in both plots since 2008. Results differed between plots 1 and 2, likely due to disturbance caused by creating a temporary bypass lane in the fall of 2009. There was a decrease in native cover since last year in plot 1, which was impacted by the bypass, while native cover increased in plot 2, the non-disturbed plot (Figure 16). Exotic cover increased in both plots, however, with a number of new exotic species recruiting to plots for the first time.

Figure 16. West Entrance Station: Native vs. Exotic Cover in Salvage Plots, 2008-2010.



1a. Native Grasses:

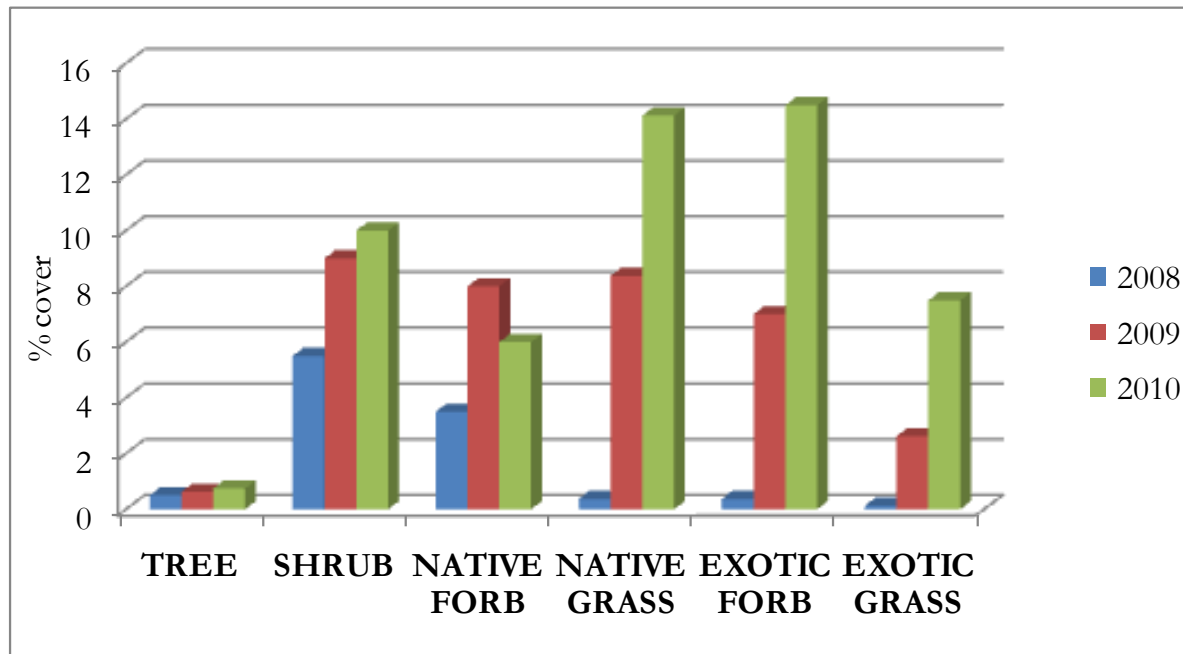
Native grasses continued to be successful the second year after planting. Cover of native grasses increased slightly in each plot, resulting in 6% cover in plot 2 and 22% cover in plot 1 (Table 26, Figure 17). *Elymus trachycaulus* greatly increased in plot 1 this year, increasing from trace to 10% cover. *Festuca occidentalis* was also successful, increasing in both plots by 1-4%. This species may be encroaching from surrounding habitats. Cover of *Bromus carinatus*, a nurse grass utilized in many revegetation projects, remained relatively stable in plot 1 and increased slightly in plot 2; *B. carinatus* cover is 6% and 4% cover, respectively.

Some seeded grasses are not performing as well, however. *Elymus glaucus*, another commonly used nurse grass, is proving to be less successful in the salvage plots. It disappeared from both plots in 2010, with only trace cover the previous year. Sedges are not showing great success in salvaged plots as well, with *Carex* species having no more than trace cover in each plot. *Calamagrostis rubescens* is remaining relatively stable or showing slight decreases with only 1% cover in both plots. Some *C. rubescens* was salvaged and some was seeded. Since it was increasingly difficult to tell which plants were salvaged two years post-planting, it is difficult to say whether salvaged plants are not faring well or whether seeded plants are being outcompeted, or both. *C. rubescens* has been observed to be easily outcompeted when seeded with a variety of other grasses and forbs.

1b. Native Forbs:

Trends in native forb cover varied between plots. There was a 5% increase in native forb cover in plot 2, compared to a 9% decrease in cover in plot 1 (Table 26). Most of the increase in plot 2 was due to a 3% increase in

Figure 17. West Entrance Station: Average Cover for Lifeforms of Salvage Plots, 2008-2010.



Achillea millefolium cover, which conversely was largely responsible for the 3% decrease in native forb cover in plot 1. There were several new recruits to plot 2 as well, including two seeded species *Potentilla gracilis* and *Solidago canadensis*, present with trace to 2% cover. Regenerating *Fragaria virginiana*, salvaged *Linnaea borealis* and seeded *Solidago canadensis* also decreased from 2 or 3 percent cover to trace cover in plot 1.

1c. Trees and Shrubs:

Tree cover, at 1% or less, remains very low in both plots (Table 26; Figure 17). Two new tree species recruited to plot 2, however, and may contribute significantly to cover in later years.

Shrub cover trends differed between plot 1 and 2. There was a slight decrease in shrub cover in plot 1, while an increase was observed in plot 2. Much of the reduction in shrub cover in plot 1 was due to the removal of *Vaccinium myrtilloides* in preparation for disturbance in the area from the bypass lane. All of these plants were moved outside the plot with one of the shrubs relocated into plot 2. Cover of *V. myrtilloides* also decreased in plot 2, although no shrubs were removed. Size of individual plants decreased in height and width in both plots (Table 25, Figure 18). Average height is 5 cm shorter and average width is over 10 cm shorter than in 2009. Size differences were very similar between shrubs that were relocated and those that were not, suggesting that it is not stress from the second transplantation event that resulted in smaller size. All transplanted *V. myrtilloides* survived from 2009 to 2010, while 7 of the non-transplanted shrubs died and 2 were missing.

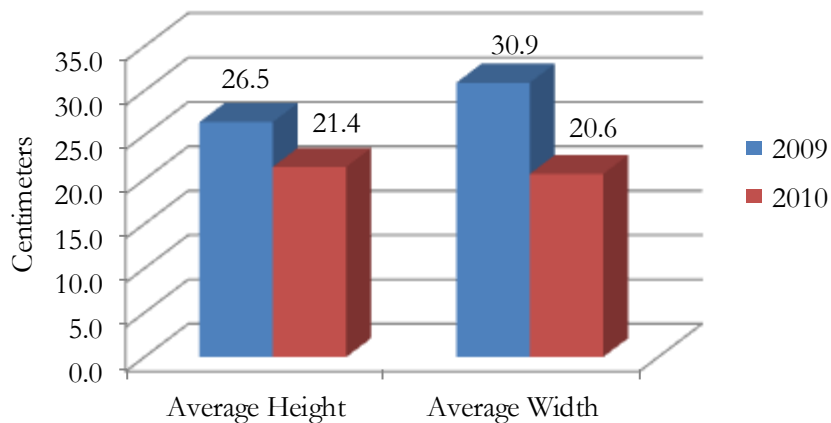
A few species of shrubs disappeared from plot 1 as well, all of which were present with only trace cover in the previous year. Shrubs found in 2009 that were not found in 2010 include *Alnus viridis*, *Mahonia repens*, *Paxistima myrsinites* and *Rubus parviflorus*. Increasing shrub cover in plot 2 appears to be mainly due to a 3% increase in *Symphoricarpos albus*. A few new shrub species recruited to this plot, including *P. myrsinites* and *Rosa acicularis*.

Table 25. West Entrance Station: Health, Height and Width of *Vaccinium myrtilloides* shrubs, 2009-2010.

Plot# MD-08-01	Health		Height		Width	
Tag #	2009	2010	2009	2010	2009	2010
1	5	4	30	28	33	27
2	4	4	38	15	42	10
3	5	4	28	31	20	24
4	5	4	34	15	30	14
5	5	4	20	22	30	33
6	5	3	19	18	23	11
7	4	3	37	26	34	20
8	3	4	17	26	35	16
9	4	4-	30	24	22	22
10	5	4	34	30	30	23

Plot# MD-08-02	Health		Height		Width	
Tag #	2009	2010	2009	2010	2009	2010
11	3	4	17	25	25	32
12	1	1	-	-	-	-
13	3	1	25	-	29	-
14	3	1	17	-	22	-
15	1	1	-	-	-	-
16	1	1	-	-	-	-
17	3	1	21	-	25	-
18	3	2	11	-	26	-
19	3	1	8	-	11	-
20	1	1	-	-	-	-
21	2	1	-	-	-	-
22	3	4	28	16	35	10
23	5-	4	12	18	22	21
24	4	4	42	42	45	36
25	5	3	29	20	34	14
26	3	1	31	-	52	-
27	3	1	14	-	44	-
28	5	5	20	17	40	22
29	5-	2	23	-	17	-
30	4-	4	36	26	38	37
31	5-	4	20	17	24	14
32	3	4	32	9	42	13
33	5-	4	13	8	12	15
34	?	5	20	17	33	19

Figure 18: West Entrance Station: Change in Average Plant Size of *Vaccinium myrtilloides*, 2009-2010



Graph data includes only the 21 *V. myrtilloides* still alive in 2010

1d. Exotic Forbs:

The cover of exotic forbs increased by 6% and 9% for plots 1 and 2, respectively (Table 26; Figure 17). The numbers of exotic species increased dramatically in both cases; from 16 to 24 species in plot 1 and from 13 to 21 species in plot 2. Most of these species, however, had very low cover. Most of the increase in cover came from clover species. *Melilotus officinale* has visibly increased in cover in the entire West Entrance Station area over the last year. The measured increase was not as dramatic in salvage plots as it was in other areas, but it increased from trace to 2% cover in plot 1 and from 0 to 3% cover in plot 2. Other clover species contributed to the increase in exotic forb cover in plot 2, including *Medicago lupulina*, *Melilotus alba* and *Trifolium hybridum*, all increasing from 1 to 3% in cover. Clover species tend to be cyclical in their population trends, especially during wet springs, as was the case in 2010 (Appendix A). Past monitoring projects have shown that high covers of clover species usually diminish over time.

Two species of noxious weeds were found in salvage plots. *Cirsium arvense* was found for the first time in the project in 2010. It was present with trace cover in plot 1. *Leucanthemum vulgare* continues to have low cover in both plots, present with only trace cover. Another species to watch, although it is not considered noxious in the state of Montana, is *Veronica officinalis*. It remains at only trace cover in both plots, but areas within West Glacier and Apgar harbor high population levels of this invasive plant which can thrive in shady conditions under the forest canopy.

1e. Exotic Grasses:

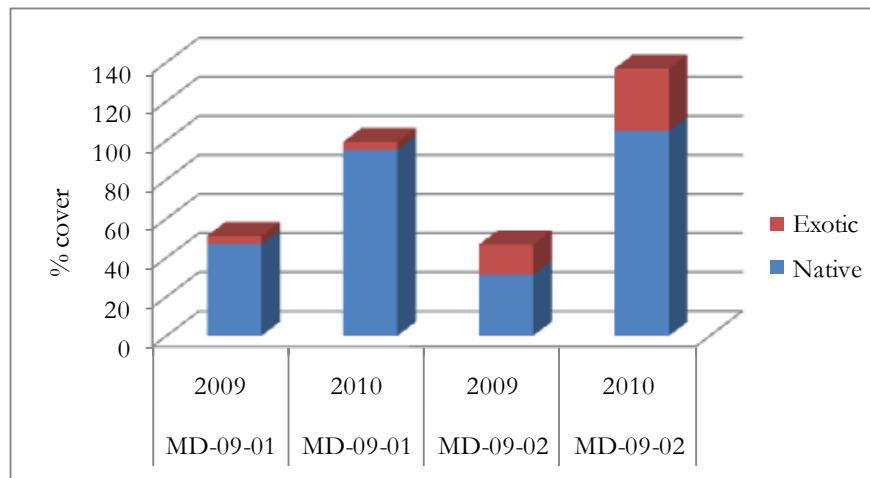
Exotic grass cover increased in both plots (Table 26; Figure 17), as did the number of exotic grass species present. Cover of *Elymus repens*, an aggressive rhizomatous grass, increased from 3 to 10% in plot 2. Another rhizomatous grass of concern is *Agrostis stolonifera*, which recruited to both plots since 2009 and rose to 2% cover in plot 1. *Poa pratensis*, which is new to plot 1, and *Bromus inermis*, which is new to plot 2, can also be aggressive rhizomatous grasses and threaten the success of this project. *Phleum pratense*, although not rhizomatous, is new to plot 2 and can also be quite aggressive. While all of these species are still present with 2% or less cover, they are species to watch over time.

2. Hydroseeded Plots

Overall cover increased dramatically in both plots from 2009 to 2010. This was expected, since this area was hydroseeded in the fall of 2008 and seed germinated in the spring of 2009. Cover increased by 90% in plot 2 and by 48% in plot 1 (Table 27; Figure 19). Native species accounted for most of the difference, increasing 48% in plot 1 and 74% in plot 2. There was virtually no change in exotic cover in plot 1, while there was a 16% increase in plot 2.

Most of the increase in exotic cover was due to *Melilotus officinalis*, which increased from 3% to 20% in cover in plot 2. This species underwent a visible increase in population at the West Entrance area from 2009 to 2010. *Melilotus officinalis* is usually cyclical in population size and, as stated above, past monitoring projects have shown that high covers of this clover species usually diminish over time.

Figure 19. West Entrance Hydroseeded Plots: Percent Cover of Native and Exotic Species, 2009-2010.



2a. Native Grasses:

As was seen in 2009, native grasses were most successful at increasing in cover since the previous year (Figure 20, Table 27). Native grasses increased by 25% in plot 1 and by 54% in plot 2 since 2009. Several species of seeded grasses were quite successful, specifically sedge species that had the greatest increases in cover in both plots. A 23% increase in *Carex* species was observed in plot 1, while a 46% rise was observed in plot 2. Sedges were lumped into *Carex* sp. due to the lack of seed heads in the majority of cases, but sedges that were identifiable at this point in time were identified as *C. pachystachya*. Also faring well was *Elymus glaucus* which increased in cover by 13% in plot 1 and by 9% in plot 2. *Bromus carinatus* remained relatively stable in hydroseeded plots with a slight increase in plot 2. These results contrast greatly with those from salvage plots, which received the same seed mix but were hand seeded. *Carex* species remained at only trace cover in salvage plots and decreased from 3% to trace cover in one plot. The success of the two “nurse grasses” differed from salvage plots as well, where *E. glaucus* disappeared after only trace cover the previous year and *B. carinatus* remained relatively stable at 4-6% cover.

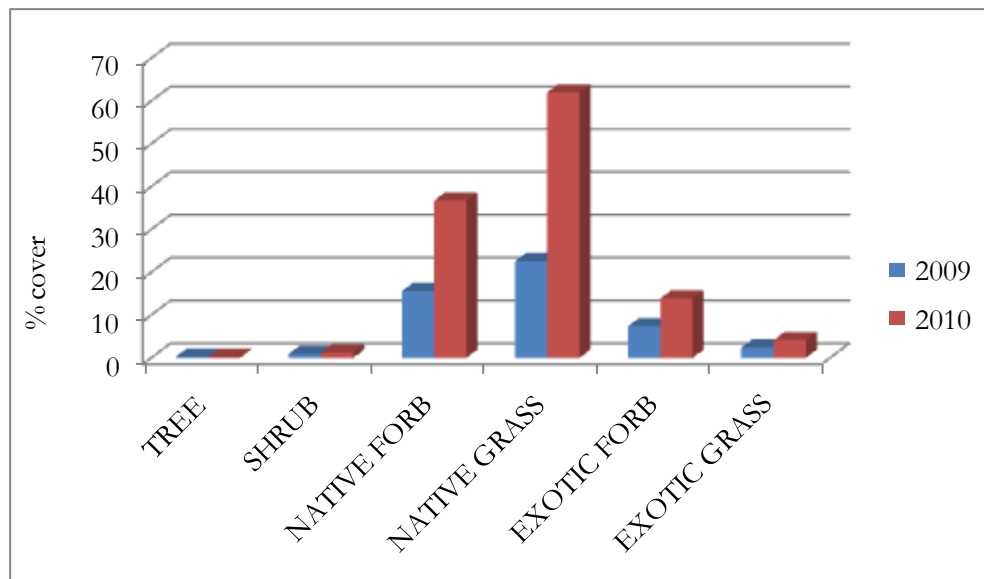
2b. Native Forbs:

As in 2009, native forbs were the second most successful lifeform in hydroseeded plots. Native forb cover increased by approximately 20% in each plot over last year (Figure 20). *Geum macrophyllum* was the most successful forb in both plots with a 9% increase in cover in plot 1 and a 20% increase in plot 2 (Table 27). *Achillea millefolium* increased by 15% in plot 1 but remained stable at 1% cover in plot 2. Several other seeded species are remaining relatively stable with covers in the single digits, including *Anaphalis margaritacea*, *Solidago canadensis* and *Symphytotrichum laeve*. These results again contrast dramatically with those from hand-seeded salvage plots where all of the above species are present with only trace cover, with the exception of *A. millefolium* that has 1-3% cover.

2c. Trees and Shrubs:

Cover of trees and shrubs continued to be negligible in 2010 (Figure 20, Table 27) with just trace cover of any species except for 1% cover of *Symphoricarpos albus* in plot 2. The two hydroseeded species, *Spiraea betulifolia* and *Rubus parviflorus*, each were present with trace cover in both plots.

Figure 20. West Entrance Hydroseeded Plots: Average Cover of Lifeforms, 2009-2010.



2d. Exotic Forbs:

Exotic forb cover remained relatively stable in plot 1 since 2009, while it increased by 12% in plot 2 (Table 27). The most prominent change in exotic forb cover came from a 17% increase of *Melilotus officinalis* in plot 2 (identified as *Melilotus* sp. in 2009). As stated above, this species had a visible presence at the West Entrance Station in 2010 following a wet spring (Appendix A). With evidence from other roadside monitoring projects, this species should decrease in cover over time. A 3% decrease in *Medicago lupulina* in plot 2 and a 3% increase in *Trifolium agrarium* in plot 1 were also observed this year, further demonstrating the fluctuating nature of clover species. Three noxious weed species were found in hydroseeded plots this year, all in plot 2. *Cirsium arvense* appeared for the first time with trace cover, *Hypericum perforatum* increased from trace to 1% cover, and *Leucanthemum vulgare* remained at trace cover.

2e. Exotic Grasses:

Exotic grass cover remained at only trace levels in plot 1 (Figure 20, Table 27). Two new species recruited to this plot, however, which could change the vegetation dynamics in subsequent years. *Poa compressa* does not generally outcompete other species readily, but the rhizomatous *Poa pratensis* can be very aggressive. *Bromus tectorum* was pulled from this plot in 2009 and has not returned. *Agrostis stolonifera* was not previously found in this project but recruited to plot 2 with 3% cover in 2010. This is another aggressive rhizomatous grass which should be monitored in the future.

D. CONCLUSIONS AND RECOMMENDATIONS

Differences were observed between salvaged plots and hydroseeded plots in 2010. Native cover only slightly increased in salvage plots while it increased an average of 61% in hydroseeded plots. In general, seeded species were not very successful in salvage plots, although it is difficult to attribute this to a specific cause. Disturbance may have played a role in the lack of success of salvaged plots, as this area was impacted by the formation of a temporary bypass lane. Seeded species in these plots may not have been able to establish or were disturbed early after germination. Additionally, seeding methods and timing differed. Hydroseeded areas were provided with light mulch, which may have aided in water retention and thus better germination and survival.

Exotic species cover increased more in salvage plots where native species have not been as competitive. Numbers of exotic plant species increased much more in salvage plots than in hydroseeded plots, although many of

these may not provide significant cover over time. Cover of weeds should be tracked over time and noxious weeds need to be consistently controlled with herbicide.

A second transplanting did not seem to further harm *Vaccinium myrtilloides* shrubs; all the transplanted shrubs survived. Non-transplanted shrubs did not fare as well, however. Given that nearly twice as many *V. myrtilloides* shrubs died this year from last year and that they are diminishing in size, they should continue to be monitored. The success of transplanting this sensitive species is still under scrutiny. Most other salvaged species are remaining stable or increasing in cover over time, including *Rosa woodsii*, *Spiraea betulifolia*, *Symphoricarpos albus*, *Fragaria vesca* and *Festuca occidentalis*.

Nurse grasses had different results in the salvage and hydroseeded plots. Although *Bromus carinatus* remained relatively stable in both areas, *Elymus glaucus* increased by an average of 11% in hydroseeded plots while it disappeared from salvage plots. Despite these differences, both of these grasses have proven to provide excellent ground cover in various projects and should continue to be utilized as colonizers before exotic species get established.

While a visual assessment of this project may be misleading, given the sudden increase in *Melilotus officinalis*, hydroseeding showed good early success. Several hydroseeded species performed very well. *Geum macrophyllum*, *Carex* species and *Elymus glaucus* provided substantial cover. It will also be important to track the success of *Calamagrostis rubescens* over time. This species usually does not do well seeded under competitive scenarios, but it is establishing well on at least one plot. Data supporting a successful seeding regime of this species would be extremely helpful, as this is a very common grass species in surrounding forests and would be an excellent roadside revegetation species.

Likely weedy clover species are not long-term threats to this project. The more likely candidates are rhizomatous weedy grasses, such as *Agrostis stolonifera*, which established on the project for the first time in 2010, as well as *Elymus repens*, *Pbleum pratense* and *Poa pratensis*. Noxious weeds have been continuously controlled along roadsides, but a few exotic forbs still pose threats to the project. *Veronica officinalis*, a member of the Scrophulariaceae family, is not affected by most herbicides used. This species has been particularly aggressive in the Headquarters/Apgar area and is shade tolerant as well. *Hypericum perforatum* is an increasingly problematic noxious weed species that also does not respond to the commonly used roadside herbicides.

This project should be monitored next in 2011, year 3 after planting.

Table 26. West Entrance Station: Percent Cover for all Species in Salvage Plots, 2008-2010.

		MD-08-01			MD-08-02		
GROUND COVER		2008	2009	2010	2008	2009	2010
Basal vegetation		3	5		2	4	
Litter/Duff		30	34		35	34	
Moss			0			0	
Bare Soil		62	20		57	50	
Gravel			30			10	
Rock		5	1		5	1	
Wood			0		1	1	
TOTAL TREE	source	1	1-	1	0	T	T+
<i>Abies lasiocarpa</i>	?	T	T	T			T
<i>Betula papyrifera</i>	salvage (in mat)	T					
<i>Picea engelmannii</i>	salvage	1 (1 TREE)	T+	T			T
<i>Pinus monticola</i>	salvage	T (1 TREE)	T-	T (1 TREE)			T
<i>Populus balsamifera</i>	natural	T	T		hanging over		
<i>Pseudotsuga menziesii</i>	natural	T (hanging over)			hanging over	T	T
unknown conifer seedlings			T			T	
Number of Tree Species Present		6	5	3	2	2	4
TOTAL SHRUB	source	9	9	7	2	9	13
<i>Arctostaphylos uva-ursi</i>	salvage	2-	2-	1	T	T+	T
<i>Alnus viridis</i>	?		T+				
<i>Amelanchier alnifolia</i>	salvage	1-	T	T	T	T	T
<i>Mabonia repens</i>	salvage	T	T		T	T	T
<i>Paxistima myrsinites</i>	salvage	T	T		T		T
<i>Prunus virginiana</i>				T			
<i>Rubus parviflorus</i>	seeded		T (1 plant)			T	T
<i>Rosa acicularis</i>	salvage	T					T
<i>Rosa woodsii</i>	salvage	1-	1	1	T	2-	3
<i>Shepherdia canadensis</i>	natural			T			
<i>Spiraea betulifolia</i>	salvage	1-	2+	2+	T	4-	5
<i>Symphoricarpos albus</i>	salvage	1-	1+	1+	T	2-	5
<i>Vaccinium caespitosum</i>	salvage	T+	T	T	T	T	T
<i>Vaccinium membranaceum</i>	salvage	1-	1-	T	T	T	T
<i>Vaccinium myrtilloides</i>	salvage	2	1+	0 (moved)	2-	1+	T
<i>Vaccinium myrtilloides</i>	natural				T		
<i>Vaccinium myrtillus</i>	natural	T+	T+	T	T	T	T
Unknown					T		
Vaccinium myrtilloides # of plants	salvage	10	10	0 (moved)	24	20	12 *
Number of Shrub Species Present		12	13	11	13	11	13
TOTAL NATIVE FORB	source	5	14	5	2	2	7
<i>Achillea millefolium</i>	salvage	T	T	1	T	T+	3
<i>Achillea millefolium</i>	seeded		4+			T+	
<i>Anaphalis margaritacea</i>	seeded		T	T		T	
<i>Antennaria borealis</i>	seeded		T	T			
<i>Arenaria serpyllifolia</i>	regen		T	T		T	1+
<i>Cardamine pensylvanica</i>	regen			T			
<i>Chamerion angustifolium</i>	regen		T	T			T
<i>Chimaphila umbellata</i>	salvage	T	T		T	dead	T
<i>Clintonia uniflora</i>	regen			T		T	
<i>Epilobium brachycarpum</i>	regen		T	T		T	T
<i>Fragaria vesca</i>	salvage	1-	1+	1	T	1-	2
<i>Fragaria virginiana</i>	regen		2+	T		T	T
<i>Galium triflorum</i>	regen					T	T
<i>Geum macrophyllum</i>	seeded		1	T		T	T
GEUPAL	regen		T				
<i>Gnaphalium macounii</i>	salvage	T					T?
<i>Linnaea borealis</i>	salvage	2-	3-	T	1	1-	1-
<i>Maianthemum racemosum</i>	regen			T			T
<i>Maianthemum stellatum</i>	regen		T	T		T	T
<i>Penstemon confertus</i>	regen			T			
<i>Polygonum douglasii</i>	regen			T			
<i>Potentilla gracilis</i>	seeded			T			T
<i>Solidago canadensis</i>	seeded		2	T			T
<i>Symphyotrichum leave</i>	seeded		T	T			
<i>Vicia americana</i>	regen		T	T		T	
<i>Viola orbiculata</i>	salvage			T	T	T-	
<i>Xerophyllum tenax</i>	salvage	1	T+(some dying)	1	1	T	T
<i>Xerophyllum tenax</i>	natural	1	1		T	T	
Number of Native Forb Species Present		6	17	22	6	16	16

Table 26 con'd. West Entrance Station: Percent Cover for all Species in Salvage Plots, 2008-2010.

		MD-08-01			MD-08-02		
		2008	2009	2010	2008	2009	2010
TOTAL NATIVE GRASS	source	T	15	22	T	2-	6+
<i>Bromus carinatus</i>	seeded		7	6		1+	4
<i>Calamagrostis rubescens</i>	seeded	T	1	1	T	1	1
<i>Calamagrostis rubescens</i>	salvage		2-				
<i>Carex concinnoides</i>	salvage	T	1-	T	T	T	
<i>Carex rossii</i>	regen			T			T
<i>Carex sp.</i>	seeded		3	T		T	T
<i>Danthonia intermedia</i>	regen		T			T	
<i>Elymus glaucus</i>	seeded		T			T	
<i>Elymus trachycaulus ssp. trachycaulus</i>	?			10			T+
<i>Festuca occidentalis</i>	salvage	T	1+	5	T	T	1
<i>Oryzopsis asperifolia</i>	salvage	T	T	T	T	T	
<i>Panicum capillare</i>	regen			T			T
Grass spp. (unknown)	?	T	T+		T		
Number of Native Grass Species Present		5	9	9	5	8	7
TOTAL EXOTIC FORB		T	8	14	T	6	15
<i>Amaranthus retroflexus</i>				T	T	T	T
<i>Capsella bursa-pastoris</i>				T			T
<i>Chenopodium album</i>							T
<i>Cirsium arvense</i>				T			
<i>Cirsium vulgare</i>			T	T		T	T
<i>Filago arvensis</i>			T-	T		T	T
<i>Leucanthemum vulgare</i>			1-	T		T	T
<i>Lactuca serriola</i>			T	T			T
<i>Madia glomerata</i>			T	T			
<i>Matricaria matricarioides</i>							T
<i>Melilotus alba</i>				T			1
<i>Medicago lupulina</i>			6	7		T+	3
<i>Melilotus officinale</i>			T	2			3
<i>Plantago lanceolata</i>				T			
<i>Plantago major</i>			1+	5		T	T
<i>Potentilla argentea</i>			T	T	T	T	T
<i>Potentilla norvegica</i>		T					T
<i>Prunella vulgaris</i>			T	T			T
<i>Rumex acetosella</i>				T			
<i>Spergularia rubra</i>				T			
<i>Taraxacum officinale</i>			T	T			T
<i>Trifolium agrarium</i>				T			
<i>Trifolium pratense</i>			T				
<i>Trifolium hybridum</i>				T		5	7
<i>Verbascum thapsus</i>				T		T	T
<i>Veronica officinalis</i>			T	T	T (pulled)	T	T
<i>Veronica serpyllifolia</i>			T	T		T	T
Unknown Mustard		T (pulled)	T	T		T	T
Unknown			T			T	
Number of Exotic Forb Species Present		2	16	24	3	13	21
TOTAL EXOTIC GRASS		T	2	5	0	3+	10
<i>Agrsotis stolonifera</i>				2			T
<i>Bromus inermis</i>							T
<i>Dactylis glomerata</i>		T		T		T	
<i>Elymus repens</i>		T	1+	2		3+	10
<i>Phleum pratense</i>			T+	T			T
<i>Poa compressa</i>			T-	T			T
<i>Poa pratensis</i>				T			
Number of Exotic Grass Species Present		2	3	6	0	2	5

* 2010: one *Vaccinium myrtilloides* transferred from plot 1 to plot 2; others from plot 1 moved outside of plot

cells that are highlighted in lt. orange = merged seeded, salvage and/or natural (can't decipher anymore)

species names in red are designated as Montana Noxious weeds

Table 27. West Entrance Station: Percent Cover for all Species in Hydroseeded Plots, 2009-2010.

		MD-09-01		MD-09-02	
		2009	2010	2009	2010
GROUND COVER	Source	Canopy cover	Canopy cover	Canopy cover	Canopy cover
Basal vegetation		5		6	10
Litter/Duff		49		60	48
Moss		0		1	7
Bare Soil		20		10	22
Gravel		25		20	10
Rock		1		1	2
Wood		0		2	1
Other		0		0	0
TREE		T	T	T	T
<i>Pseudotsuga menziesii</i>	regen		T		T
Unknown conifer seedlings	regen	T		T	
number of species		1	1	1	1
SHRUB		T	T+	T	1
<i>Alnus viridis</i>	regen	T	T	T	
<i>Betula papyrifera</i>	regen			T	
<i>Rosa acicularis</i>	regen			T	T
<i>Rubus parviflorus</i>	seeded	T	T		T
<i>Spiraea betulifolia</i>	seeded	T	T	T	T
<i>Symphoricarpos albus</i>	regen	T	T	T	1
number of species		4	4	5	4
NATIVE FORB		18	40	10	30
<i>Achillea millefolium</i>	seeded	8	18	1-	1
<i>Aquilegia flavescens</i>	seeded				
<i>Anaphalis margaritacea</i>	seeded	1	5	T	1
<i>Antennaria howellii</i>	seeded	T	T	T	
<i>Aralia nudicaulis</i>	regen			T	T
<i>Arnica cordifolia</i>	seeded				
<i>Campanula rotundifolia</i>	seeded				
<i>Chamerion angustifolium</i>	regen	1+	T	T	T
<i>Cerastium arvense</i>	regen			T	
<i>Eurybia conspicua</i>	seeded				
<i>Epilobium brachycarpum</i>	regen	T	T	T	T
<i>Equisetum arvense</i>	regen			1	T
<i>Fragaria vesca</i>	regen	T			
<i>Fragaria virginiana</i>	regen	T	T	T	T
<i>Geum macrophyllum</i>	seeded	6	12	6+	23
<i>Galium triflorum</i>	regen				T
<i>Geranium bicknellii</i>	regen				T
<i>Heracleum maximum</i>	seeded				
<i>Iliamna rivularis</i>	seeded				
<i>Arenaria serpyllifolia</i>	regen			T	
<i>Osmorhiza berteroi</i>	regen			T	
<i>Penstemon confertus</i>	seeded	T	T	T	T
<i>Potentilla gracilis</i>	seeded	T	T	T	
<i>Potentilla sp. (pinnate)</i>	regen		T		
<i>Rubus parviflorus</i>	seeded				
<i>Solidago canadensis</i>	seeded	1	3	T	2
<i>Symphiotrichum laeve</i>	seeded	T	1+	1+	3
<i>Viola orbiculata</i>	regen	T	T	T	
<i>Xerophyllum tenax</i>	seeded				
<i>Xerophyllum tenax</i>	salvage				
<i>Xerophyllum tenax</i>	natural/regen	T	1	T	
number of species		14	14	18	14

Table 27 con'd. West Entrance Station: Percent Cover for all Species in Hydroseeded Plots, 2009-2010.

		MD-09-01		MD-09-02	
		2009	2010	2009	2010
	Source	Canopy cover	Canopy cover	Canopy cover	Canopy cover
NATIVE GRASS		27	52	18	71
<i>Agrostis scabra</i>	regen			T	1
<i>Bromus carinatus</i>	seeded	14	2	7	5
<i>Bromus marginatus</i>	seeded				
<i>Bromus vulgaris</i>	seeded				
<i>Calamagrostis rubescens</i>	seeded	3	10	8	2
<i>Carex athrostachya</i>	seeded				
<i>Carex concinnoides</i>	regen		T		T
<i>Carex deneyana/ douglassii</i>	seeded				
<i>Carex pachystachya</i>	seeded				
<i>Carex sp.</i>	seeded	6	25	1-	48
<i>Danthonia intermedia?</i>	regen			T	T
<i>Elymus glaucus</i>	seeded	3+	15	1-	10
<i>Festuca campestris</i>	regen				T
<i>Festuca idahoensis</i>	regen			1	5
<i>Festuca occidentalis</i>	regen		T		
<i>Poa palustris</i>	regen	T+			
<i>Pseudoroegneria spicata</i>	regen			T	T
number of species		5	6	8	10
EXOTIC FORB		3	3	10	22
<i>Artemisia absinthium</i>	regen	T			
<i>Capsella bursa-pastoris</i>	regen	T		T	
<i>Cirsium arvense</i>	regen				T
<i>Cirsium vulgare</i>	regen				T
<i>Galium aparine</i>	regen				T
<i>Hypericum perforatum</i>	regen			T	1
<i>Filago arvensis</i>	regen	T			T
<i>Lactuca serriola</i>	regen	T			T
<i>Leucanthemum vulgare</i>	regen			T	T
<i>Medicago lupulina</i>	regen	T	T	3	T
<i>Melilotus officinalis</i>	regen		T		20
<i>Melilotus sp.</i>	regen			3	
<i>Plantago lanceolata</i>	regen			T	T
<i>Plantago major</i>	regen			1-	T
<i>Taraxacum officinale</i>	regen			T	T
<i>Trifolium agrarium</i>	regen		3		
<i>Trifolium sp.</i>	regen	T		T	
<i>Verbascum thapsus</i>	regen	3-	T	3	1-
<i>Veronica officinalis</i>	regen			T	T
<i>Veronica serpyllifolia</i>	regen			T	T
<i>unknown</i>	regen			T	
number of species		7	4	13	15
EXOTIC GRASS		T	T	4	7
<i>Agrostis stolonifera</i>					3
<i>Bromus inermis?</i>	regen			T	
<i>Bromus tectorum</i>	regen	T (pulled)			
<i>Dactylis glomerata</i>	regen			1	T
<i>Pheum pratense</i>	regen			3	4
<i>Poa palustris</i>	regen				T
<i>Poa pratensis</i>	regen		T		
<i>Poa compressa</i>	regen		T	T	T
<i>unknown</i>	?			T	
number of species		1	2	5	5

species names in red are designated as Montana Noxious Weeds

VI. LAKE MCDONALD –LEWIS DORM

A. BACKGROUND AND PURPOSE

The new Lewis Dorm in Lake McDonald village was completed in 2009 and is located approximately 40 meters southeast of the general store (Figure X). Prior to construction, the building site was a wooded area of about 50% conifer cover, mainly western larch (*Larix occidentalis*) and western hemlock (*Tsuga heterophylla*). Several other conifers were present in the area, including western red-cedar (*Thuja plicata*), plus lesser amounts of deciduous trees closer to existing developed areas. A site analysis completed prior to construction, with details of the vegetation and forest composition, is described in the 2007 Revegetation Monitoring Report for further reference (Asebrook et. al. 2007).

Revegetation of the building site occurred in the spring of 2009, including seeding and the planting of nursery stock. This effort is being monitored with two methods: 1) three permanent, cover estimate plots and 2) three photo monitoring plots. All plots are adjacent to Lewis Dorm (Figure 21).

Also, three existing dorms (Jammer Dorm, Boys 1 and Boys 2) have been moved from their original location near Snyder Creek to southwest of Lewis Dorm. These 3 dorms will serve as temporary housing for GPI employees until a new dorm is completed. Construction of this new dorm commenced in September 2010 and its design will be the same as Lewis Dorm.

Figure 21. Lake McDonald Dorm: Site and plot locations



B. METHODS

In the fall of 2009, three permanent level II monitoring plots were installed to monitor ocular estimates of canopy cover for all native and exotic species within the plot, as well as estimates of ground cover (Table 31). Photographs were taken of each plot. The three plots were chosen to depict three distinct revegetated areas on the north, south and west sides of the dorm. The first two plots, MD09-03 and MD09-04, were located in the areas that were seeded only. MD09-03 is located on the west side of the dorm alongside the sidewalk where soil had been brought in from outside the park prior to hydroseeding. MD09-04 is south of the Lewis Dorm in between the dorm and the temporary dorms. This site has local soil that was replaced after construction. The third plot, MD09-05, was located on the north side of the dorm where it was seeded and planted with nursery and salvage plants. Photomonitoring occurred in other revegetated areas that were not monitored with survey plots (Table 28).

Table 28. Lake McDonald Dorm: Photomonitoring Plots at Lewis Dorm.

Site #	Facing	Description	Purpose
1	East	On North side of dorm next to grate in center of ditch facing East toward drain pipe.	To document planted vegetation. Two <i>Rubus parviflorus</i> , 3 <i>Cornus sericea</i> , patch of <i>Symphoricarpos albus</i> .
2	North	On E side of Dorm. 10 Paces S of gravel area for drain pipe in ditch facing <i>Cornus</i> (north).	To document planted <i>Cornus sericea</i> . 12 live plants present in 2009.
3	Northeast	Taken right at SE corner of building facing NE.	To document planted vegetation. <i>Betula papyrifera</i> and <i>Cornus sericea</i> .

The seed prescription used at the Lewis Dorm site is shown in Table 29. All areas that were disturbed during construction were hydro-seeded using a cultivar grass blend and a native forb, sedge and shrub mix sufficient for approximately 18,000 ft².

Approximately 500 plants were planted at the site in the spring of 2009. One hundred and thirty of these were salvaged before dorm construction and then replanted. The rest were containerized plants from the nursery (Table 30). Plants were only installed along the north and east sides of the dorm.

Table 29. Lake McDonald Dorm: Hydro-seed Prescription used for Lewis Dorm.

Shrubs	Wt.	Forbs	Wt.	Sedges	Wt.	Grass Cultivar Blend	Wt.
<i>Rosa sp.</i>	45g	<i>Anaphalis margaritacea</i>	10g	<i>Carex athrostachya</i>	384g	<i>Achnatherum hymenoides</i>	2lb
<i>Rubus parviflorus</i>	10g	<i>Antennaria sp.</i>	5g	<i>Carex pachystachya</i>	1.86lb	<i>Festuca occidentalis</i>	3lb
<i>Spiraea betulifolia</i>	10g	<i>Aster sp.</i>	11g			<i>Elymus trachycaulus</i>	2lb
<i>Symphoricarpos albus</i>	205g	<i>Chamerion angustifolium</i>	10g			<i>Deschampsia caespitosa</i>	1lb
		<i>Geum macrophyllum</i>	10g				
		<i>Penstemon albertinus</i>	10g				
		<i>Penstemon confertus</i>	10g				

Blue denotes species included in 2007 recommended species list.

Seed weights are total amounts included in hydro-seed for an 18,000ft² area.

Table 30. Lake McDonald Dorm: Containerized Nursery Plants Planted around Lewis Dorm.

Trees	Shrubs	Forbs
<i>Betula papyrifera</i>	<i>Acer glabrum</i>	<i>Apocynum androsaemifolium</i>
<i>Tsuga heterophylla</i>	<i>Amelanchier alnifolia</i>	<i>Arnica cordifolia</i>
	<i>Arctostaphylos uva-ursi</i>	<i>Dryopteris filix-mas</i>
	<i>Mabonia repens</i>	<i>Fragaria virginiana</i>
	<i>Prunus virginiana</i>	<i>Geum macrophyllum</i>
	<i>Rubus parviflorus</i>	
	<i>Spiraea betulifolia</i>	

Blue denotes species included in 2007 recommended species list.

C. RESULTS

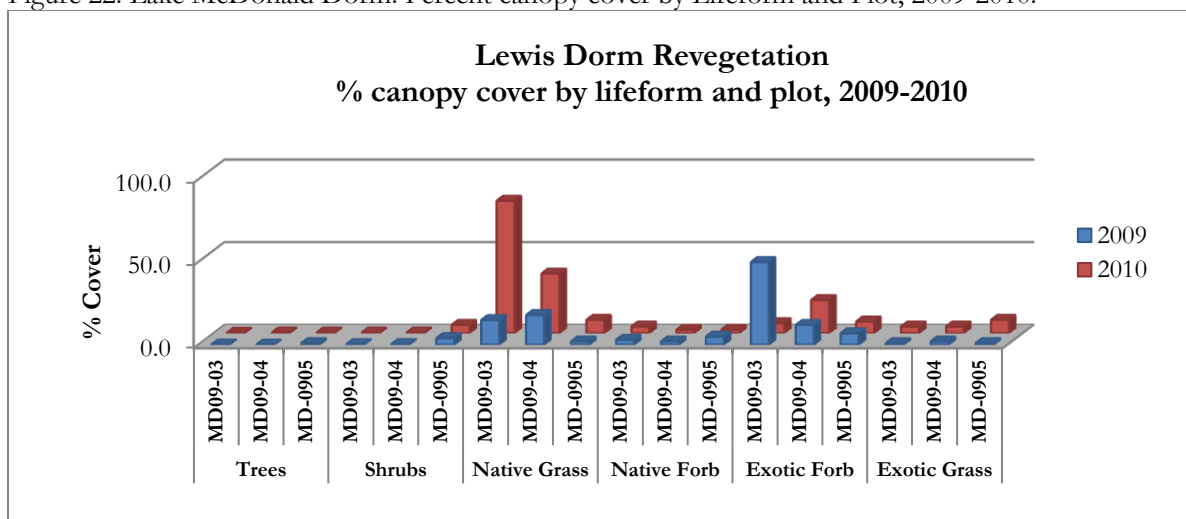
Collectively, plot data from 2010 showed an increase in overall plant cover as compared to 2009. This is due almost exclusively to increases in native grass cover that increased substantially on two plots and moderately on one plot (Table 31, Figure 22). *Festuca occidentalis*, in particular, dramatically increased in two of the plots and was the primary reason for the overall change in native grass cover. Within plots MD09-03 and MD09-04, the cover of *F. occidentalis* increased from 11% to 65% and from 15% to 35%, respectively. The only other native grass that made a notable increase was *Elymus trachycaulus v. trachycaulus* on plot MD09-03, increasing from 3% to 15%. Currently, native grasses have the highest cover of any lifeform on all plots. In terms of other native lifeforms, tree, shrub and native forb cover showed little cover change over the past year and remain with low cover in most plots (Table 31, Figure 22). Shrubs had the highest cover in plot MD09-05 where they were planted with greater density.

Exotic forb cover decreased in total, but the change was very different in each plot (Table 31, Figure 22). MD09-04 had a marked increase in cover, due largely to an increase of *Veronica officinalis*. Also present in this plot were several exotic forbs first observed in 2010 that contributed to increased cover, including *Trifolium agrarium*, *Cirsium arvense*, *Cerastium fontanum* and *Arenaria serpyllifolia*. Conversely, plot MD-09-05 saw a dramatic decrease in exotic forb cover. This was primarily due to notable decreases of two mustards, *Capsella bursa-pastoris* and *Thlaspi arvense*. This is often typical of colonizing mustards to have very high cover initially after disturbance and then quickly decrease in cover as other plants become established. Exotic forb cover on plot MD09-05 was essentially unchanged. Exotic grasses comprised less than 5% of the average total cover in 2010. However, aggressive *Agrostis stolonifera* that was not observed in 2009, now has the highest cover (3%) of any exotic grass.

Of the 32 species originally seeded, planted or salvaged in 2009, 23 were observed in 2010 (Table 31). Four of the original 32 species were observed in 2009 and not 2010, including *Pinus monticola*, *Chamerion angustifolium*, *Xerophyllum tenax* and *Achnatherum hymenoides*. Five others have yet to be observed either year, including *Cornus sericea*, *Rosa sp.*, *Tiarella trifoliata*, *Carex athrostachya* and *Carex pachystachya*. Observations of *Carex sp.* have been made, so *C. athrostachya* and/or *C. pachystachya* may indeed be present. In terms of non-native species, 31 exotic plants were observed in the monitoring plots in 2010, including 23 forbs and 8 grasses (Table 31). Of these 31 plants, 18 were observed for the first time in 2010 at the site, indicating continued recruitment of non-native plants.

Finally, cover of *Corydalis sempervirens* stayed constant from 2009 to 2010 (Table 31). Similar to previous years, *C. sempervirens*, a species of concern, was found in all three plots and in most of the disturbed areas around the dorm with low cover. In the state of Montana, this plant has an S2 ranking meaning it is “at risk because of very limited or declining numbers, range, and/or habitat, making it vulnerable to global extinction or extirpation in the state”. This species is almost exclusively found in burned areas following disturbance and is generally fire or disturbance dependent. The seeds were clearly in the seed bank in this area and germinated with the disturbance caused by the construction of the Lewis dorm. As *C. sempervirens* is a biennial, these plants may not persist in the Lewis dorm area much longer.

Figure 22. Lake McDonald Dorm: Percent canopy cover by Lifeform and Plot, 2009-2010.



D. CONCLUSIONS AND RECOMMENDATIONS

While not all monitoring plots are responding in the same way to revegetation efforts, there are a few trends that are common throughout the project. First, there is generally an overall increase in native grasses, particularly *Festuca occidentalis*. *F. occidentalis* is the dominant native plant in all plots and the dominant plant overall in two of the three plots. As this grass is a relatively new species to use in west-side revegetation projects, these results are encouraging. This grass, along with a few more native grass species that typically offer long-term cover, should be monitored over time to record its persistence and cover.

Another common trend is the relatively low cover of native trees, shrubs, and native forbs throughout the project. Low cover of trees and shrubs is expected since very few trees and shrubs were planted or seeded in the project. Native forb cover, on the other hand, remains relatively low and is not changing quickly over time. The first explanation is that forbs were seeded at a much lower seed rate in comparison to native grasses (Table 29). Also, unlike native grasses, forbs often take longer to grow to notable size, especially by year two, leading to lower cover. Finally, it is possible that the success of native grasses is impacting native forb cover by competing with them for resources. Continued monitoring should track the trend of this lifeform. Continued monitoring should also track the cover of the sensitive native forb on this project, *Corydalis sempervirens*, as described above.

Native forbs may also be competing for resources with increasing exotic species. Overall, exotic grass cover is increasing in all plots. This was due primarily to increases of *Agrostis stolonifera*, a difficult rhizomatous, exotic grass to control. Exotic forbs followed no trend except that the plot with imported soil had a dramatic decrease in exotic forb cover while a plot with salvaged soil had a dramatic increase in exotic forb cover this year. As mentioned above, the decrease in exotic forbs on the plot with imported soil was due to the disappearance of *Capsella bursa-pastoris* and *Thlaspi arvense*, colonizing mustards that tend to have high cover initially after disturbance but quickly decrease in cover as other plants become established. The increase in exotic forbs on the plot with salvaged soil was due to increases of *Veronica officinalis*, *Chrysanthemum leucanthemum*, and *Trifolium agrarium*. While *T. agrarium* seems to decrease in cover over time, *V. officinalis* is a shade-tolerant, mat-forming weed that is quite persistent in these forest types and *C. leucanthemum* is a noxious weed that is often difficult to control due to its prolific seeding. Despite the fact that unknown weeds can be introduced with imported soil, there may be some benefit to importing soil when the existing soil has high cover of weed species that are difficult to control. It would remain important to carefully inspect all soil prior to importing it to the park, however, imported soil may be the best option in circumstances where the native soil seed bank has already been contaminated with certain exotic forbs. Without control efforts, it is very likely that *C. leucanthemum*, *Centaurea biebersteinii*, *Cirsium arvense*, and *Verbascum thapsus* will maintain or increase in cover over time. Species such as *V. officinalis*, *Medicago lupulina*, *Trifolium hybridum*, and *T. agrarium* do not have effective controls and will also likely maintain or increase in cover over time. Most other exotic forbs, which typically thrive with disturbance and/or are shade-intolerant, will likely decrease in cover over time. Future monitoring should continue to track these trends.

Monitoring plots at the Lake McDonald dorm site should be monitored again in 2011. This will mark year three after restoration efforts.

Table 31. Lake McDonald Dorm: Percent canopy cover by species for each plot at Lewis Dorm, 2009-2010

Ground Cover		MD-09-03		MD-09-04		MD-09-05	
		2009	2010	2009	2010	2009	2010
Basal Veg		4	8	3	0.2	2	3
Bare Ground		60	45	20	27	5	10
Gravel		2	2	56	25	20	40
Litter		34	45	20	35	66	40
Moss		0	0	0	3	1	1
Rock		0	0	1	2	5	5
Wood		0	0	0	0	1	1
Other		0	0.2	0	3	0	0
Species	source						
Trees		0.2	0.2	0.2	0.4	1	0.4
<i>Abies lasiocarpa</i>	regen				0.1		
<i>Betula papyrifera</i>	planted				0.1	0.5	0.2
<i>Pinus monticola</i>	planted					0.2	
<i>Populus balsamifera</i>	regen	0.2	0.2	0.2	0.2	0.2	0.2
Shrubs		0.4	0.4	0.4	0.4	4	5
<i>Acer glabrum</i>	planted					0.2	0.2
<i>Amelanchier alnifolia</i>	planted					0.2	0.2
<i>Arctostaphylos uva-ursi</i>	planted					0.5	0.2
<i>Cornus sericea</i>	planted						
<i>Holodiscus discolor</i>	regen			0.2			
<i>Linnaea borealis</i>	planted					0.2	0.5
<i>Mahonia repens</i>	planted					0.5	0.5
<i>Prunus virginiana</i>	regen						0.2
<i>Rubus idaeus</i>	planted	0.2	0.2			0.5	0.5
<i>Rubus idaeus</i>	seeded			0.2	0.2	0.2	
<i>Salix bebbiana</i>	planted					0.2	0.2
<i>Spirea betulifolia</i>	seeded						0.2
<i>Symphoricarpos albus</i>	planted					1	2
<i>Symphoricarpos albus</i>	seeded	0.2	0.2		0.2	0.2	
<i>Rosa sp.</i>	seeded						
Native Forbs		3	4	2	2	5	2
<i>Achillea millefolium</i>	regen	0.1	0.2		0.2		
<i>Athyrium filix-femina</i>	planted					1	0.2
<i>Anaphalis margaritacea</i>	seeded	0.2	0.2	0.2	0.2	0.2	
<i>Antennaria howellii</i>	seeded			0.2		0.2	0.2
<i>Aquilegia flavescens</i>	regen					0.2	
<i>Chamerion angustifolium</i>	seeded			0.2			
<i>Chimaphila umbellata</i>	regen					0.2	
<i>Conyza canadensis</i>	regen	0.2					
<i>Corydalis sempervirens</i>	regen	0.2	0.2	0.2	0.2	0.7	0.2
<i>Fragaria vesca</i>	regen	0.1	0.2	0.2	0.2	0.2	0.2
<i>Galium triflorum</i>	regen			0.2			
<i>Geum macrophyllum</i>	seeded	0.1	0.2	0.2	0.2		
<i>Geum macrophyllum</i>	planted					0.1	0.2
<i>Hieracium scouleri?</i>	regen					0.2	0.2
<i>Maianthemum stellatum</i>	regen				0.1	0.2	0.2

Table 31 (con'd). Lake McDonald Dorm: percent canopy cover by species for each plot at Lewis Dorm, 2009-2010

Species	source	MD-09-03		MD-09-04		MD-09-05	
		2009	2010	2009	2010	2009	2010
Native Forbs con'd							
<i>Penstemon confertus</i>	seeded				0.1		0.2
<i>Solidago canadensis</i>	seeded	2	3	0.2	0.2	0.2	0.2
<i>Symphyotrichum laeve</i>	seeded	0.2	0.2	0.2	0.2		
<i>Tiarella trifoliata</i>	seeded						
<i>Viola orbiculata</i>	regen			0.2			
<i>Xerophyllum tenax</i>	salvage					0.5	
<i>Xerophyllum tenax</i>	regen/undisturbed				0.2	0.5	1
Native Grasses		14	80	18	36	2	8
<i>Agrostis scabra</i>	regen	0.2		0.2	0.2		
<i>Carex athrostachya</i>	seeded						
<i>Carex concinnoides</i>	salvage?					0.2	0.2
<i>Carex pachystachya</i>	seeded						
<i>Carex rossii</i>	regen					0.2	1
<i>Carex</i> spp.	seeded	0.2	0.2	0.5	0.2		
<i>Deschampsia caespitosa</i>	seeded		0.2		0.1		
<i>Elymus trachycaulus</i> v. <i>trachycan</i>	seeded	3	15	2.2	0.2	1	0.2
<i>Elymus glaucus</i>	planted					0.2	0.2
<i>Festuca occidentalis</i>	seeded	11	65	15	35	0.5	6
<i>Festuca idahoensis</i>	regen		0.2		0.2		
<i>Poa palustris</i>	regen				0.1		0.2
Exotic Forbs		50	6	11	20	7	7
<i>Amaranthus</i> (flowers in axils)	regen	0.2					
<i>Arenaria serpyllifolia</i>	regen	0.5	0.2		0.2	0.2	0.2
<i>Capsella bursa-pastoris</i>	regen	25		0.2	0.2	0.5	0.2
<i>Centaurea biebersteinii</i>	regen					0.2	0.2
<i>Cerastium fontanum</i>	regen				0.2		
<i>Cirsium arvense</i>	regen		0.2		0.2		
<i>Cirsium vulgare</i>	regen					0.2	0.5
<i>Digitalis?</i>	regen			0.2			
<i>Descurainia sophia</i>	regen	0.2					
<i>Erodium cicutarium</i>	regen	0.2	0.2				
<i>Filago arvensis</i> / <i>Gnaphalium pal</i>	regen	0.2	0.2	0.2	0.2	0.2	
<i>Leucanthemum vulgare</i>	regen	1.2	2	0.2	3	1	1
<i>Lactuca serriola</i>	regen	0.2					
<i>Medicago lupulina</i>	regen	1.2	0.2	0.2	0.2	0.2	0.2
<i>Melilotus</i> spp.	regen		0.2	2			
<i>Plantago major</i>	regen	0.2				0.2	0.2
<i>Polygonum aviculare</i>	regen	0.2				0.2	
<i>Polygonum convolvulus</i>	regen	2.7		0.1		0.2	0.2
<i>Potentilla argentea</i>	regen					0.2	0.2
<i>Potentilla norvegica</i>	regen			0.1	0.2	0.2	0.2
<i>Prunella vulgaris</i>	regen			0.1			
<i>Rumex acetocella</i>	regen			0.5	0.2	0.7	2
<i>Silene latifolia</i>	regen	0.2				0.2	0.2
<i>Sisymbrium altissimum</i>	regen	0.7					

Table 31 (con'd). Lake McDonald Dorm: percent canopy cover by species for each plot at Lewis Dorm, 2009-2010

Species	source	MD-09-03		MD-09-04		MD-09-05	
		2009	2010	2009	2010	2009	2010
Exotic Forbs con'd							
<i>Taraxacum officinale</i>	regen	0.2	0.2		0.2		
<i>Thlaspi arvense</i>	regen	16			0.2	0.2	
<i>Tragopogon dubium</i>	regen		0.2				
<i>Trifolium agarium</i>	regen				2	0.5	0.5
<i>Trifolium hybridum</i>	regen			0.5	0.2	0.5	0.2
<i>Trifolium pratense</i>	regen	0.2					
<i>Trifolium spp.</i>	regen	0.2	0.2				
<i>Verbascum thapsus</i>	regen	0.5	1	1	0.2	1	0.5
<i>Veronica officinalis</i>	regen	0.2	1	6	13	0.7	2
<i>Veronica serpyllifolia</i>	regen			0.2			
Exotic Grasses		1	4	2	4	1	8
<i>Achnatherum hymenoides</i>	seeded?	0.2		1		0.2	
<i>Agrostis stolonifera</i>	regen		2		3		4
<i>Avena sativa</i>	regen	0.2		0.2			
<i>Bromus inermis</i>	salvage		1			0.5	1
<i>Dactylis glomerata</i>	regen	0.2	0.2		0.2		
<i>Elymus repens</i>	salvage		0.2		0.2	0.2	1
<i>Lolium multiflorum</i>	regen			0.2			
<i>Poa compressa</i>	regen				0.2		0.2
<i>Phleum pratense</i>	regen	0.2	0.2	0.2			1
<i>Poa pratensis</i>	regen	0.2	0.2	0.2		0.2	
"Regreen"	seeded?				0.2		
<i>Setaria glauca</i>	regen			0.2			

VII. HERBICIDE/REVEGETATION EXPERIMENTAL PROJECTS

A. BACKGROUND AND PURPOSE

Noxious weeds have become an immense problem in our native ecosystems. Herbicide treatment is a common and effective way to reduce and sometimes eradicate weed populations. In populations with a high weed density and a persistent seed bank, repeat applications are necessary for many years, sometimes decades. However, with numerous applications many problems arise with native plant populations. While each herbicide application is killing the target weed and in theory depleting its seed bank, it leaves open spaces in the habitat for new colonization. Repeat herbicide applications may not only diminish the seed bank of the target weed, but of desirable species as well. Certain native forb species can especially be affected. This often leads to an increase in colonization by aggressive non-native species, due to opportunistic seeding by prolific weed species or quick colonization by non-native rhizomatous grasses. Once this happens there is very limited space for natives to return.

The purpose of this project is to test the effects of repeated weed control in combination with seeding desirable native species to see if the habitat can be more effectively restored to a native population than weed control alone. The overall aim is to replace the desired seed source after the target weed species and its seed bank has been reduced, in hope that the native seeds will be able to fill the recently opened spaces. The goals for this study are as follows.

1. To reduce noxious weed species using a combination of herbicide and revegetation.
2. To restore native vegetation to areas opened up by the removal of non-native species, thus preventing other exotic plant invasion.
3. To document changes in species composition and cover over time.

B. METHODS

Two different sites were chosen for this experiment. Sites were chosen based on six criteria:

1. **Sites were of manageable size for revegetation and monitoring.** Sites need to be large enough to merit revegetation and monitoring efforts ($\geq 200\text{m}^2$) but not too large (≤ 1 acre) so that revegetation and monitoring assessment becomes difficult.
2. **Weed species must not include *Linaria vulgaris* or *Euphorbia esula*.** Currently, Tordon is the only effective herbicide to use on these two weed species. Both require high concentrations of herbicide that likely have negative impacts on certain native species. It was decided that these areas would not be the best locations to test this experimental protocol.
3. **Weed species must have at least moderate cover and fairly even distribution at a site.** Very low, scattered cover of a weed species would not create enough open spaces when removed to provide for effective reseeding treatment. Areas with extremely high cover of a weed species usually had little to no native cover and were determined difficult to restore. To best test this experimental treatment, it was determined that moderate cover and even distribution of a weed species best fit our criteria.
4. **Site must have some concentration of native species that are able to be seeded.** Since we are interested in seeding native species as a revegetation treatment (due to lower cost and time involved), native species must be present in the target community that can be restored through seeding. A minor amount of planting from containers may be considered.
5. **Site must have low cover of non-native grasses.** As non-native grasses are usually aggressive, often rhizomatous, and have no controls, areas with high to moderately high cover of these exotic grasses were not considered as study sites. From past research, areas with high cover of non-native grasses generally increase in cover dramatically after the decrease in cover of a weed forb species such as spotted knapweed (Tyser and Asebrook, in press). Sites with high cover of non-native grasses are difficult to restore and were not considered for this study.
6. **Site must be relatively accessible.** Since these areas must be sprayed several times, revegetated, and monitored several times, it is best that these sites be accessible (within $\frac{1}{4}$ mile) from a road.

To date, two sites have met the above-listed criteria. The first site is located above the St. Mary Campground. This site was dominated by moderate cover of *Centaurea maculosa*. The second site is located off the Camas Road at the Camas Creek Overlook. The dominant weed species at this site was *Hieracium piloselloides*. Permanent level III experimental plots were set up in each location to evaluate pre-treatment canopy cover, ground cover, and to obtain a species list for each location. Plot locations were selected to sample representative vegetation. Plots were also photo-monitored to see a visual change over time.

1. St. Mary Campground

This site is at the end of a small social trail on a hill just north of the St. Mary Campground (Figure 23). In 2008, two experimental macroplots, 08-01 and 08-02, were set up at this location, one on a flat spot at the top of the hill and one on the slope of the hill to capture the change in microhabitat with slope change. In 2009, an additional plot, 09-01, was established just north of plot 08-01 on the flat spot at the top of the hill. This additional area seemed to have higher shrub cover than the other plots, even after being sprayed with herbicide, which we wanted to document. All three plots are permanent 100m² macroplots, measuring 20m by 5m and marked at all four corners with 12" spikes. In 2008, 2009, and 2010, 20 quarter square meter microplots have been monitored within each plot, re-randomized each year using the x and y axis of the plot. There is no overlap of the microplots to prevent double sampling.

Herbicide has been applied to the entire site or a portion of the site three times. On July 10, 2008, Milestone was sprayed on 0.48 acres of the site at 5 oz/acre. The entire site was not treated at this juncture, including half of plot 08-01, because of time and herbicide limitations. On Aug 25, 2008, 0.98 acres was sprayed with Milestone at the same rate and with Curtail at a rate of 64 oz/acre. The second treatment encompassed both plots, as well as the area that we established plot 09-01 in 2009. The third herbicide treatment occurred on June 15, 2009 just prior to the monitoring of these plots. The entire area was sprayed with Milestone at a rate of 5 oz/acre. This site was spot sprayed in July 2010 a few weeks before monitoring took place. No seeding of this site will take place this year.

2. Camas Creek Overlook

This site consists of a small area alongside the Camas Creek Overlook pullout (Figure 24). This site is along the road shoulder and was originally revegetated in 1998 with the pullout reconstruction. Due to size constraints, only one permanent 50m² rectangular plot, 08-03, was set up in this location. The plot is 10m by 5m with all four corners marked using 12" spikes. Plot location was chosen to best represent the weed population in the area. In 2008, 2009, and 2010, 20 quarter square meter microplots have been monitored within each plot, re-randomized each year using the x and y axis of the plot. There is no overlap of the microplots to prevent double sampling.

The roadside adjacent to this site was treated in early June of 2008. It is uncertain whether the specific study site was treated during this year or not. The Camas Road, including the study site, was treated again on June 1, 2009 with Milestone at a rate of 5 oz/acre. All of the target yellow hawkweed was sprayed at the site at this time. This site has not yet been sprayed in 2010 but is scheduled to be sprayed at the end of July 2010. No seeding of this site will take place this year.

C. RESULTS

1. St. Mary Campground

Although the amount of non-native plant disturbance at this site makes association typing difficult, this area was likely a *Festuca campestris* – (*Festuca idahoensis*) – *Achnatherum richardsonii* grassland prior to dominance of spotted knapweed. The area resembles an open dry grassland – aspen parkland type with a fair amount of *Populus tremuloides* beginning to encroach around the edges and into the upper site. These sites contain a large variety of native forbs and low occurrence of non-native grasses, particularly rhizomatous species, making them ideal conditions for this project.

Prior to herbicide: Prior to spraying herbicide in spring 2008, plot 08-01 was forb dominated, particularly by non-native forbs. Non-native forbs had an average cover of 45% and native forbs had 24% average cover (Table 28). *Centaurea maculosa* had the highest cover of all species present at 44.3%. The only other exotic forbs present were *Taraxacum officinale* and *Tragopogon dubius*. The most predominant native forb species in this plot were *Cerastium arvense* at 4.7%, *Lupinus sericeus* at 3.9%, *Fragaria virginiana* at 3.7%, *Erigeron speciosus* at 2.6%, and *Lomatium triternatum* at 2.2%. There were no tree species present in the microplots, however, *Populus tremuloides* was present in the area. Native

Figure 23. St Mary Weed Revegetation Site: Location of Plots



Figure 24. Camas Creek Overlook Weed Revegetation Site: Location of Plot



Table 32. St. Mary Weed Revegetation Project: Canopy Cover (%) by Species for all plots, 2008-2010.

(1) Ocular cover estimated for species found in macroplot but not in microplots (2) Orange cells are significantly different (90% CI) between years within individual plot; did not run statistics in 2010.

	WEED REVEG 08-01						WEED REVEG 08-02						WEED REVEG 09-01			
	2008		2009		2010		2008		2009		2010		2009		2010	
Species	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover
TOTAL NATIVE TREE		0		0		0		0		0				0		
<i>Populus tremuloides</i>	T															
TOTAL NATIVE SHRUB		4.30		0.56		12.56		3.80		1.80		1.65		3.91		3.00
<i>Amelanchier alnifolia</i>	T				T	0.48		1.95		1.60	1	0.50		0.85		0.00
<i>Arctostaphylos uva-ursi</i>		0.55		0.35		0.85					T			0.80		0.25
<i>Dasiphora floribunda</i>		0.90	1.5	0.06		10.51	T				T			1.75		0.75
<i>Rosa acicularis</i>		1.65				0.25						0.30				
<i>Rosa woodsii</i>		1.20		0.16		0.95		1.85		0.20		0.85		0.51		2.35
<i>Prunus virginiana</i>	T						T				T					
TOTAL NATIVE GRASS		3.24		10.12		19.00		7.40		21.74		25.85		9.01		14.90
<i>Carex sp. (at least 3, inc rossii)</i>		1.48		4.51		5.45		2.81		5.85		3.95		4.10		2.82
<i>Danthonia intermedia</i>		0.01		0.01	T			0.07		0.41		0.22				
<i>Pseudoroegneria spicata</i>		0.05						0.39		2.61		3.61				
<i>Elymus trachycaulus ssp. subsecundus</i>				0.76		1.41		0.06		0.40		0.05		0.10		0.30
<i>Festuca campestris</i>		0.67		2.31		2.35		0.51		1.36		0.02		0.90		2.05
<i>Festuca idahoensis</i>		0.81		1.11		4.90		0.77		2.46		4.17		1.95		2.15
<i>Helictotrichon bookeri</i>								0.15				0.05				
<i>Koeleria macrantha</i>		0.13		0.95		2.05		1.41		3.01		5.81		1.41		3.60
<i>Poa secunda ssp. juncifolia</i>								0.20								
<i>Stipa nelsonii</i>		0.01		0.11		0.86		0.33		0.56		0.81		0.05		0.53
<i>Stipa richardsonii</i>		0.10		0.38		2.00		0.73		5.11		7.12		0.50		3.50
TOTAL NATIVE FORB		23.76		13.57		23.40		19.45		13.59		18.30		14.94		26.00
<i>Achillea millefolium</i>		0.48	T		T			0.57		0.06		0.05				
<i>Agoseris glauca</i>				0.11		0.30								0.21		0.25
<i>Allium cernuum</i>								0.11		0.11		0.35				
<i>Androsace septentrionalis</i>						1.07		0.86								
<i>Anemone multifida</i>		0.36	T		T	0.01				0.40		1.40	T	0.05		0.00
<i>Antennaria anaphaloides</i>		0.05		0.25										0.15		0.00
<i>Antennaria rosea</i>		0.15		0.05			T									
<i>Arabis glabra</i>						0.01										0.65

Table 32 (cont.). St Mary Weed Revegetation Project: Canopy Cover (%) by Species for all plots, 2008-2010.

	WEED REVEG 08-01						WEED REVEG 08-02						WEED REVEG 09-01			
	2008		2009		2010		2008		2009		2010		2009		2010	
Species	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover
TOTAL NATIVE FORB con'd																
<i>Arabis nuttallii</i>	T	0.00		0.01		0.01				0.05				0.01		0.00
<i>Arabis sp.</i>												0.05				
<i>Arenaria capillaris</i>								0.71		0.70		0.05				
<i>Arnica sororia</i>								0.46								
<i>Aster campestris</i>										1.05		0.55				
<i>Aster laevis</i>		0.56		0.10	T	0.01								0.05		0.00
<i>Campanula rotundifolia</i>		1.01		0.05		0.05		0.46		0.01		0.22		0.01		0.25
<i>Cerastium arvense</i>		4.66		2.91		10.11		2.55		1.26		2.56		8.31		10.16
<i>Comandra umbellata</i>			T					0.06		0.25		0.10				
<i>Dracocephalum parviflorum</i>																0.1
<i>Erigeron speciosus</i>		2.62		0.20		1.15		0.05			T	0.40	T			
<i>Erigeron caespitosus</i>								3.06		1.50		5.18				
<i>Fragaria virginiana</i>		3.70		2.65		4.60								1.70		7.55
<i>Gaillardia aristata</i>		0.26						0.30		0.01		0.20				
<i>Galium boreale</i>		0.71		0.05		0.25		1.21		0.20		1.55	T			1.75
<i>Galium triflorum</i>								0.35								
<i>Geranium viscosissimum</i>	T		T		T	0.25								0.20		0.00
<i>Geum triflorum</i>								0.45		0.50		0.05				
<i>Hedysarum sulphurescens</i>		0.10						4.30		0.50		0.10				
<i>Heterotheca villosa</i>							T		T			0.10				
<i>Lithospermum ruderales</i>		0.65		0.80	T	1.05		1.45		0.86		0.85		0.05		0.00
<i>Lupinus sericeus</i>		3.86		1.90		1.33		0.95		0.45	T			0.15		0.55
<i>Lomatium triternatum</i>		2.21		3.30		2.40			T					3.25		1.85
<i>Monarda fistulosa</i>							T					0.20				
<i>Penstemon confertus</i>		1.35		0.35		0.55		0.11		0.15		0.50		0.10		0.05
<i>Polemonium pulcherrimum</i>									T							
<i>Potentilla gracilis</i>		0.86		0.31		0.60			T		T			0.41		1.65
<i>Potentilla hippiana</i>			T			0.01							T			
<i>Potentilla pensylvanica</i>								0.06								
<i>Selaginella densa</i>										3.60		1.56				
<i>Senecio canus</i>		0.20						0.20	T		T					
<i>Sisyrinchium montanum</i>		0.06						0.06	T		T					0.10
<i>Solidago multiradiata</i>		0.15		0.55	T			1.05		1.80		2.21		0.31		0.00
<i>Viola adunca</i>								0.11								
<i>Zigadenus venenosus</i>							T			0.15		0.01				

Table 32 (cont.). St Mary Weed Revegetation Project: Canopy Cover (%) by Species for all plots, 2008-2010.

Species	WEED REVEG 08-01						WEED REVEG 08-02						WEED REVEG 09-01			
	2008		2009		2010		2008		2009		2010		2009		2010	
	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover
TOTAL EXOTIC GRASS		0.53		1.11		8.27		2.57		6.76		9.86		2.32		5.10
<i>Agrostis stolonifera</i>		0.12														
<i>Phleum pratense</i>		0.22		0.36		1.47		1.37		5.21		9.06		0.17		1.97
<i>Poa compressa</i>		0.01														0.15
<i>Poa pratensis</i>		0.19		0.75		6.81		1.20		1.55		0.80		2.16		3.00
TOTAL EXOTIC FORB		44.68		0.10		11.11		37.37		0.05		4.95		0.36		12.90
<i>Alyssum alyssoides</i>					T							0.15				
<i>Centaurea maculosa</i>		44.25				9.96		37.15	T			4.80		0.01		11.30
<i>Chenopodium album</i>					T											
<i>Decurainia sophia</i>						0.02										
<i>Taraxacum officinale</i>		0.06		0.10		0.71		0.06						0.35		0.86
<i>Tragopogon dubius</i>		0.38				0.47		0.16		0.05			T			0.51
# of CENMAC plants		118.65		0		41.15		97.05		0		4.2		0.10		4.95

shrub cover was low at 4.3%. *Rosa acicularis* and *Rosa woodsii* were the most frequently occurring shrub species at 1.7% and 1.2% cover, respectively. Native grasses were also low with 3.2% cover, dominated by a variety of *Carex* species at 1.5% cover. *Carex rossii* was the only species that could be positively identified; all others were in a vegetative phase and could not be keyed. Exotic grass cover was extremely low with only 0.5% cover. *Poa pratensis* was the most common exotic grass at 0.2% cover while *Agrostis stolonifera* was present with 0.1% cover.

Plot 08-02 was also primarily dominated by *Centaurea maculosa* with 37.2% canopy cover (Table 28). *Taraxacum officinale* and *Tragopogon dubius* each had trace cover, resulting in 37.4% total exotic forb cover. Native forbs had 19.5% cover, dominated by *Hedysarum sulphurescens* at 4.3% cover, *Erigeron caespitosus* at 3.1% cover, and *Cerastium arvense* at 2.6% cover. Shrubs made up 3.8% cover with 2.0% cover of *Amelanchier alnifolia* and 1.8% cover of *Rosa woodsii*. Native grass cover was 7.4%, dominated by *Carex sp.* at 2.8% cover and *Koeleria macrantha* at 1.4% cover. Exotic grasses have a slightly higher cover in this plot with 2.6% cover, consisting of 1.4% *Poa pratensis* and 1.2% *Poa pratensis*.

No data was not collected on plot 09-01 prior to herbicide treatment. It is assumed that conditions were similar on this plot to plot 08-01 described above.

Post-herbicide but prior to re-seeding: Plots were monitored in July 2010, after most of the area had been spot sprayed in the spring and had been sprayed three times in prior years. Similar trends for all three plots include increases in all lifeforms, both native and exotic, except for shrubs which remained the same in plots 08-02 and 09-01. Unlike last year when both native and exotic forbs showed significant declines in cover, both lifeforms increased in cover this year. Both native and exotic grasses continued to increase in cover, similar to last year. There was no tree cover detected in any plot in any year.

The recovery of native forbs within this project is perhaps the most dramatic result of this year. Currently, native forbs are the dominant lifeform on all three plots. Native forbs on plot 08-01 increased by approximately 10%, on plot 08-02 by approximately 5%, and on plot 09-01 by approximately 11% (Table 32). This increase is due primarily to increases in cover of *Cerastium arvense*, *Fragaria virginiana*, and *Galium boreale* throughout the project and of *Potentilla gracilis*, *Androsace septentrionalis*, *Erigeron speciosus*, *Erigeron caespitosus*, and *Anemone multifida* on certain plots. The trend for these species is completely opposite of results last year when all of these species, except for *Anemone multifida*, decreased in cover. It appears that the change from blanket spraying to spot spraying, even in the period of one year, can allow certain species to recover. Other native forb species that continue to show some increase in cover, indicating their tolerance for herbicide application, include *Arabis glabra* and *Campanula rotundifolia*. *Achillea millefolium*, *Agoseris glauca*, *Allium cernuum*, *Heterotheca villosa*, *Lithospermum ruderae*, *Lupinus sericeus*, *Monarda fistulosa*, *Penstemon confertus*, *Senecio canus*, and *Sisyrinchium montanum* appear to maintain but not increase their cover with spot-spraying herbicide application. Finally, a few species had mixed results, increasing or maintaining cover on some plots while decreasing on other plots. These include *Arabis nuttallii*, *Gaillardia aristata*, *Geranium viscosissimum*, *Lomatium triternatum*, *Potentilla hippiana*, *Solidago multiradiata*, and *Zigadenus venenosus*. Only *Antennaria anaphaloides*, *Antennaria rosea*, *Arenaria capillaris*, *Arnica sororia*, *Aster campestris*, *Symphotrichum laeve*, *Comandra umbellata*, *Galium triflorum*, *Geum triflorum*, *Hedysarum sulphurescens*, *Polemonium pulcherrimum*, *Potentilla pensylvanica*, and *Viola adunca* decreased or continued to decrease in cover throughout all plots. Many of these species belong to the aster and pea families that tend to be more sensitive to herbicide application.

Total native grass cover also increased on all three plots, resulting in the second highest lifeform cover on the project. Native grass cover increased by 9% on plot 08-01, by 4% on plot 08-02, and by 6% on plot 09-01. These increases were due primarily to increases of *Festuca idahoensis*, *Koeleria macrantha*, *Stipa nelsonii*, and *Stipa richardsonii* throughout the project and *Pseudoroegneria spicata* where it was present. *Elymus trachycaulus ssp. trachycaulus* is also slowly increasing where it is present. *Carex spp.*, which significantly increased in cover last year, decreased in cover on two plots this year and increased in cover on one plot. Despite the decreases, it remains one of the dominant grass species of the project area with moderate cover on all three plots. *Festuca campestris* also had mixed results, maintaining cover on one plot, decreasing in cover on one plot, and increasing in cover on one plot. As this grass is not usually negatively impacted by herbicide, reasons for these results are unknown and future monitoring may better track the trend of this grass. *Danthonia intermedia* remained with low, unchanged cover on two plots where it has been present. Finally, while herbicide may have negatively impacted *Poa secunda ssp. juncifolia* which disappeared from plot 08-02, *Helictotrichon bookeri* has returned to plot 08-02 with low cover where it was originally documented.

Another clear result of monitoring in 2010 is that spraying of *Centaurea maculosa* must continue on a regular schedule to control this noxious weed species over time. Although cover of exotic forbs, mostly comprised of *Centaurea maculosa*, significant declined last year from 37% - 44% down to 0.05% - 0.36%, cover has significantly

increased this year to 4.8% - 11.3%. While this cover has not reached pre-treatment levels, the dramatic increase of *Centaurea maculosa* in such a short time frame reiterates the importance of consistent spot spraying. As stated, the increase of exotic forb cover is due almost exclusively to the significant increase of *Centaurea maculosa* which increased on all three plots and is the dominant exotic forb species. It is important to note, however, that this area had just been sprayed in July a few weeks prior to monitoring. It was clear that a fair amount of *Centaurea maculosa* was dying but it was still green at the time of monitoring and thus counted as live material. It is very possible that if we had monitored this area later in the summer, *Centaurea maculosa* and exotic forb cover would be much lower. In addition, it is important to note that no other exotic forb species have become established in this area, likely due to the low diversity of exotic forbs prior to treatment. *Taraxacum officinale* and *Taraxacum officinale*, the only other exotic forb species in the project area, remain with low cover where they are present.

Similarly, the diversity of exotic grasses in this project area also remains very low. Only three exotic grass species are present, including *Phleum pratense*, *Poa pratensis*, and *Poa compressa*. *Phleum pratense* and *Poa pratensis* dominate different plots and both are generally increasing throughout the project, resulting in the overall increase of exotic grasses on all three plots. This is typical of these grasses under continued disturbance where they are opportunistic at filling in open spaces and outcompeting native species for resources. *Poa compressa* remains with low cover on one plot and *Agrostis stolonifera*, which disappeared from one plot two years ago, has not re-established in the area.

Finally, shrub cover, which was negatively impacted by herbicide application last year, generally maintained or increased in cover this year indicating that some of these shrub species may have the ability to recover after initial impacts from herbicide. Plot 08-01 had the biggest changes over the last two years with a decrease in *Dasiphora floribunda*, *Rosa acicularis*, and *Rosa woodsii* cover last year, which conversely this year, all increased in cover. Most of the increase was due to a significant increase of *Dasiphora floribunda* that increased from 0.56% cover last year to 10.51% cover this year. *Rosa woodsii* increased this year to near its pre-treatment cover and *Rosa acicularis* is slowly increasing in cover after disappearing from the plot. Cover of *Amelanchier alnifolia* decreased on plots 08-02 and 09-01, although an increase in cover of *Rosa woodsii* (after decreasing last year) resulted in similar overall shrub cover to last year on both plots. *Prunus virginiana*, which disappeared from both plots last year, re-established on plot 08-02 this year.

2. Camas Creek Overlook

This site was previously revegetated in 1998 as part of a larger restoration effort along the Camas Road. This site is a road shoulder that had been disturbed and revegetated to make a parking area for the overlook. Although the modifications to the road shoulder area now make this a different kind of plant community, a site analysis done in 1995 before construction took place reveals that the adjacent forest falls within a *Picea engelmannii*/*Vaccinium caespitosum* habitat type. This site analysis will assist us in making seeding and planting recommendations for this site. Overall, the small size of this site, its accessibility, the diversity of native forbs and grasses, and low cover of exotic grasses provided another set of good conditions for this project.

Prior to herbicide: Prior to spraying herbicide, this site was forb dominated with native forbs comprising 16% cover and non-native forbs comprising almost 15% cover (Table 29). *Achillea millefolium*, *Penstemon confertus*, and *Fragaria virginiana* were the most dominant native plants comprising 12% of the native forb cover. *Hieracium piloselloides* and *Medicago lupulina* dominated the non-native plants with 6.4% and 5.6% cover, respectively. Trees had 5% cover, mainly due to the one *Picea engelmannii* sapling in the plot. Shrubs had 1.9% cover with *Rosa woodsii* and *Salix drummondiana* comprising all of the cover. Native grass had nearly 10% cover, dominated by 5.3% cover of *Festuca idahoensis* and 4% cover of *Koeleria macrantha*. Finally, exotic grass had almost 5% cover, dominated by *Agrostis stolonifera* with 2.5% cover and *Phleum pratense* with 1.5% cover.

Hieracium piloselloides had a much higher frequency on the west side of the plot. Due to the randomization of the microplots, the thickest area of *H. piloselloides* was not commonly sampled. Therefore, this site may have been slightly under sampled for this weed species.

Post-herbicide but prior to re-seeding: Unlike results at St. Mary Campground where almost all native and exotic lifeforms increased in cover this year, spraying of herbicide at the Camas Overlook site caused all native and exotic lifeforms to decrease in cover this year. This is a different trend for this site compared to last year when shrub, native grasses, and exotic grasses each increased in cover.

On a positive note, it is encouraging to see both exotic forbs and exotic grasses decrease in cover. For exotic forbs, this is the second year in a row that exotic forbs have decreased, indicating that herbicide application is indeed controlling weed species at this site. Exotic forbs at the Camas Overlook site have decreased from 14.5% to 7.4% to

Table 33. Camas Creek Overlook Weed Revegetation Project: Canopy Cover (%) by species, 2008-2010.

(1) Ocular cover estimated for species found in macroplot but not in microplots (2) Orange cells are significantly different (90% CI) between years within individual plot; did not run statistics in 2010

Species	WEED REVEG 08-03					
	2008		2009		2010	
	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover
TOTAL NATIVE TREE		4.55		1.75		0.20
<i>Larix occidentalis</i>	1	0.05		0.50		0.01
<i>Picea engelmannii</i>		4.50		1.25		
<i>Populus balsamifera</i>			T			
<i>Pseudotsuga menziesii</i>	T		T			
TOTAL NATIVE SHRUB		1.85		2.66		0.51
<i>Rosa woodsii</i>		1.10		2.66		0.36
<i>Salix sitchensis</i>		0.75	1			0.15
<i>Spiraea betulifolia</i>	T				T	
TOTAL NATIVE GRASS		9.82		12.96		7.42
<i>Bromus carinatus</i>				0.01		
<i>Danthonia intermedia</i>		0.01				0.03
<i>Elymus glaucus</i>		0.32				
<i>Elymus trachycaulus?</i>				0.56		
<i>Festuca idahoensis</i>		5.30		6.30		4.52
<i>Festuca occidentalis</i>		0.05				0.01
<i>Koeleria macrantha</i>		3.95		6.11		2.96
<i>Poa interior</i>		0.20				
TOTAL NATIVE FORB		15.94		7.29		5.8
<i>Achillea millefolium</i>		4.26		1.87		1.28
<i>Antennaria rosea</i>	T		T			0.05
<i>Antennaria howellii</i>			T			0.01
<i>Aster sp.</i>	T		T			
<i>Collinsia parviflora</i>				0.11		
<i>Collomia linearis</i>				0.06		
<i>Epilobium sp.</i>						0.01
<i>Epilobium brachycarpum</i>		0.52		0.01		0.36
<i>Fragaria virginiana</i>		1.90		0.15		0.10
<i>Lupinus sericeus</i>	T		T		T	
<i>Microsteris gracilis</i>		1.62		0.12		0.73
<i>Penstemon confertus</i>		6.00	3	3.86		2.83
<i>Potentilla gracilis</i>		0.10	T			
<i>Solidago canadensis</i>		0.15	1	0.15	1	
<i>Senecio sp.</i>	in area					
<i>Symphotrichum laeve</i>		0.95		0.85		0.60
Unk. hairy alternate lvs (solidago like)		0.11				
<i>Viola sp.</i>		0.01				
TOTAL EXOTIC GRASS		4.83		5.37		3.22
<i>Agrostis sp.</i>		2.50		0.71		0.41
<i>Bromus inermis</i>		0.01		0.30		
<i>Elymus repens</i>		0.61				0.31
<i>Phleum pratense</i>		1.51		3.27		2.46
<i>Poa compressa</i>				0.30		
<i>Poa pratensis</i>		0.21		0.80		0.11

Table 33 (con'd). Camas Creek Overlook Weed Revegetation Project: Canopy Cover (%) by species, 2008-2010.

Species	WEED REVEG 08-03					
	2008		2009		2010	
	Ocular Cover	Average Cover	Ocular Cover	Average Cover	Ocular Cover	Average Cover
TOTAL EXOTIC FORB		14.54		7.36		5.45
<i>Arenaria serpyllifolia</i>		0.61		0.46		0.22
<i>Capsella bursa-pastoris</i>						0.01
<i>Centaurea maculosa</i>	<i>in area</i>					
<i>Cirsium arvense</i>	<i>T</i>					
<i>Filago arvensis</i>		0.33		0.13		0.19
<i>Hieracium piloselloides</i>		6.40		0.02		1.20
<i>Hypericum perforatum</i>	<i>in area</i>					
<i>Leucanthemum vulgare</i>	<i>T+</i>			0.01		0.06
<i>Myosotis micrantha</i>		0.61		0.33		0.15
<i>Medicago lupulina</i>		5.61		4.53		1.92
<i>Melilotus sp.</i>			<i>T</i>			
<i>Rumex acetosella</i>		0.40		0.26		0.48
<i>Taraxacum officinale</i>		0.81		1.36		0.90
<i>Thlaspi arvense</i>		0.01				0.01
<i>Tragopogon dubius</i>		0.11		0.41		0.52
<i>Trifolium agrarium</i>					<i>1</i>	
<i>Trifolium pratense</i>	<i>T</i>				<i>T</i>	
<i>Veronica peregrina</i>				0.01		0.02
<i>Veronica serpyllifolia</i>						0.02
<i>Verbascum thapsus</i>	<i>T</i>					0.30
<i>Vicia villosa</i>	<i>T</i>					
# of HIEPIL rosettes		9.10		0.20		3.20

5.5% cover over the past three years, due mostly to consistent decreases in cover of *Medicago lupulina*, *Myosotis micrantha*, and *Arenaria serpyllifolia*. *Hieracium piloselloides* significantly decreased in cover and density last year, but regained some of that cover and density this year. This is likely due to the fact that this site has not yet been sprayed in 2010. As stated above, the quick increase in the cover of noxious weeds at both of these sites in a short time frame reiterates the importance of consistent spot spraying. All other weed species basically maintained their cover. *Tragopogon dubius* is the only other species that increased in cover. Currently, *Medicago lupulina*, *Hieracium piloselloides*, *Taraxacum officinale*, and *Tragopogon dubius* are the most dominant exotic forbs within the project area.

Unlike last year when exotic grasses increased in cover, exotic grasses decreased slightly in cover this year. Overall cover decreased from 5.37% to 3.22%, due primarily to small decreases of all exotic grasses on the project. This is an interesting trend given that almost all of these exotic grasses had slight increases in cover this year. *Pbleum pratense* remains the dominant exotic grass in this area. Although *Elymus repens* was observed again after not being documented last year, both *Poa compressa* and *Bromus inermis* disappeared from the restoration area. Overall, exotic grass cover remains relatively low in comparison to other restoration projects. It is a positive result that exotic cover has remained lower than both native forb and native grass cover at this point in time.

Similar to the exotic plants on this project, both native forbs and native grasses also decreased in cover. Native forbs continued to decrease for the second year in a row from 7.3% to 5.8% cover at the Camas Overlook site. Declines were due mostly to decreases of *Achillea millefolium*, *Symphyotrichum laeve*, *Penstemon confertus* and the disappearance of *Collinsia parviflora*, *Collomia linearis*, and *Potentilla gracilis*. Most of these species decreased in cover last year as well, indicating a negative response to herbicide application. All of these species are listed below as either species negatively impacted by herbicide or having mixed results with herbicide application (Table 34). At the same time, several species increased or maintained their cover. Species that increased slightly in cover include *Epilobium brachycarpum* and *Microsteris gracilis*, while species that maintained their cover include *Antennaria rosea*, *Fragaria virginiana*, *Lupinus sericeus*, *Solidago canadensis*, and *Antennaria howellia*. These are unusual results as many of these species are often negatively impacted by herbicide (Table 34).

After increasing in cover last year, overall native grasses declined in 2010. Native grass cover decreased from 12.96% to 7.42%. The decrease was due to decreases of *Festuca idahoensis* and *Koeleria macrantha*, two grass species that increased in cover last year. Adding to the decline in cover is the disappearance of *Elymus trachycaulus*, *Bromus carinatus*, and *Elymus glaucus*, species that existed last year with trace cover. Despite this decrease in cover, native grasses remain the lifeform with the highest cover for the second year in a row and *F. idahoensis* and *K. macrantha* remain the most dominant native grasses at this site. Both of these grass species often increase in cover when herbicide application reduces the cover of other species.

Finally, unlike last year when trees decreased in cover and shrubs increased in cover, this year both trees and shrubs decreased in overall cover. Total tree cover decreased from 4.6% to 1.8% to 0.2% cover over the last three years, due primarily to the mortality of the one *Picea engelmannii* sapling that was within the plot. It may be that herbicide application negatively affected this individual tree. Total native shrub cover decreased as well from 2.7% to 0.5% cover. This was due to a notable decrease in cover of *Rosa woodsii* that had increased in cover only the year before. It is interesting to note that *R. woodsii* significantly decreased on the St. Mary site after herbicide application.

D. CONCLUSIONS AND RECOMMENDATIONS

Overall, herbicide treatment at the two selected project sites has been effective at significantly reducing target weed populations. *Centaurea maculosa* at the St. Mary site and *Hieracium piloselloides* at the Camas Overlook site had each been reduced to trace cover last year and remain lower in cover than pre-treatment levels this year. That said, cover of both noxious weeds is increasing again and it is clear that herbicide application must continue on an annual basis to assure the long-term control of these weeds. Herbicide application has also reduced other non-target exotic forb species, providing additional benefit that would be good to continue.

Data have also documented negative impacts of herbicide application, particularly the loss of certain native forb species, the decline of all native lifeforms at the Camas Overlook site, and the ‘release’ of certain exotic grasses that often opportunistically increase with additional space. These impacts, however, were typically less than observed on other projects, very few native forb species have disappeared altogether, and finally, as evidenced at the St. Mary site, several native forb species that had decreased in cover in the past are beginning to rebound. Similarly, increases of exotic grass cover were less than observed on other projects and native grasses were also ‘released’ with the removal of weed species, increasing dramatically at the St. Mary site.

The challenge remaining to this project is twofold:

- (1) Maintain low cover of target weed species by ongoing weed control, including herbicide application and/or hand pulling. Herbicide application may now exist as spot spraying since cover of target weed species is lower.
- (2) Return native species and cover to these sites to fill the space once occupied by weed species. It is important to return the appropriate native species to these sites that may withstand future herbicide application.

To address the first management item, both sites should be sprayed again in the spring of 2011 and if possible, spot sprayed in the fall of 2011 prior to seeding in the fall. A total of seven herbicide applications over a period of three year period should not only have reduced overall cover of the target weed species but also control new germinants from the seed bank. Although *Centaurea maculosa* seeds can have viability for as long as ten years, studies show that the seed bank can decrease as much as 81% after 15 months of treatment (Chicoine, 1984). Consistent treatment of *Hieracium piloselloides* can also reduce the seed bank of this weed species, as well as prevent the establishment of stolons that this plant uses to spread.

To address the second management item, it is first important to understand which of our local grassland species have shown the ability to persist under an herbicide spraying regime. In addition to data collected from these two projects sites, data concerning the response of both native and exotic species to clopyralid (“Stinger”) herbicide application was also collected during a study along the Going-To-The-Sun Road near Two Dog Flats from 1992 to 2002 (Tyser and Asebrook, in press). The combination of the data from the three sites is the basis for a preliminary table delineating the impacts of herbicide on native and exotic grassland plants of our area (Table 34). Please note in the “mixed impact” column that results were either mixed due to the use of two different herbicides (Stinger vs. Milestone) on the three projects or the fact that sometimes a plant was initially impacted by herbicide but was able to recover substantially over time. In the future with additional data, there may be another column assessing plant species ability to recover under no to little herbicide application.

Table 34. Herbicide Impacts on Certain Native and Exotic Plants in Glacier NP.

Herbicide Negatively Impacts	Herbicide Positively Impact	Herbicide has Neutral Impact	Herbicide has Mixed Impact
Shrubs			
<i>Amelanchier alnifolia</i>		<i>Arctostaphylos uva-ursi</i>	<i>Dasiphora floribunda</i>
<i>Prunus virginiana</i>			<i>Symphoricarpos albus</i>
<i>Spiraea betulifolia</i>			<i>Rosa acicularis/ woodsii</i>
Native forbs			
<i>Achillea millefolium</i>	<i>Polemonium pulcherrimum</i>	<i>Allium cernuum</i>	<i>Agoseris glauca</i> (↑ Milestone, ↓ Stinger)
<i>Antennaria anaphaloides</i>	<i>Potentilla glandulosa</i>	<i>Arabis nuttallii</i>	<i>Androsace septentrionalis</i> (↓ Milestone, ↔ Stinger)
<i>Antennaria rosea</i>	<i>Potentilla hippiana</i>	<i>Arenaria capillaris</i>	<i>Anemone multifida</i> (can recover)
<i>Arnica sororia</i>		<i>Arenaria rubella</i>	<i>Aster campestris</i>
<i>Astragalus spp.</i>		<i>Comandra umbellata</i>	<i>Campanula rotundifolia</i> (can recover)
<i>Epilobium brachycarpum</i>		<i>Lomatium triternatum</i>	<i>Cerastium arvense</i> (can recover)
<i>Gaillardia aristata</i>		<i>Geranium viscosissimum</i>	<i>Collinsia parviflora</i>
<i>Galium triflorum</i>		<i>Geum triflorum</i>	<i>Collomia linearis</i>
<i>Hedysarum sulphurescens</i>		<i>Heuchera cylindrica</i>	<i>Erigeron caespitosus</i> (can recover)
<i>Monarda fistulosa</i>		<i>Heterotheca villosa</i>	<i>Erigeron speciosus</i> (can recover)
<i>Oxytropis spp.</i>		<i>Lithospermum ruderales</i>	<i>Fragaria virginiana</i> (↓ Milestone, ↑ Stinger)
<i>Rhinanthus crista-galli</i>		<i>Polygonum douglasii</i>	<i>Galium boreale</i> (↓ Milestone, ↔ Stinger)
<i>Solidago canadensis</i>		<i>Senecio canus</i>	<i>Lupinus sericeus</i> (can recover)
<i>Symphyotrichum laeve</i>		<i>Sisyrinchium montanum</i>	<i>Microsteris gracilis</i> (↓ Milestone, ↔ Stinger)
<i>Vicia americana</i>			<i>Penstemon confertus</i> (↓ Milestone, ↑ Stinger)
<i>Viola adunca</i>			<i>Potentilla gracilis</i> (↓ Milestone, ↑ Stinger)
<i>Zigadenus venenosus</i>			<i>Potentilla pensylvanica</i> (not enough info)
			<i>Solidago multiradiata</i>
Native grasses			
<i>Elymus lanceolatus</i>	<i>Agrostis scabra</i>	<i>Pseudoroegneria spicata</i>	<i>Danthonia intermedia</i>
<i>Festuca occidentalis</i>	<i>Bromus carinatus</i>		<i>Elymus glaucus</i>
<i>Helictotrichon hookeri</i>	<i>Carex spp.</i>		<i>Poa secunda</i>
<i>Poa interior</i>	<i>Elymus trachycaulus spp. trachycaulus</i>		

Herbicide Negatively Impacts	Herbicide Positively Impact	Herbicide has Neutral Impact	Herbicide has Mixed Impact
	<i>Elymus trachycaulus</i> spp. <i>unilaterale</i>		
	<i>Festuca campestris</i>		
	<i>Festuca idahoensis</i>		
	<i>Koeleria macrantha</i>		
	<i>Stipa nelsonii</i>		
	<i>Stipa richardsonii</i>		
Exotic forbs			
<i>Centaurea maculosa</i>		<i>Alyssum alyssoides</i>	<i>Taraxacum officinale</i>
<i>Cirsium arvense</i>		<i>Arenaria serpyllifolia</i>	<i>Tragopogon dubius</i>
<i>Hieracium piloselloides</i>		<i>Leucanthemum vulgare</i>	<i>Verbascum thapsus</i>
<i>Medicago lupulina</i>		<i>Rumex acetosella</i>	
<i>Melilotus</i> spp.			
<i>Myosotis micrantha</i>			
<i>Thlaspi arvense</i>			
<i>Trifolium</i> spp.			
<i>Vicia villosa</i>			
Exotic grasses			
<i>Agrostis stolonifera</i>	<i>Bromus inermis</i>		
<i>Elymus repens</i>	<i>Bromus tectorum</i>		
	<i>Phleum pratense</i>		
	<i>Poa compressa</i>		
	<i>Poa pratensis</i>		

Other studies are also beginning to gather data on the effects of herbicide on native forbs and shrubs. In particular, Halsvedt et. al. (2010) have established field experiments to test the effects of Milestone on native forbs and shrubs at ten sites throughout Montana, North Dakota, Minnesota, and Colorado. Their report includes a list of plants and their tolerances to herbicide including tolerant (<15% plant injury in stand), moderately tolerant (15-50% plant injury), moderately susceptible (51-75% plant injury), and susceptible (>75% plant injury). Although our results did not use this same ranking system and our definition of susceptible was stricter in the sense that notable decreases in cover included the plant in the “herbicide negatively impacts” category, a number of our conclusions about herbicide tolerances were similar (Table 35). Cells highlighted in red indicate notable differences in herbicide tolerance results between our study and Halsvedt et. al. It is important to note that results for these differences may be due to the differences in how each study determined “tolerant” versus “susceptible”. In addition, certain plants that were compared in Table 35 were similar but not always the same species.

Table 35. Herbicide Tolerance Rankings for Certain Native and Exotic Species in Glacier NP.

Species (Halsvedt species / GNP species)	Halsvedt et. al. ranking (year 1)	GNP ranking
<i>Lomatium triternatum</i>	Moderately tolerant	Neutral Impact - tolerant
<i>Gaillardia aristata</i>	Moderately tolerant	Negative Impact - susceptible
<i>Solidago canadensis</i>	Moderately susceptible	Negative Impact - susceptible
<i>Heterotheca villosa</i>	Moderately tolerant	Neutral impact - tolerant
<i>Solidago missouriensis</i> vs. <i>Solidago multiradiata</i>	Moderately tolerant	Mixed Impact - tolerant
<i>Arnica fulgens</i> vs. <i>Arnica sororia</i>	Susceptible	Negative Impact - susceptible
<i>Antennaria rosea</i>	Moderately tolerant	Negative Impact - susceptible
<i>Erigeron pumilus</i> vs. <i>Erigeron caespitosus</i>	Moderately tolerant	Mixed Impact - tolerant
<i>Symphyotrichum laeve</i>	Moderately tolerant	Negative Impact - susceptible
<i>Melilotus officinalis</i>	Susceptible	Negative Impact - susceptible
<i>Achillea millefolium</i>	Susceptible	Negative Impact - susceptible
<i>Lithospermum ruderales</i>	Moderately tolerant	Neutral impact - tolerant
<i>Arabis nuttallii</i>	Tolerant	Neutral impact - tolerant
<i>Cerastium arvense</i>	Moderately susceptible	Mixed Impact - susceptible
<i>Arenaria capillaris</i>	Susceptible	Neutral impact - tolerant
<i>Lupinus sericeus</i>	Tolerant	Mixed Impact - tolerant
<i>Astragalus miser</i> vs. <i>Astragalus</i> spp	Susceptible	Negative Impact - susceptible

Species (Halsvedt species / GNP species)	Halsvedt et. al. ranking (year 1)	GNP ranking
<i>Zigadenus venenosus</i>	Tolerant	Negative Impact - susceptible
<i>Monarda fistulosa</i>	Tolerant	Negative Impact - susceptible
<i>Allium stellatum</i> vs. <i>Allium cernuum</i>	Tolerant	Neutral impact - tolerant
<i>Epilobium paniculatum</i> vs. <i>Epilobium brachycarpum</i>	Susceptible	Negative Impact - susceptible
<i>Collomia linearis</i>	Susceptible	Mixed Impact - tolerant
<i>Microsteris gracilis</i>	Tolerant	Mixed Impact - tolerant
<i>Androsace occidentalis</i> vs. <i>Androsace septentrionalis</i>	Moderately susceptible	Mixed Impact - tolerant
<i>Potentilla arguta</i> vs. <i>Potentilla glandulosa</i>	Susceptible	Positive Impact - tolerant
<i>Geum triflorum</i>	Moderately tolerant	Neutral impact - tolerant
<i>Potentilla gracilis</i>	Susceptible	Mixed Impact - tolerant
<i>Fragaria virginiana</i>	Tolerant	Mixed Impact - tolerant
<i>Collinsia parviflora</i>	Tolerant	Mixed Impact - tolerant
<i>Viola nuttallii</i> vs. <i>Viola adunca</i>	Moderately susceptible	Negative Impact - susceptible
<i>Arctostaphylos uva-ursi</i>	Tolerant	Neutral impact - tolerant
<i>Prunus virginiana</i>	Moderately tolerant	Negative Impact - susceptible
<i>Amelanchier alnifolia</i>	Susceptible	Negative Impact - susceptible
<i>Rosa woodsii</i>	Susceptible	Mixed Impact - tolerant

Using the above information on herbicide tolerances, a recommended species list for seeding each area was compiled. These species lists incorporate existing native vegetation, tolerances to herbicide, and nearby existing vegetation. Given the higher diversity of plant species at the St. Mary Campground site, two species lists are proposed: one for initial seeding in the fall of 2011 and one for one to three years after initial seeding when the area only requires minimal herbicide application or annual spot spraying (Table 36). Only one seeding prescription is recommended for the Camas Overlook site (Table 37). Both sites should continue to be monitored at years 1, 2, 3, 5, 10, and 20 after revegetation. Sites should also be monitored for presence of weed populations so that continued control can take place.

Table 36. Recommended Revegetation Species for St. Mary Weed Revegetation Site

Species in *blue* were found within plots

Species in *black* were found in the macroplots or in the nearby area, but were not located within the microplots.

Grasses and Forbs to seed in the fall of 2011

<u>Dominant Grasses</u>	<u>Common Grasses (lower seed rate)</u>	<u>Dominant Forbs</u>	<u>Common Forbs (lower seed rate)</u>
<i>Carex hoodii</i>	<i>Carex filifolia</i>	<i>Penstemon confertus</i>	<i>Geranium viscosissimum</i>
<i>Carex petasata</i>	<i>Carex geyeri</i>		<i>Geum triflorum</i>
<i>Festuca campestris</i>	<i>Elymus trachycaulus</i> ssp. <i>trachycaulus</i>		<i>Polemonium pulcherrimum</i>
<i>Festuca idahoensis</i>	<i>Pseudoroegneria spicata</i>		<i>Potentilla gracilis</i>
<i>Koeleria macrantha</i>	<i>Stipa nelsonii</i>		
	<i>Stipa richardsonii</i>		

Potential forbs, grasses, and shrubs to seed/plant at later date (1 to 3 years from 2011):

<u>Shrubs to Plant</u>	<u>Dominant Forbs</u>	<u>Grasses</u>
<i>Arctostaphylos uva-ursi</i>	<i>Antennaria rosea</i>	<i>Carex obtusata</i>
<i>Dasiphora floribunda</i>	<i>Fragaria virginiana</i> (plant)	<i>Carex rossii</i>
<i>Mahonia repens</i>	<i>Erigeron speciosus/caespitosus</i>	<i>Danthonia intermedia</i>
	<i>Gaillardia aristata</i>	
	<i>Hedysarum sulphurescens</i>	
	<i>Heterotheca villosa</i>	
	<i>Lupinus sericeus</i>	
	<i>Symphyotrichum laeve</i>	

Table 37. Recommended Revegetation Species for Camas Creek Overlook Weed Revegetation Site

Forbs

Penstemon confertus
Solidago canadensis
Symphotrichum laeve

Grasses

Elymus trachycaulus spp. *trachycaulus*
Festuca idahoensis
Koeleria macrantha

Potential forbs, grasses, and shrubs to seed/plant at later date (1 to 3 years from 2011):

Shrubs to Plant

Rosa woodsii
Shepherdia canadensis
Spiraea betulifolia

Forbs

Antennaria rosea
Fragaria virginiana (plant)
Lupinus sericeus

VIII. ST. MARY VISITOR CENTER

A. BACKGROUND AND PURPOSE

Construction surrounding the St. Mary Visitor Center coincided with creation of the Apgar Transit System, which provides shuttle service across the Going-to-the-Sun Road. The parking lot around the St. Mary Visitor Center was renovated while accommodating a new transit stop and was completed in 2008. Parking lot islands and bare areas surrounding the visitor center were initially planted in the spring and fall of 2008. A total of 3,582 plants were planted in June and September in the various islands in the parking lot (Table 40). These areas were not supplementally seeded. Bark mulch was used to cover the soil for moisture retention. However, most of this mulch was blown away throughout the winter of 2008-2009. Many plants did not survive the winter due to root exposure when topsoil was blown away along with the mulch. The perimeter of the parking lot and visitor center were also hydroseeded in the fall of 2008. A total of 1.5 acres were hydroseeded in the St. Mary Visitor Center area (Table 39). Weeds recruited due to open habitat on parking lot islands and since much of the hydroseed didn't germinate until the fall of 2009.

During the season of 2009, plants were added to all of the islands. During May, June, August and September, 1,514 additional forbs, shrubs and grasses were planted in the islands around the St. Mary Visitor Center. The islands were also weeded extensively on multiple occasions. *Cirsium arvense*, *Bromus tectorum*, *Polygonum convolvulus*, *Centaurea stoebe*, *Kochia scoparia*, *Thlaspi arvense*, and *Linaria vulgaris* were the most common weeds found growing in the planting areas (Revegetation Crew Completion Report 2009). Weeds were also prolific in the hydroseeded area and some of these were pulled as well.

Supplementary plant material was again added in 2010. In May and June, 767 forbs, shrubs, and grasses were added to parking lot islands of St. Mary Visitor Center. Additional work to the area is recommended in the future with several islands still in need of more plant material. Non-native grasses continue to dominate areas, particularly those that have previously been mowed, and it is suggested that non-native grasses be removed or a barrier be placed between these areas and planted areas (Revegetation Crew Completion Report 2010).

B. METHODS

In August 2010, six monitoring plots were established at the St. Mary Visitor Center (Figure 25). Plots are not permanently marked and the size and shape of plots were determined by site parameters (Table 38). Three plots are located in parking lot islands, each encompassing the entire island. Two plots are located adjacent to the parking lot with dimensions for each measuring 20m x 5m. One plot is located adjacent to the visitor center. This plot is triangular in shape to avoid the pre-construction presence of *Elymus repens* adjacent to the plot.

Plots were evaluated using Level II monitoring protocol. All species within plots were identified and given ocular cover estimates. Ground cover was also estimated within plots.

Table 38. St. Mary Visitor Center: Dimensions and Location of Monitoring Plots

Plot Number	Plot dimensions	UTM N	UTM E
SM-10-01	entire island	5402152	320821
SM-10-02	20 m x 5 m	5402141	320800
SM-10-03	20 m x 5 m	5402189	320812
SM-10-04	entire island	5402189	320778
SM-10-05	triangle	5402266	320725

Figure 25. St. Mary Visitor Center: Location of Monitoring Plots



Table 39. St. Mary Visitor Center: Seeding Prescription for Areas Adjacent to Parking Lot

Seeds per ft ²	Lifeform	Species:	Weight:
15	grass	<i>Festuca idahoensis</i>	930 g
20	grass	<i>Festuca campestris</i>	2.5 kg
5	grass	<i>Koeleria macrantha</i>	63.7 g
10	grass	<i>Juncus balticus</i>	no seed weight
5	grass	<i>Elymus trachycaulus ssp. subsecundus</i>	1.024 kg
5	grass	<i>Bromus carinatus</i>	1.776 kg
5	grass	<i>Elymus smithii</i>	1.38 kg
5	grass	<i>Carex aurea</i>	no seed weight
5	grass	<i>Carex obtusata</i>	no seed weight
5	grass	<i>Carex filifolia</i>	no seed weight
10	forb	<i>Achillea millefolium</i>	110 g
5	forb	<i>Dasiphora floribunda</i>	104 g
5	forb	<i>Fragaria virginiana</i>	160 g
10	forb	<i>Geum triflorum</i>	451 g
5	forb	<i>Anemone multifida</i>	389 g
5	forb	<i>Heuchera cylindrica</i>	21 g
5	forb	<i>Penstemon confertus</i>	55 g
10	forb	<i>Potentilla gracilis</i>	204 g
10	forb	<i>Solidago sp.</i>	50 g

80 total seeds of grass per square foot; 65 total seeds of forb per square foot

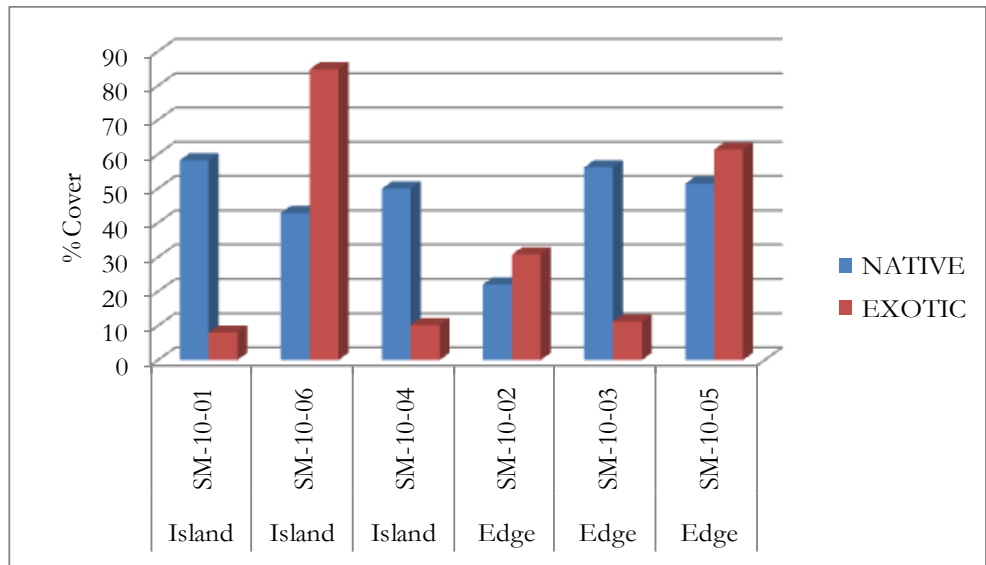
Table 40. St. Mary Visitor Center: Species Planted in Islands within Parking Lot

Shrubs	2008	2009	2010
	<i>Arctostaphylos uva-ursi</i>	<i>Arctostaphylos uva-ursi</i>	<i>Amelanchier alnifolia</i>
	<i>Danthonia intermedia</i>	<i>Dasiphora floribunda</i>	<i>Arctostaphylos uva-ursi</i>
	<i>Mahonia repens</i>	<i>Mahonia repens</i>	<i>Mahonia repens</i>
	<i>Paxistima myrsinites</i>	<i>Paxistima myrsinites</i>	<i>Paxistima myrsinites</i>
	<i>Spiraea betulifolia</i>	<i>Rosa woodsii</i>	
	<i>Symphoricarpos albus</i>	<i>Rubus parviflorus</i>	
		<i>Spiraea betulifolia</i>	
Grasses/Sedges		<i>Symphoricarpos albus</i>	
	<i>Danthonia intermedia</i>	<i>Carex microptera</i>	<i>Carex pachystachya</i>
	<i>Festuca idahoensis</i>	<i>Koeleria macrantha</i>	<i>Carex petasata</i>
Forbs	<i>Koeleria macrantha</i>		<i>Festuca idahoensis</i>
	<i>Anaphalis margaritacea</i>	<i>Anemone multifida</i>	<i>Anaphalis margaritacea</i>
	<i>Anemone multifida</i>	<i>Artemisia ludoviciana</i>	<i>Artemisia frigida</i>
	<i>Antennaria sp.</i>	<i>Fragaria sp.</i>	<i>Fragaria sp.</i>
	<i>Aster/ Erigeron mix</i>	<i>Gaillardia aristata</i>	<i>Gaillardia aristata</i>
	<i>Aquilegia flavescens</i>	<i>Geum triflorum</i>	<i>Gaillardia aristata</i>
	<i>Erigeron speciosus</i>	<i>Hedysarum boreale</i>	<i>Geum triflorum</i>
	<i>Eriogonum umbellatum</i>	<i>Gaillardia aristata</i>	<i>Heuchera cylindrica</i>
	<i>Forb mix</i>	<i>Fragaria sp.</i>	<i>Penstemon confertus</i>
	<i>Fragaria vesca</i>	<i>Lupinus sericeus</i>	<i>Phacelia sericea</i>
	<i>Gaillardia aristata</i>	<i>Polemonium pulcherrimum</i>	<i>Polemonium pulcherrimum</i>
	<i>Geranium viscosissimum</i>		<i>Potentilla hippiana</i>
	<i>Geum triflorum</i>		
	<i>Heuchera cylindrica</i>		
	<i>Oxytropis splendens</i>		
	<i>Penstemon albertinus</i>		
	<i>Penstemon confertus</i>		
	<i>Polemonium pulcherrimum</i>		
	<i>Potentilla gracilis</i>		
	<i>Potentilla sp.</i>		

C. RESULTS

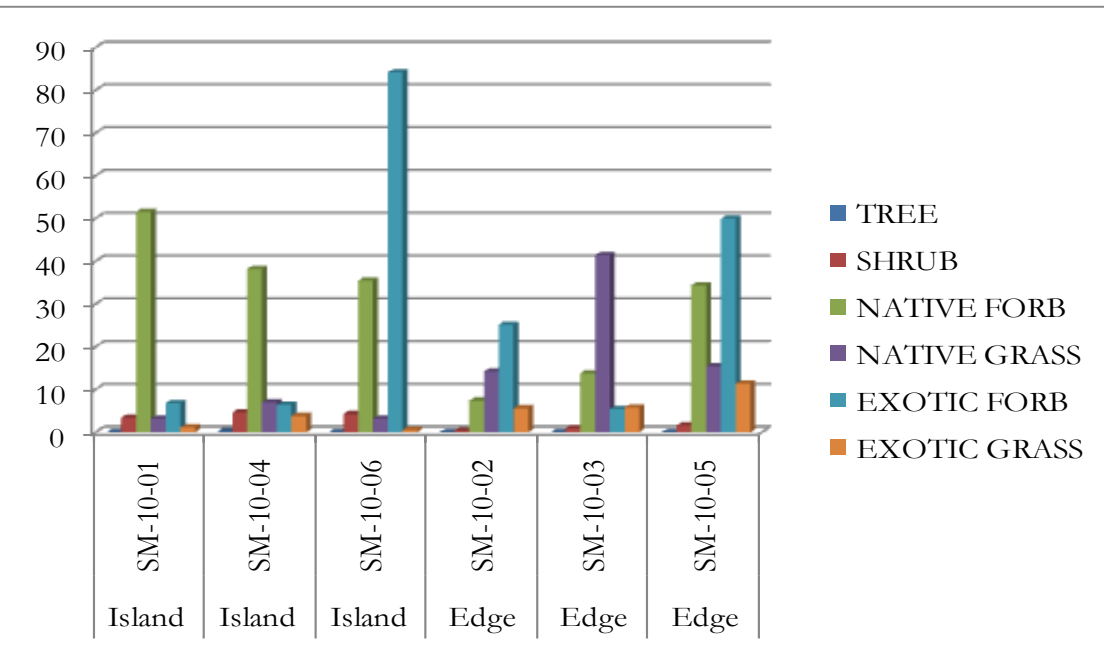
Results varied among plots. In general, plots located in parking lot islands, which were planted without hydroseeding, had higher covers of native species and lower covers of exotic species (Figure 26). Island plots had 50% average native cover and hydroseeded edge plots had 43% average native cover. Average cover of exotic species was the same, at 34%, for both island plots and edge plots. Exotic covers were quite variable among plots and no single species was responsible for high covers of weeds in all plots.

Figure 26. St. Mary Visitor Center: Percent Native and Exotic Cover by Plot, 2010.



Lifform composition also varied among plots (Figure 27). In general, native forb cover was highest in planted island plots, while native grass cover was higher in seeded edge plots.

Figure 27. St. Mary Visitor Center: Percent Cover of Lifeforms by Plot, 2010.



a. Native forbs

Cover of native forbs was generally higher in island plots, as would be expected, since nursery stock was planted in these plots between 2008 and 2010. *Artemisia ludoviciana* had the highest cover of almost all native forbs with 7 to 20% cover in island plots where it was planted (Table 41). *Gaillardia aristata* is another planted species performing well with 5-10% cover in island plots. Edge plots were seeded in 2008 and are beginning to have substantial cover of certain native forb species. Plot 5, a seeded edge plot, has relatively high native forb cover two years after seeding. This is mainly due to a 20% cover of *Solidago canadensis*, although a number of other seeded species have between 1% and 5% cover. *Achillea millefolium* is also showing success from seed with 1-10% cover in edge plots.

b. Native grasses

Native grasses performed best in seeded plots, although plugs of planted grasses in island plots are also doing well in island plots. Most successful in seeded plots was *Achnatherum nelsonii* which had 35% cover in plot 3 (Table 41). *Koeleria macrantha* performed fairly well regardless if it was seeded or planted. Higher covers were observed in seeded plots, however, where covers ranged from 3-15%. Planted covers were only between 1% and 3%. *Elymus trachycaulus* also had good establishment from seed. One seeded plot had 6% cover by the second year after hydroseeding and one planted island plot saw a 3% cover of this species. Native grasses appear to be more successful at gaining ground cover when seeded but often at the price of increased weedy species with longer initial barren ground exposure.

c. Exotic Forbs

No clear trend emerged for exotic forb invasion between planted island plots in comparison to seeded edge plots. High exotic forb cover was found in three plots, two of which were seeded and one of which was planted. Each high weed cover plot was dominated by different exotic species (Table 41): *Medicago lupulina* had 15% cover in plot 3 (edge plot), *Polygonum aviculare* and *Melilotus officinale* had 30% and 10% cover, respectively, in plot 5 (edge plot), and *Capsella bursa-pastoris* and *Sisymbrium altissimum* had 20% and 50% cover in plot 6 (island plot). This area has been actively weeded for the last several years. Likely not all areas are weeded at the same time which is potentially why some species can gain ground in some areas and not in other nearby areas. All of the exotic forb species with high covers, with the exception of *P. aviculare*, tend to be cyclical in their population sizes and likely will not be dominant next year.

d. Exotic Grasses

Plot 5, directly adjacent to the visitor's center, was the only plot to have exotic grass cover above 2%. *Elymus repens* is a threat to this area and dominates the region directly adjacent to the plot. This aggressive rhizomatous species has potential to take over many revegetated areas as it also dominates other areas bordering the visitor center. While the other plots have relatively low exotic grass cover at this time, quite a few species are present in most plots and have potential to be destructive. *Bromus tectorum* was found in all plots with trace cover. *Poa pratensis* was also found in all plots with trace to 2% cover. While only found in three of the five plots with trace to 2% cover, *Phleum pratense* is also potentially very aggressive.

D. CONCLUSIONS AND RECOMMENDATIONS

Wind has been the biggest challenge in this project. Most of the bark mulch that was applied around plantings in 2008 was dispersed by wind, scoring the soil and exposing plant roots. Exotic species were also given the opportunity to invade. Despite the wind, diligent annual attention for the past three years, including substantial additional planting and weeding events, has allowed natives to establish and has kept most exotics at a manageable level. Most of the exotic species that were present in the project in 2010 are species that generally exhibit cyclical populations and likely will not persist. Exotic species from the mustard and pea family are likely to be less persistent. Several species, however, can be perennially aggressive and need to be controlled. A few noxious weeds were present, including *Centaurea stoebe*, *Cirsium arvense* and *Linaria vulgaris*, and will need to be controlled with herbicide and/or hand pulling. *Polygonum aviculare* is another persistent exotic forb that will likely require hand pulling.

Weedy grasses are perhaps the most threatening to the project. *Bromus tectorum*, an annual species which was present in all plots, may be able to be controlled by weeding. Rhizomatous perennials will be more difficult to hand pull, including *Bromus inermis* and *Poa pratensis*. It may be manageable, however, to hand pull the parking lot island areas. Edge areas will be more difficult to control for rhizomatous weedy grasses. *Elymus repens* is perhaps the largest challenge to this area. It was present in high covers prior to restoration and persists in areas that were not revegetated that are adjacent to restoration areas. This grass can be extremely aggressive and may need to be removed from surrounding areas in order to protect the area as a whole. Hand weeding of all exotic species is also necessary to continue on an annual basis.

Native forbs are performing best in parking lot islands where they were planted, while native grasses have higher covers along edges where they were seeded. If high native cover were the only goal, it may be best to plant select native forbs and supplement seed in the same area with other species of native forbs as well as native grasses. However, given the landscaping goals of the parking lot islands, abundant seeded grasses may detract from the aesthetic appeal. Cost also prohibits planting edge areas with abundant native forbs. In this case, continued weeding efforts are necessary, as well as eradication of surrounding quack grass by herbicide or hand pulling.

Table 41. St. Mary Visitor Center: Ocular Percent Cover for all Species by Plot, 2010.

* s = seeded (adjacent to parking lot only, not in islands)

* p = planted in islands

¹ = direct seeded into ground after scarification, cold moist stratification and inoculation with root-slurry

		Island	Edge	Edge	Island	Edge	Island
		SM-10-01	SM-10-02	SM-10-03	SM-10-04	SM-10-05	SM-10-06
	source*	2010	2010	2010	2010	2010	2010
TREE		0	0	0	T	0	0
<i>Populus balsamifera</i>					T		
SHRUB		3	T	1	5	2	4+
<i>Arctostaphylos uva-ursi</i>	p	T			1	T	1-
<i>Dasiphora floribunda</i>	p			T	T	T	
<i>Rosa woodsii</i>	p	2	T	1-	3	T	1+
<i>Spiraea betulifolia</i>	p	T			T		1
<i>Symphoricarpos albus</i>	p	1	T		T	1	1+
NATIVE FORB		53	6	12	35	33	35
<i>Achillea millefolium</i>	s	T	5	10	T	1	2
<i>Androsace septentrionalis</i>			T				
<i>Anemone multifida</i>	s & p	T		T	T+	T	T
<i>Antennaria howellii</i>	p [?]	4			3		
<i>Arabis glabra</i>			T				
<i>Aquilegia flavescens</i>	p						1-
<i>Arabis sp.</i>							T
<i>Arnica sororia</i>	p					T	
<i>Artemisia frigida</i>	p				T		
<i>Artemisia ludoviciana</i>	p	20			7		15
<i>Artemisia michauxiana</i>	p [?]					1	
<i>Chamerion angustifolium</i>		1		T	2		1-
<i>Conyza canadensis</i>					T		
<i>Epilobium brachycarpum</i>		T			T		
<i>Equisetum laevigatum</i>						1	1-
<i>Equisetum variegatum</i>		T					
<i>Erigeron speciosus</i>	p	2+			2		T
<i>Eriogonum flavum</i>	p [?]		T				
<i>Fragaria vesca</i>	p						T
<i>Fragaria virginiana</i>	p	3		T	3	2	3
<i>Gaillardia aristata</i>	p	10	T	T	8	1	5
<i>Galium boreale</i>	p		T				
<i>Geranium viscosissimum</i>	p	T					1-
<i>Geum triflorum</i>	s & p	1			T	T	1-
<i>Grindelia squarrosa</i>				T			
<i>Hackelia micrantha</i>				T			
<i>Hedysarum sulphureum</i>	p [?]				T		
<i>Heuchera cylindrica</i>	s & p	1			2	T	1+
<i>Lupinus sericea</i>	s ¹	T			T	T	

Table 41 con'd: St. Mary Visitor Center: Ocular Percent Cover for all Species by Plot, 2010.

		Island	Edge	Edge	Island	Edge	Island
		SM-10-01	SM-10-02	SM-10-03	SM-10-04	SM-10-05	SM-10-06
	Source*	2010	2010	2010	2010	2010	2010
NATIVE FORB, con't							
<i>Oenothera villosa</i>				1			
<i>Oxytropis campestris</i>		1	T		T		
<i>Oxytropis splendens</i>	p		T	T	1		
<i>Penstemon albertinus</i>	p	T	T			T	
<i>Penstemon confertus</i>	s & p	1	T		1	1	1+
<i>Phacelia sericea</i>	p					T	
<i>Polemonium pulcherrimum</i>	p	1			3	1	T
<i>Polygonum achoreum</i>			T	1			
<i>Polygonum douglasii</i> ssp. <i>douglasii</i>			T				
<i>Potentilla arguta</i>		6	T		1		
<i>Potentilla gracilis</i>	s & p	1		T	2		
<i>Potentilla hippiana</i>	p				T		
<i>Pyrrocoma carthamoides?</i>					T		
<i>Solidago canadensis</i>	s?	T			T	20	2
<i>Solidago multiradiata</i>	s?			T			T
<i>Symphytotrichum campestre</i> (<i>Aster campestris</i>)						5	
<i>Symphytotrichum laeve</i> (<i>Aster laevis</i>)					T		
NATIVE GRASS		3	15	41	7	15	3-
<i>Achnatherum nelsonii</i> (<i>Stipa nelsonii</i>)	s?		3	35		T	
<i>Bromus carinatus</i>	s						
<i>Bromus pumpellianus</i>				T			
<i>Carex pachystachya</i>	p						1
<i>Carex</i> sp.	s?					T	
<i>Danthonia intermedia</i> (<i>spicata?</i>)	p	T					T+
<i>Elymus glaucus</i>			T				
<i>Elymus trachycaulis</i> var. <i>trachycaulis</i>			6		3		
<i>Festuca idahoensis</i>	s & p	1	2	1	1		T
<i>Hordeum jubatum</i>				T			T
<i>Koeleria macrantha</i>	s & p	2	3	5	3	15	1
EXOTIC FORB		5	24	2+	6	49	82
<i>Alyssum alyssoides</i>			T			1	
<i>Arenaria serpyllifolia</i>		T	T	T	T	T	
<i>Atriplex</i> sp.							1
<i>Capsella bursa-pastoris</i>		3	3	T	2	5	20
<i>Centaurea stoebe</i> (<i>C. maculosa</i>)			T	1-			
<i>Chenopodium album</i>		1	T	T	1	T	T+
<i>Chenopodium simplex</i> (new to Park)				T			
<i>Chenopodium</i> sp.							T
<i>Cirsium arvense</i>				T	T	T+	
<i>Cirsium vulgare</i>				T			
<i>Descurainia sophia</i>		T	T		1		T
<i>Erodium cicutarium</i>		T	T	T			

Table 41 con'd: St. Mary Visitor Center: Ocular Percent Cover for all Species by Plot, 2010.

		Island	Edge	Edge	Island	Edge	Island
		SM-10-01	SM-10-02	SM-10-03	SM-10-04	SM-10-05	SM-10-06
	Source*	2010	2010	2010	2010	2010	2010
EXOTIC FORB, con't							
<i>Filago arvensis</i>		T	T	T	T		T
<i>Gnaphalium palustris</i>				T			
<i>Lactuca serriola</i>			T		T		T
<i>Linaria vulgaris</i>							T
<i>Medicago lupulina</i>		T	15		T	T	1
<i>Melilotus alba</i>				T			
<i>Melilotus officinale</i>			2	T+		10	8
<i>Polygonum aviculare</i>		T	2			30	3
<i>Polygonum convulvulus</i>			T		T	T	T
<i>Salsola pestifer</i>				T			
<i>Silene latifolia</i>			T				
<i>Sisymbrium altissimum</i>		1	1-	T+	1	1	50
<i>Taraxacum officinale</i>		T	T			1	
<i>Thlaspi arvense</i>		T				T	T
<i>Verbana bracteata</i>			T	1-		T	
<i>Verbascum thapsis</i>				T	T		
<i>Veronica peregrinus</i>		T					
EXOTIC GRASS		1	6	5	4	12	T
<i>Avena sativa</i>						T	
<i>Bromus tectorum</i>		T	T	T	T	T	T
<i>Bromus inermis</i>			1	T	1		
<i>Elymus repens</i>		T	2	1	2	10	T
<i>Lolium multiflorum</i>				1			
<i>Phleum pratense</i>			2	T	T		
<i>Poa compressa</i>			T	1			
<i>Poa pratensis</i>		1-	T	2	T	1	T
<i>Setaria glauca</i>				T			
<i>unknown exotic grass</i>					T		

red text = Montana noxious weed species

IX. HIDDEN LAKE SOCIAL TRAILS RESTORATION

A. BACKGROUND AND PURPOSE

The fragile subalpine and alpine environments of Logan Pass are easily accessible to the estimated 1.2 million people who visit Glacier National Park annually. Over the years, heavy visitation caused degradation of soil and floral resources and created a network of social trails, especially in areas adjacent to popular features such as the Logan Pass Visitor Center, the boardwalk and the Hidden Lake area. In 1995, efforts began to restore sites in the area. Site preparation began on degraded sites and vegetation was planted.

In July of 2000, restoration work began at Hidden Lake to eradicate the numerous social trails that had become established on the north shore. The soil was scarified, treated with Biosol organic fertilizer, and planted or seeded with various native forbs and grasses. Additionally, plants larger than four inches were treated with Osmocote slow release fertilizer. Monitoring plots were established within the Hidden Lake restoration area immediately following planting. For a complete list of seeded /planted species and dates see the 2000 and 2001 Resource Management Project Implementation Plans (Lapp 2000, Withed 2001) (Table 43).

The purpose of monitoring the Hidden Lake area is to determine how revegetation efforts are progressing by: (1) estimating the canopy cover of all native and exotic species in each monitoring plot, and by (2) tracking the success of seeded and planted material through estimates of canopy cover.

B. METHODS

Six monitoring plots were established at various locations along the lakeshore and adjacent sites (Table 42, Figures 28 and 29). Five of the plots were 4m x 0.5m (2m²) and one plot was 3.5m x 0.5m (1.57m²). Plot size varied to accommodate the planted area. Photographs of the plots were taken before, during, and after work was completed.

Table 42. Hidden Lake Social Trails: Revegetation Monitoring Plots

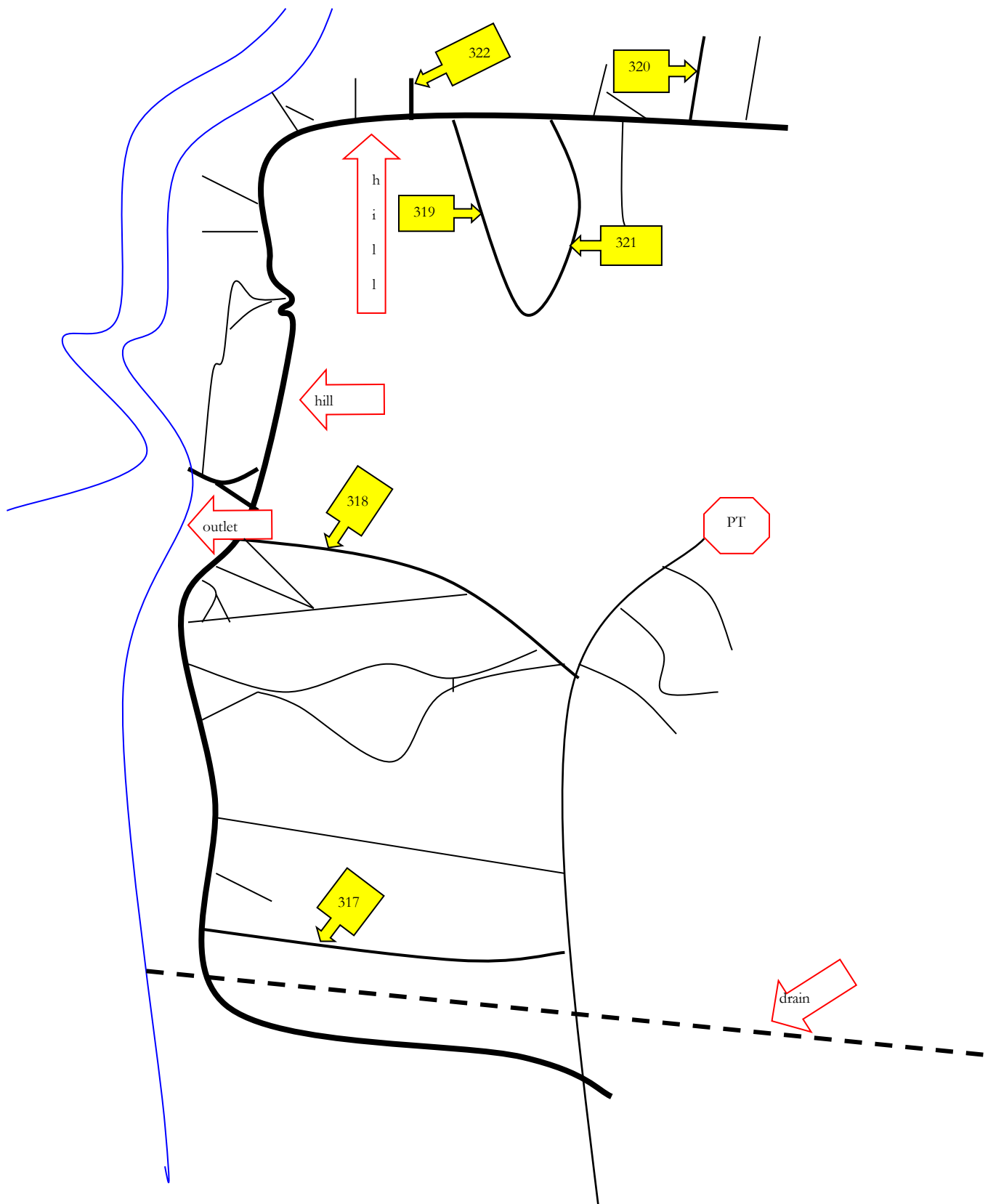
PLOT #	Trail #	Area	DIRECTIONS
317	29	4m x 0.5m	Along skinny social trail that once connected lake trail to pit toilet trail. Plot is 4 large steps from lake trail and 5.5 large steps from pit toilet trail. Upper L and lower R corners are marked. Trailside plot.
318	17	4m x 0.5m	Off of lake trail along long skinny trail that used to connect to pit toilet trail. Plot is 1 large step from lake trail. Marked lower R corner is on meadowside and marked upper L corner is on tree side. Trailside plot.
319	7	4m x 0.5m	Slight arc to the left in the plot. 11 steps off main trail to LR corner marker. Very large tree to go over. Marked lower L corner nearer to main trail. Lower R corner marked. Trailside plot.
320	2	4m x 0.5m	Creekside plot is curved to the right. Marked lower L corner at trail. Marked upper R corner just beyond first exposed bedrock.
321	5	4m x 0.5m	Plot curves to the right. Marked lower L corner 4 large steps from trail. Marked upper R corner at treeside.
322	8	3.5 m x 0.5m	Creekside plot. Just after second hill.

In 2003, 2005 and 2010, Level II monitoring was conducted on all plots, which included ocular estimates of canopy cover for all native and exotic species. Photographs were taken of each plot during each monitoring event.

Figure 28. Hidden Lake Social Trails: Location of Revegetation Monitoring Plots



Figure 29. Hidden Lake Social Trails: Location of social trails and monitoring plots

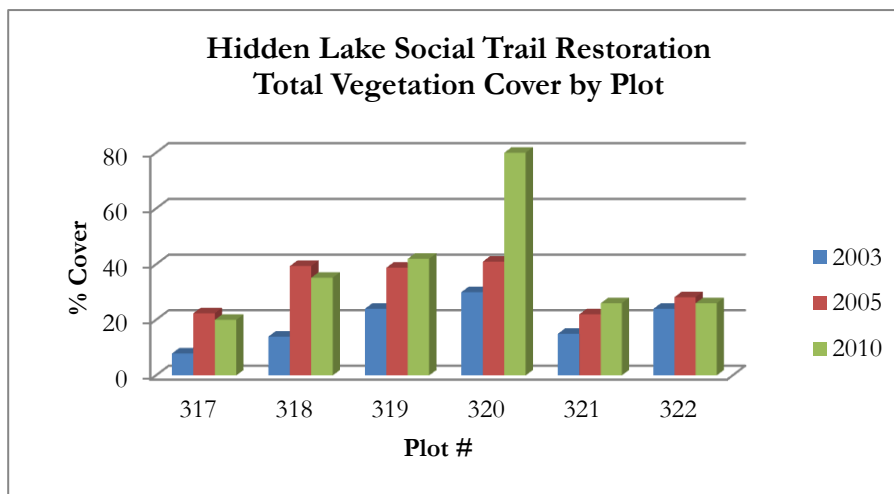


C. RESULTS AND DISCUSSION

1. Vegetation Cover

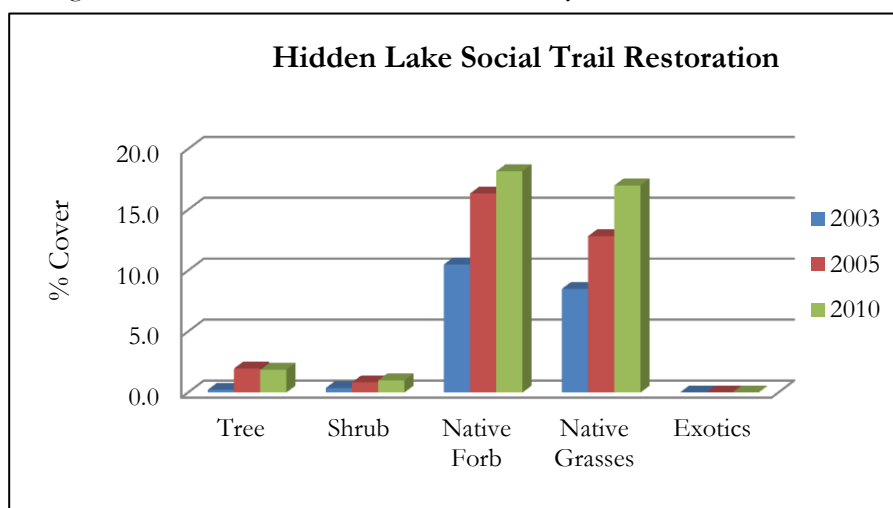
In general, all plots except one are essentially unchanged since 2005 in regards to overall vegetation cover (Figure 30). This is quite different from 2003 to 2005 when cover increased markedly in all plots. Currently, five out of the six plots have 20% to 40% cover, similar to results from 2005. Only plot #320, reaching 80% cover, has doubled in cover since 2005. This is due to significant increases in native grass and forb cover, due primarily to increases of *Achillea millefolium*, *Aster laevis*, *Arnica diversifolia*, *Luzula hitchcockii*, and *Carex nigricans*.

Figure 30: Hidden Lake Social Trails: Total Vegetation Cover by Plot, 2003-2010.



Similar to years past, native forbs and grasses continue to dominate vegetation cover in all plots (Figure 31, Table 43). Native forbs and grasses were the dominant plants used for revegetating these social trails, due to the fact that these lifeforms are common in this understory. Both native forbs and grasses each showed small overall increases since 2005, although this is likely due to the large increase of each of these lifeforms in plot #320. Shrub and tree seedling cover remains low. No exotic species were observed within any of the plots.

Figure 31: Hidden Lake Social Trails: Cover by Lifeform, 2003-2010.

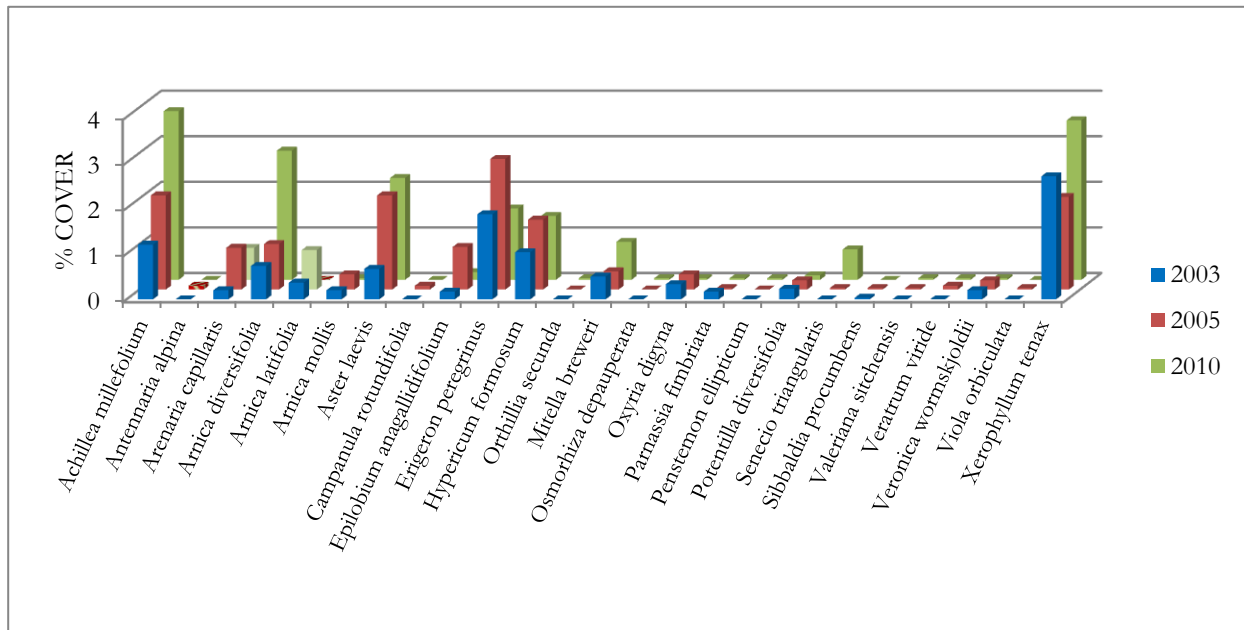


1a. Native Forbs

A total of 21 native forb species were identified within the six plots (Table 43). This is two fewer total native forb species than were observed in 2005. Since 2005, *Campanula rotundifolia*, *Viola orbiculata*, and seeded species *Antennaria alpina*, *Arnica latifolia*, and *Sibbaldia procumbens* have disappeared from the plots, while *Orthilia secunda*, *Osmorhiza depauperata*, and *Penstemon ellipticus* have recruited to plots. Of the 15 native forbs that were seeded or planted, 12 were present in at least one plot in 2010. The three seeded or planted species that were not found in any plot were *Antennaria alpina*, *Arnica latifolia*, and *Sibbaldia procumbens*. These three species were present in the past but disappeared from the few plots where they were present.

Forbs with the highest average cover in 2010 include *Achillea millefolium*, *Arnica diversifolia*, and *Xerophyllum tenax*, although much of the *X. tenax* cover is naturally occurring plants that are expanding into the social trails (Figure 32 and Table 43). *Erigeron peregrinus*, which had the highest average cover in 2005, has decreased in cover in the past five years (Figure 32 and Table 43). *E. peregrinus*, however, and *Aster laevis* both had the highest frequency of all forb species, present in all six plots. Other species with high frequency were *Achillea millefolium*, *Arnica diversifolia*, and *Epilobium anagallidifolium*, each present in 5 out of 6 plots.

Figure 32. Hidden Lake Social Trails: Average cover for native forb species, 2003-2010.

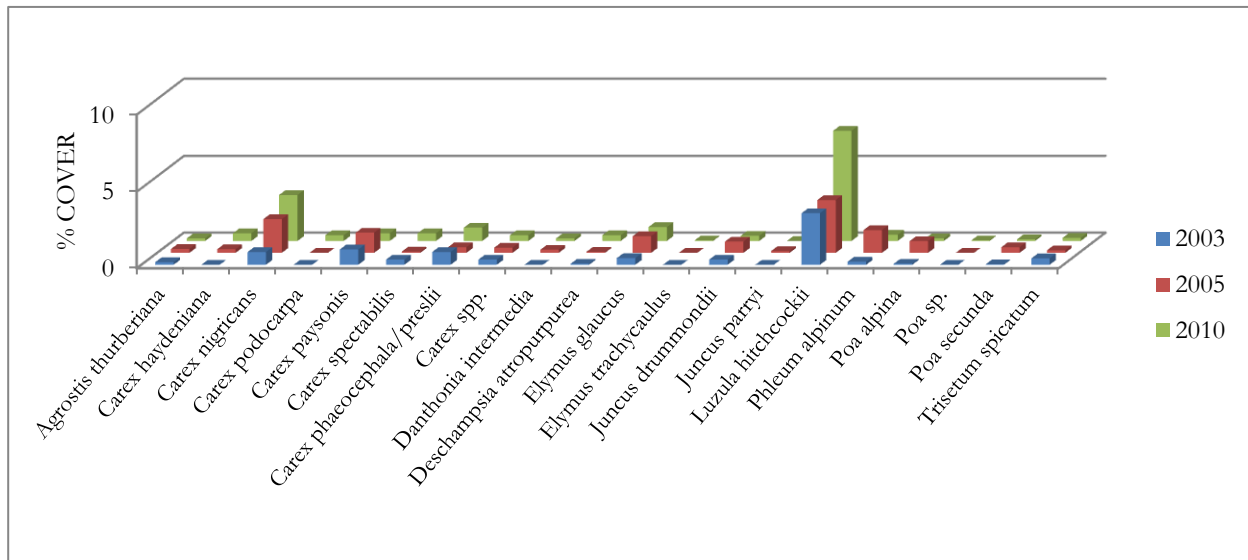


1b. Native Grasses

Nineteen native grass species were observed in 2010 (Table 43). This is four more total native grass species than were observed in 2005. Since 2005, *Juncus parryi* has disappeared from the plots, but *Carex podocarpa*, *Elymus trachycaulus*, and *Poa spp.* have recruited to plots. Of the 9 native grasses that were seeded or planted, 8 species are present in at least one plot in 2010. Similar to 2005, *Juncus mertensianus* was the only seeded species not observed in 2010.

Most planted/seeded grass species were present in 2 to 6 plots with most species having trace cover (Figure 33 and Table 43). The native grass species with the highest cover is clearly *Luzula hitchcockii*, which increased on all plots between 2005 and 2010. It was also the native grass species with the highest frequency, present in all 6 plots. Other grass species with relatively high cover include volunteer species *Carex nigricans* and seeded grasses *Elymus glaucus* and *Carex phaeocephala* (some of which appears to be similar-looking *Carex preslii*). *Poa alpina* was observed in 5 of the 6 plots, while *Elymus glaucus* and *Phleum alpinum* were observed in 4 of the 6 plots (Table 43).

Figure 33. Hidden Lake Social Trails: Average cover for native grass species, 2003-2010.



1c. Shrubs and Trees

Because no trees or shrubs were planted for this project, cover for woody species remains low, although some shrubs and tree seedlings are beginning to spread into the plots (Table 43 and Figure 31). *Vaccinium membranaceum* was observed with low cover on two plots, while *Vaccinium scoparium* is now only present with low cover on one plot (Table 43). *Abies lasiocarpa* seedlings are present on 5 of the 6 plots with cover ranging from trace to 5%.

1d. Photomonitoring

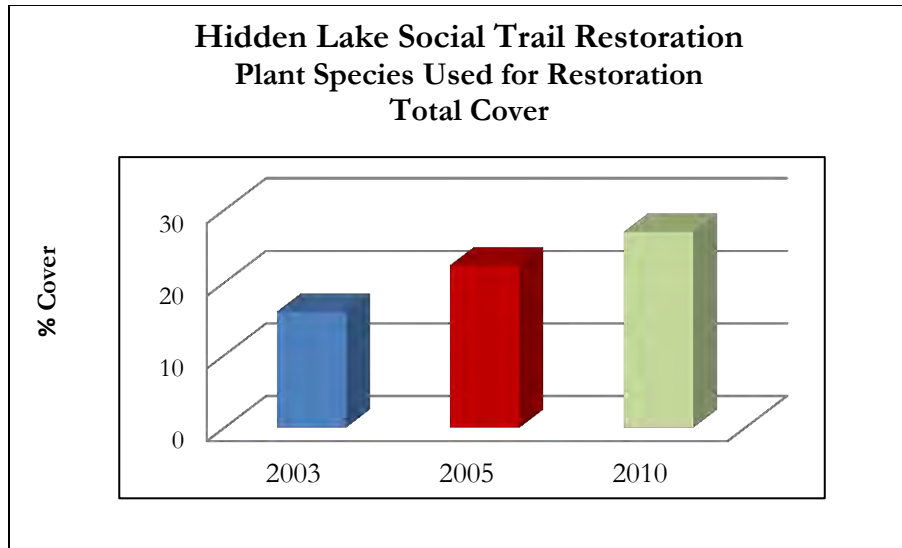
Photographs of each plot were taken in 2003, 2005, and 2010. While photographs generally capture the amount of vegetation colonizing each social trail, the photos also showed significant changes in the amount and placement of limbs, boles and other wood meant to deter traffic through these areas. Some of the change is natural decay of the wood, but in most plots some amount has been removed or added, likely determining their continued use as social or game trails. In 2010, plots 317 and 320 show considerably less woody material, yet a large tree bole has been added to plot 318.

D. CONCLUSIONS AND RECOMMENDATIONS

Future success to establishing vegetation in these social trails will come from reducing the trampling and disturbances that still continue. Since there is a trend of increasing plant cover between 2003 to 2010, restoration efforts appear to be succeeding. Currently, 9 of the 10 most abundant species were those that were seeded or planted and total cover for species used for restoration continues to increase each year (Figure 34). However, vegetation change is occurring very slowly and half of the social trails remain with 20% to 25% cover, not enough to deter use. Only plot #320, with 80% cover, does not appear as a social trail ten years after revegetation. Despite efforts to discourage use of social trails with downed wood and “restoration area” signs, 5 of the 6 plots still show distinct paths, sometimes a new path, and movement of woody debris.

Most of this disturbance is likely human, although impact from goats is possible. During the field visit in 2010 while the crew was measuring plot 322, a group of park visitors walked directly through the plot then returned through it a few minutes later. This is probably typical behavior for people nearing the end of the “official trail” and wish to keep exploring the lakeside. Without more effective barriers, it may be impossible to fully restore some of these visible social trails that appear to lead to somewhere interesting.

Figure 34: Hidden Lake Social Trail Restoration: Total Cover of Plant Species Used for Restoration



Monitoring should be continued and should emphasize changes in overall lifeform cover, changes in species cover and diversity, and future invasion of exotics, if any. The Hidden Lake plots should be monitored in 2015 at project year fifteen.

Table 43. Hidden Lake Social Trails: Canopy cover (%) by species and plot, 2003-2010.

		Plot 317			Plot 318			Plot 319			Plot 320			Plot 321			Plot 322		
Species Name	planted/ seeded?	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010
TOTAL TREE *		1	2	3	0	1	0	t	1	1		5	5	0	2	2	t	t	0
<i>Abies lasiocarpa</i> (seedling)		1-	2+	3		1+	t	t	t+	1		5	5		2	2	t	t	
TOTAL SHRUB **		0	0	0	0	0	0	t	1	2	0	0	1	0	0	0	2	4	3
<i>Vaccinium membranaceum</i>													1				2	4	3
<i>Vaccinium scoparium</i>								t	1	2								t?	
TOTAL NATIVE FORB		3	12	7	8	24	20	13	19	14	24	28	54	3	3	3	12	12	11
<i>Achillea millefolium</i>	p & s		t	1	2	7	8	3	3	1	2	2	12				t	t	t
<i>Antennaria alpina</i>	p								t+										
<i>Arenaria capillaris</i>		t	t+	t	1	5	4												
<i>Arnica diversifolia</i>	p & s			1						3	4	5	10	t	t+	1	t	1+	2
<i>Arnica latifolia</i>	p & s	t	1+			1		2	3										
<i>Arnica mollis</i>	p & s							t	2	t	1								
<i>Aster laevis</i>	p & s		1	1		1+	1	1	2	1	1	7	10	2	1+	t			t
<i>Campanula rotundifolia</i>						t+													
<i>Epilobium anagallidifolium</i>	s	t	1	t	t	t	t		1	t	t	3		t	t	t	t	t	t
<i>Erigeron peregrinus</i>	p & s	1	5	1	2	3	t	3	4	4	3	2+	3	t	1	1	2	2	t
<i>Hypericum formosum</i>	p & s	2	3	2	3	5	6	t	t	t							1	1	t
<i>Orthillia secunda</i>																			t
<i>Mitella breneri</i>	p & s								t	1	1	t	3				2	2	1
<i>Osmorhiza depauperata</i>													t						
<i>Oxyria digyna</i>	p & s										1	1					1	1	t
<i>Parnassia fimbriata</i>											1	t	t						
<i>Penstemon ellipticus</i>							t												
<i>Potentilla diversifolia</i>	p				t		t	1	1	t							t	t	t
<i>Senecio triangularis</i>												t	4						
<i>Sibbaldia procumbens</i>	p & s				t	t													
<i>Valeriana sitchensis</i>			t	t															
<i>Veratrum viride</i>												t+	t						
<i>Veronica wormskejoldii</i>	p & s				t			1	1+	t									
<i>Viola orbiculata</i>																		t	
<i>Xerophyllum tenax</i>	s							1	1	2	10	7	12	t	t	1	5	4	6

Table 43 con'd. Hidden Lake Social Trails: Canopy cover (%) by species and plot, 2003-2010.

		Plot 317			Plot 318			Plot 319			Plot 320			Plot 321			Plot 322		
Species Name	planted/ seeded?	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010	2003	2005	2010
TOTAL NATIVE GRASS		4	8	10	6	14	15	11	18	25	6	8	20	12	17	21	10	12	12
<i>Agrostis thurberiana</i>									t+		1	1	1						
<i>Carex haydeniana</i>			1+	3								t							
<i>Carex nigricans</i>								5	9	9		1+	5		3	4			
<i>Carex podocarpa</i>										1			1			t			
<i>Carex paysonis</i>		1	2-					3	2+	1				2	4	2			
<i>Carex spectabilis</i>	s				2	t+	3												
<i>Carex phaeocephala/preslii</i>	s	2	1	1	2	1+	4+							1					
<i>Carex</i> spp.				t							1						1	2	2
<i>Danthonia intermedia</i>						1+	1												
<i>Deschampsia atropurpurea</i>	s							t	t	2				t	t	t			
<i>Elymus glaucus</i>	s	t	t		t	t	2		t	t	2	3-	3		2		t	1+	t
<i>Elymus trachycaulus</i>													t						
<i>Juncus drummondii</i>		1	1+	1	1	3	1					t							
<i>Juncus parryi</i>												1-							
<i>Luzula hitchcockii</i>	s	t	1+	1		t+	1	2	4	11	2	2	8	8	7	13	8	6	9
<i>Phleum alpinum</i>	s	t	1	1	1	4			2-	t		1	1					1+	t
<i>Poa alpina</i>	s		t	t	t	2+	t		t	t			t			t	t+	2	
<i>Poa</i> sp.				t															
<i>Poa secunda</i>					t	2	t								t	t			t
<i>Trisetum spicatum</i>	p							1						1	1	1	t+		t
TOTAL EXOTIC FORB		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXOTIC GRASS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL VEGETATION COVER		8	22	20	14	39	35	24	39	42	30	41	80	15	22	26	24	28	26

X. GRINNELL GLACIER PICNIC AREA

A. BACKGROUND AND PURPOSE

The Grinnell Glacier Trail is one of the most visited trails in Glacier National Park. The Grinnell Glacier picnic area, located a few hundred meters from Grinnell Glacier itself, is heavily used during most summer days. There are several benches within the picnic area, as well as two outhouses, allowing visitors to spread out in different locations of the picnic area. Despite the installation of trails to benches and the outhouses, social trails and denuded ground have developed throughout the area over time.

In 2008, the Grinnell Glacier picnic area was evaluated for restoration of social trails and resource impacts around the benches and two outhouses. Seed collection also began in 2008 at the site to begin restoration efforts. In 2009, the outhouses were moved so as not to be visible from the benches; new benches were also constructed. A new trail was designated to the outhouses, however, the old trails, including social trails, were not rehabilitated.

In 2010, the Grinnell Glacier picnic area was evaluated again for restoration of social trail and resource impacts. The goals of the visit were to: (1) map all existing social trails and denuded ground; (2) create a species list for the area; (3) outline the areas in need of restoration, blocking, and signage; and (4) continue to collect seed from the site that is different from species that were collected in 2008.

B. METHODS

In September 2010, members of the revegetation and monitoring crews visited the Grinnell Glacier picnic area. During the visit, the monitoring crew created a site species list while the revegetation crew mapped social trails and denuded areas and collected seed. Both crews worked together to outline the areas in need of restoration.

C. RESULTS AND RECOMMENDATIONS

1. Mapping of social trails and recommendations for restoration

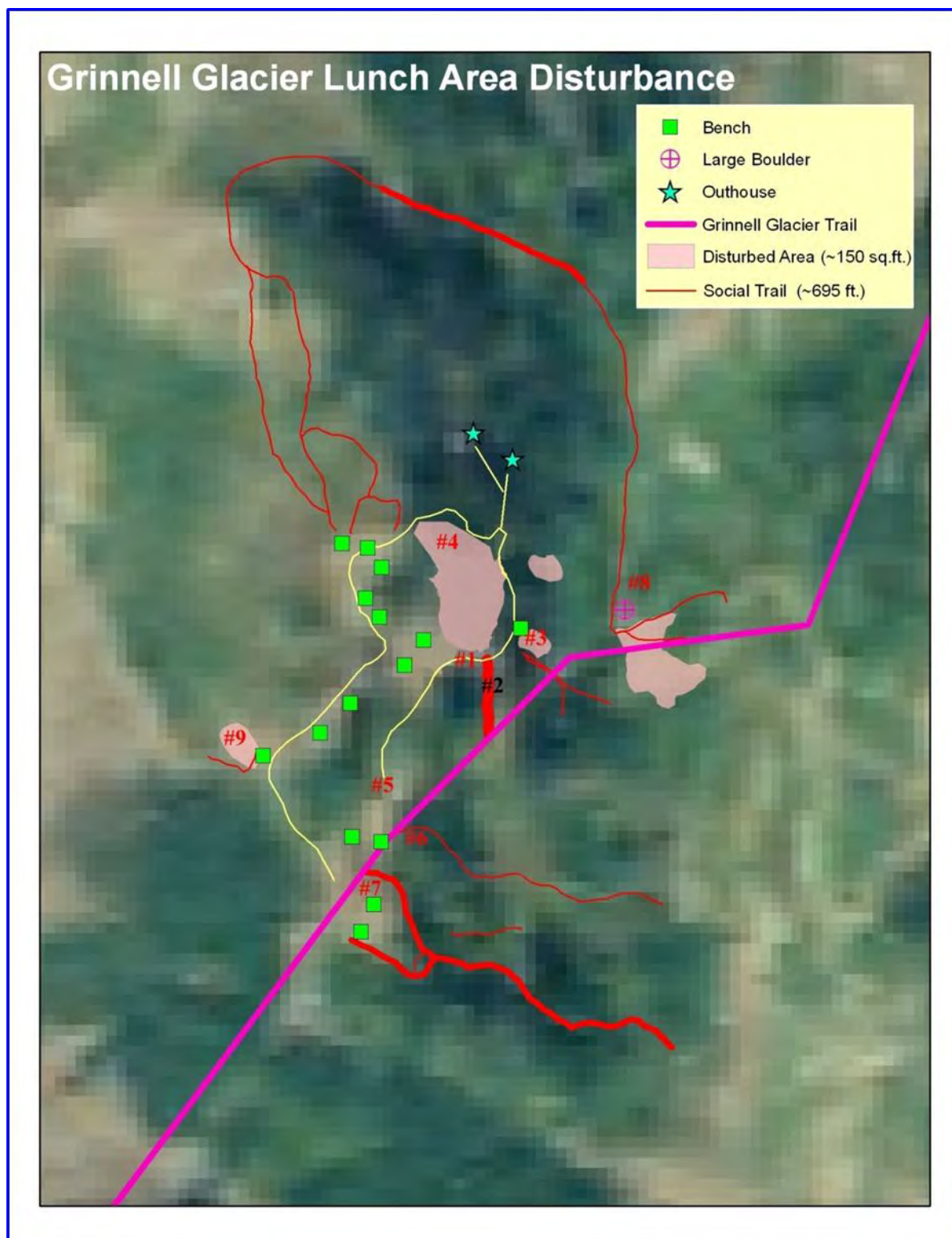
While evaluating the resource issues at the picnic area, use patterns of the trails to the outhouses were observed. In general, now that the outhouses are not visible from the benches, the established trails are being used. The only individuals that did not use the trails were two NPS employees. Regardless of use, the established trail is difficult to discern and the likelihood of continued use in the disturbed areas is high.

Overall, there are five social trails, totaling approximately 695 feet, and three larger denuded areas, measuring approximately 150ft², (Figure 35) that need to be planted, blocked and signed. Social trails #2, #5, #6, and #7 (Figure 35) each need to be revegetated and blocked off. Social trail #8 (Figure 35) may only need planting and blocking at the beginning the trail since it is larger and may recover on its own if effectively blocked off. Social trails #6 and #7 may also recover on their own if the area near the established trail is planted and blocked. Social trails #5, #6, and #7 are areas where the benches used to exist.

On the way to the outhouses, there is a large denuded area with lots of roots intersecting the trail, making it unclear where the trail is. This disturbed area #4 (Figure 35) is in the middle of the trail circle leading up to the outhouses. This area should be planted and blocked off with the official trail set up with more defined boundaries. Denuded areas #3 and #9 also need to be planted, blocked off, and signed.

Most areas will require planting of containerized material, as well as direct seed application. Planting containerized material will give these disturbed areas instant cover that, along with blocking and signage, may effectively keep visitors away from these areas. Trees, shrubs, and forbs should be the primary plants from containerized stock. Seeding, specifically of grasses, sedges, and some forbs, should fill in the gaps in between planted material.

Figure 35. Grinnell Glacier picnic area: Location of social trails and disturbed areas.



2. Species list for picnic area site and seed collection

A species list was created for the Grinnell Glacier picnic area by lifeform (Table 44). Seed that was collected in 2008 is highlighted in red. Seed that was collected in 2010 is highlighted in blue. Other species that could be planted in this area if there is available seed or plant material have been highlighted in green.

Table 44. Grinnell Glacier picnic area: Species list and plants recommended for restoration

Species observed	Species observed
Trees	Forbs continued
<i>Abies lasiocarpa</i>	<i>Mitella pentandra</i>
<i>Picea engelmannii</i>	<i>Orthilia secunda</i>
<i>Pinus albicaulis</i>	<i>Oxyria digyna</i>
Shrubs	<i>Pedicularis contorta</i>
<i>Alnus viridis</i>	<i>Pedicularis groenlandica</i>
<i>Dasiphora floribunda</i>	<i>Phacelia hastata</i>
<i>Kalmia polifolia</i>	<i>Phyllodoce empetrifolia</i>
<i>Lonicera involucrata</i>	<i>Potentilla diversifolia</i>
<i>Lonicera utahensis</i>	<i>Sedum lanceolatum</i>
<i>Menziesia ferruginea</i>	<i>Senecio cymbalaria</i>
<i>Penstemon ellipticus</i>	<i>Senecio cymbalarioides</i>
<i>Ribes lacustre</i>	<i>Senecio triangularis</i>
<i>Salix arctica</i>	<i>Sibbaldia procumbens</i>
<i>Salix boothii</i>	<i>Thalictrum occidentale</i>
<i>Salix farriar</i>	<i>Tofieldia occidentalis</i>
<i>Salix sitchensis/ drummondii</i>	<i>Valeriana sitchensis</i>
<i>Salix vestita</i>	<i>Veratrum viride</i>
<i>Sambucus racemosa</i>	<i>Veronica wormskjoldii</i>
<i>Sorbus scopulina</i>	<i>Viola orbiculata</i>
<i>Spiraea splendens</i>	<i>Xerophyllum tenax</i>
<i>Vaccinium membranaceum</i>	<i>Zigadenus elegans</i>
Forbs	Grasses, Sedges, Rushes
<i>Achillea millefolium</i>	<i>Agrostis scabra</i>
<i>Anaphalis margaritacea</i>	<i>Agrostis thurberiana</i>
<i>Anemone multifida</i>	<i>Carex haydeniana</i>
<i>Anemone occidentalis</i>	<i>Carex nigricans</i>
<i>Antennaria alpina</i>	<i>Carex pachystachya</i>
<i>Arnica sp.</i>	<i>Carex phaeocephala</i>
<i>Campanula rotundifolia</i>	<i>Carex preslii</i>
<i>Chamerion angustifolium</i>	<i>Carex spectabilis</i>
<i>Erythronium grandiflorum</i>	<i>Danthonia intermedia</i>
<i>Fragaria virginiana</i>	<i>Elymus trachycaulus</i>
<i>Gentiana calycosa</i>	<i>Juncus drummondii</i>
<i>Geum macrophyllum</i>	<i>Juncus mertensianus</i>
<i>Hedysarum sulphurescens</i>	<i>Pbleum alpinum</i>
<i>Heuchera cylindrica</i>	<i>Poa alpina</i>
<i>Hypericum formosum</i>	<i>Trisetum spicatum</i>

Most of the plant material collected from the picnic area is being grown in the fall of 2010 and spring of 2011, since much of this material is shrubs and trees. Outplanting may need to wait until the stock is more established in 2012. This may also offer one more opportunity for additional seed collecting at the site.

In addition, whitebark pine was observed in the picnic area, as well as along the trail leading up to the picnic area. There is also potential to plant whitebark pine in this area given its presence and accessibility. Exact planting sites would need to be further investigated.

XI. WHITEBARK AND LIMBER PINE RESTORATION PROJECT

A. INTRODUCTION

Whitebark pine (*Pinus albicaulis*), is a long-lived, slow-growing mid to high-elevation five-needled pine tree. In Glacier National Park, this species is found on the east and west sides of the Continental Divide, although it is more abundant on the east side. Whitebark pine is considered a keystone species because of the important role it plays in the ecosystem. It is a hardy subalpine conifer that tolerates poor soils, steep slopes, windy exposures, and tree-line environments (Arno and Hoff 1990). This species provides valuable cover, shelter and nesting opportunities for many wildlife species. The grizzly bear and Clark's nutcracker rely on their seed for food. These trees also influence vegetation patterns by pioneering dry, exposed sites where no other tree species can grow. Because they establish on windy ridges and have broad crowns, they accumulate and retain snow which lengthens the snow melt period.

Another five-needled pine, limber pine (*Pinus flexilis*), is also considered to be a keystone species. This tree is found only on the east side of the Continental Divide in the park. Small to medium in size, it often grows on rocky ridges and its form is frequently irregular. At the lower tree line it mixes with other conifers. Being relatively shade-intolerant, it is mostly a pioneer species and maintains its presence only on somewhat severe sites. Like whitebark pine, this species also provides valuable cover, shelter and nesting opportunities. The large seeds are a nutritious food source for birds, rodents, and bears.

Whitebark and limber pine populations have declined dramatically in Glacier National Park, largely due to the introduction of a non-native fungus, white pine blister rust (*Cronartium ribicola*). White pine blister rust is a disease of five-needled pines and has been linked to the decline of all five-needled pines in the Park. Severe climatic events, mistletoe, fire exclusion, and/or mountain pine beetles may have also contributed to the poor health of these trees. Whitebark pine mortality has been estimated at 44% within the park with approximately 78% of the remaining live trees infected (Kendall and Keane 2001). Kendall and Keane. (2001) have also estimated limber pine mortality in Glacier National Park at 39% with 78% of the remaining live trees infected. Recent anecdotal evidence regarding limber pine stands indicates that current mortality and infection rates for this species have increased since 2001 and may be comparable to those observed in whitebark pine populations.

Some mature whitebark and limber pines have shown phenotypic genetic resistance to blister rust including few to no blister rust cankers, healthy needles, and cone production. These 'plus' trees continue to be identified in the park. Restoration efforts for these two species began in 1997 when seeds were collected from trees that showed phenotypic genetic resistance. In 1998, Glacier National Park received funding from the Intermountain Region Natural Resource Fund to continue collection efforts, grow seedlings from collected seeds, and plant seedlings at specific sites around the park. These seedlings have been planted in an effort to restore the ecosystem with disease-resistant trees. Limber pine seedlings have been planted at select sites on the east-side of the Park and whitebark pine seedlings have been planted at four sites, two on the east-side and two on the west-side. Sites were selected based on accessibility for planting, appropriate habitat characteristics, and recent burn activity. Planting years are chosen based on the availability of seedlings.

Due to the mortality and expense associated with growing and planting seedlings, another restoration approach was initiated in 2006 and continued in 2007. To date, seeds from potentially resistant whitebark pine trees were directly planted at three sites, two of which have burned in recent years. Seeds were cached in groups, mimicking planting schemes of Clark's nutcrackers. The idea behind this strategy is not only to minimize expense, but also to provide a more natural scenario whereby seed can germinate when environmental conditions are favorable. Seedlings were also planted at two of the sites for comparison.

1. *Limber Pine*

Limber pine seedlings have been planted on thirteen sites, seven of which are still active (Table 45 & Figure 36). A total of 4,778 seedlings have been planted in the park between 2002 and 2006. Plantings typically occurred in the fall but a few plantings occurred in the spring. Planting sites and the total number of seedlings planted varied between years. Monitoring plots captured 23% of total planted seedlings (Table 45).

Table 45. Limber Pine Monitoring Plot Establishment

<i>Site</i>	<i>Year</i>	<i># of Plots Established</i>	<i># of Trees Planted Overall</i>	<i>Total # Trees Captured</i>	<i>% Trees Monitored</i>
Apikuni Flats	2002	2	160	25	16%
Total		2	160	25	16%
Baring Creek	2004	5	450	91	20%
	2006	3	250	71	28%
Total		8	700	162	23%
Base Altyn Peak	2002	1	160	27	17%
	2004	2	200	40	20%
Total		3	360	67	19%
Dead Horse Point	2002	5	800	188	24%
	2004	2	250	53	21%
	2006	1	262	20	8%
Total		8	1312	261	20%
Firebrand Pass	2002	2	140	38	27%
Total		2	140	38	27%
Poia Lake TH	2002	2	160	41	26%
Total		2	160	41	26%
Rocky Point	2002	2	150	37	25%
Total		2	150	37	25%
Scenic Point	2002	4	200	74	37%
	2005	6	700	149	21%
Total		10	900	223	25%
Sun Point	2002	2	220	53	24%
	2004	2	250	54	22%
Total		4	470	107	23%
Two Medicine CG	2002	2	160	35	22%
Total		2	160	35	22%
Two Medicine CS	2003	1	26	26	100%
Total		1	26	26	100%
Two Medicine RS	2002	2	140	38	27%
Total		2	140	38	27%
Wild Goose Island TO	2002	1	100	29	29%
Total		1	100	29	29%
Overall Total		47	4,778	1,089	23%

Figure 36. Limber Pine Seedling Monitoring Sites



2. *Whitebark Pine*

Whitebark pine seedlings have been planted at six sites between 2000 and 2010 (Table 46 & Figure 37). Monitoring plots captured 21% of total planted seedlings (Table 46). The number of plots created at each site was dependent on planting densities and number of seedlings planted at the site. Data on the survival and health of individuals were collected during each monitoring event.

Table 46. Whitebark Pine Seedling Monitoring Plot Establishment

<i>Site</i>	<i>Year Established</i>	<i># of Plots Established</i>	<i># of Trees Planted</i>	<i># of Trees Monitored</i>	<i>% Trees Monitored</i>
Flattop Mtn.	2001(spring)	16	1,500	282	19%
	2001(fall)	11	1,438	348	24%
	2002 (fall)	11	2,222	281	13%
Total		38	5,160	911	18%
Grinnell Point	2000 (fall)	7	96	96	100%
Total		7	96	96	100%
Caper Peak	2006 (fall)	2	139	139	100%
Total		2	139	139	100%
Red Eagle	2007 (fall)	9	2,000	420	21%
Total		9	2,000	420	21%
Divide Creek	2010 (fall)	5	1126	261	23%
Total		5	1126	261	23%
Hole-in-the-Wall	2010 (fall)	5	830	159	19%
Total		5	830	159	19%
Overall Total		66	9,351	1,986	21%

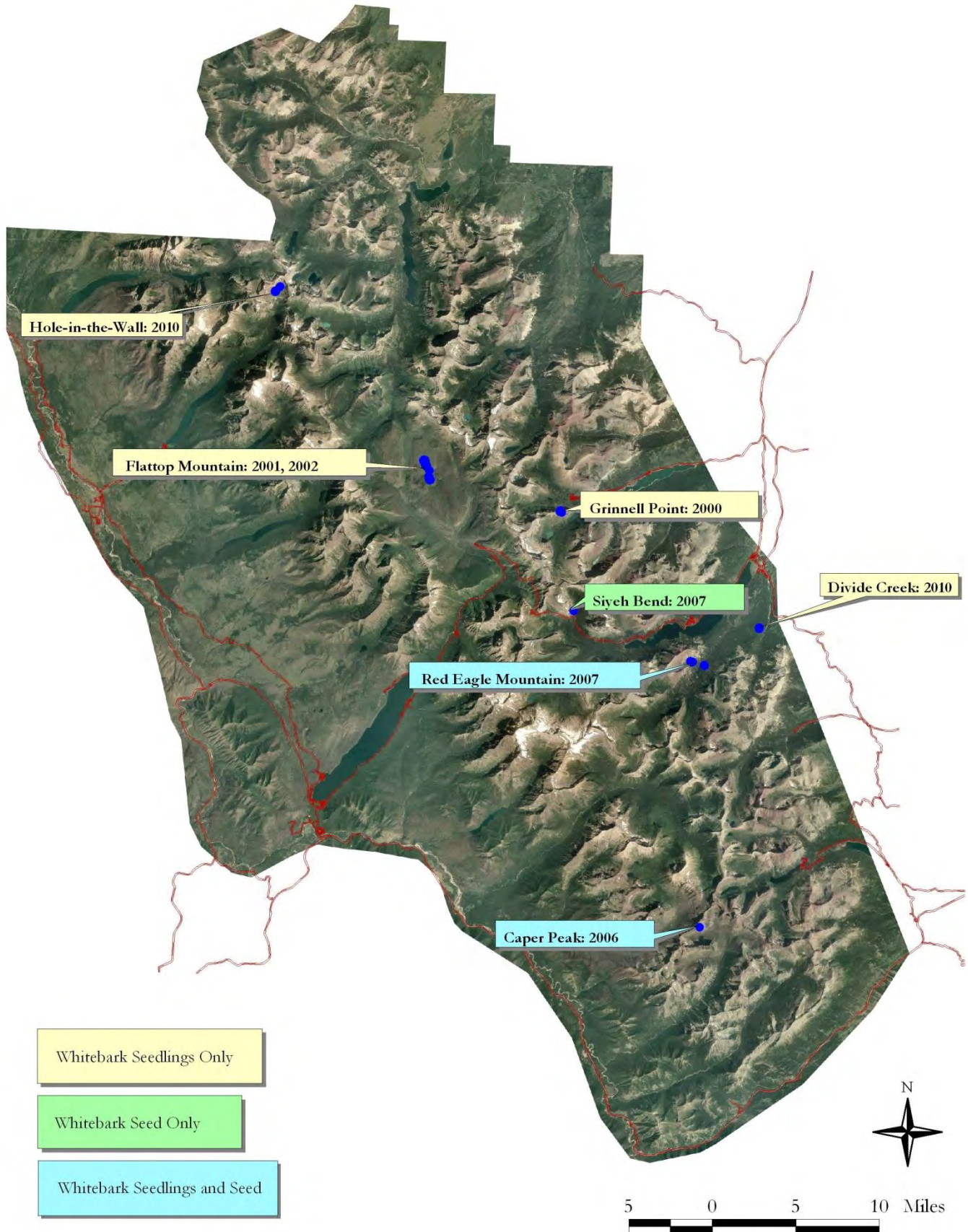
In the fall of 2000, 96 seedlings were planted at Grinnell Point, after the Grinnell Point Fire passed through the site earlier in the season. Plantings in this area range in elevation from 6,560 – 7,320 feet. All seedlings planted at this site were incorporated into monitoring plots. These plots have not been visited by Glacier National Park Staff since planting.

The majority of whitebark pine seedlings have been planted at Flattop Mountain, another site that has experienced recent fire. Seedlings were planted at this location, which burned in the McDonald Creek Fire of 1998, at elevations between 6,300 and 6,800 feet. A total of 5,160 trees were planted on Flattop Mountain between 2001 and 2002 with 921 trees incorporated in monitoring plots, capturing 18% of planted seedlings (Table 46). Plantings occurred in early summer and fall with various numbers of seedlings planted during each planting event.

In fall of 2006, 139 seedlings were planted at Caper Peak above Lake Isabel. This site is located at 6,520 feet and burned in the Rampage Fire of 2003. All seedlings planted at this site were included in monitoring plots. Due to the remote location of these sites, they were not monitored until 2008. In addition, whitebark pine seeds have been directly planted in the ground at this site (Figure 37 & Table 47). A total of 423 whitebark pine seeds were planted in the fall of 2006 in caches of 4 to 13 seeds. All seeds planted at this site were placed in monitoring plots. Germination rates and survival results of direct seeding may take several years to determine.

In 2007, 2,000 whitebark pine seedlings were planted along the eastern flank of Red Eagle Mountain and near the Red Eagle Campground that burned in the 2006 Red Eagle Fire (Figure 37). A total of 421 seedlings, 21% of the planted trees, were captured in nine monitoring plots; 352 seedlings are being monitored on the midslope of Red Eagle Mountain at elevations between 5,700 and 5,900 feet, while 63 seedlings are being monitored on an open knoll near the campground at 4,800 feet in elevation. A new methodology was used to install two transects to monitor whitebark pine seed directly planted into the

Figure 37. Whitebark Pine Seedling and Seed Monitoring Sites



ground (see Methods section). A total of 102 whitebark pine seeds were planted in caches along a 25m transect on the midslope of Red Eagle Mountain, while 98 whitebark pine seeds were planted in caches along a 20m transect on the same open knoll near the Red Eagle Campground (Table 47).

Using the same methodology, three additional transects were installed at Siyeh Bend along the Going-To-The-Sun Road that will monitor whitebark pine seed germination and tree growth in a more natural setting (Figure 37). Thirty-one seeds were planted along one 20m transect that was installed on a flatter section of slope, while 70 seeds were planted within two transects that were installed on flat benches near Siyeh Bend (Table 47).

Table 47. Whitebark Pine Seed Plot Establishment

<i>Site</i>	<i>Year Established</i>	<i># of Plots Established</i>	<i># of Seeds Monitored</i>	<i>Source of Seed</i>
Caper Peak	2006 (fall)	2	423	unknown
Siyeh Bend	2007 (summer)	3	101	Preston Park, 2005 (#155)
Red Eagle Mtn.	2007 (fall)	1	102	Preston Park, 2005 (#155)
Red Eagle CG	2007 (fall)	1	98	Preston Park, 2005 (#155)
Total		7	724	

Two new whitebark pine planting sites were added in the fall of 2010. The Hole-in-the-Wall Campground area is the first site where whitebark pine seedlings have been planted in a non-burned area. Whitebark pine, however, currently grows in this area and historical whitebark pine stands also existed in the area. Divide Creek was the second planting site established in 2010. This site burned in the 2006 Red Eagle Fire with moderate severity. Whitebark pine has not historically grown at this site but the area located within potential whitebark pine habitat.

In August 2010, a total of 830 whitebark pine seedlings were planted in the Hole-in-the-Wall campground area and in the cirque area above the campground. Elevations of planting sites ranged from 6,349 to 6,922 feet. Since this site has not been burned, an area of vegetation was “scalped” surrounding planting sites to reduce competition. Additionally, special attention was given to planting in sites with minimal surrounding vegetation, especially *Xerophyllum tenax*. Seedlings were preferentially planted near *Vaccinium scoparium*, *Luzula hitchcockii*, *Carex geyeri* and *Carex rossii*, since whitebark pine is disproportionately associated with these species (Izlar 2007). Microsites were utilized or provided for seedlings when possible. Five monitoring plots were established containing 159 seedlings, monitoring 19% of planted trees.

In September 2010, a total of 1,126 whitebark pine seedlings were planted on a ridge above Divide Creek. The elevation of this area ranged from 5,720 to 5,760 feet. Existing burned stumps and logs were used as planting microsites. As part of the planting, 300 of the seedlings planted at Divide Creek had been previously inoculated at Montana State University with a slurry made from ectomycorrhizal (ECM) mushroom species. Pines require ECM fungi for normal growth and survival and studies have confirmed whitebark pine to be ectomycorrhizal (Cripps and Mohatt 2005). These seedlings were planted together in groupings of 3 trees per hole throughout the revegetation site. Five monitoring plots were installed, encompassing 261 seedlings or 21% of the total trees plants. Forty of the monitored seedlings were inoculated, 13% of the total inoculated seedlings.

B. METHODS

1. Seedling Monitoring Plots

Shortly after seedlings are planted, monitoring plots are installed. Plot locations are chosen based on areas that are representative of the planting site and that contain a relatively high concentration of newly planted trees. UTM coordinates are taken at plot center and directions to the plot are recorded. To further assist with center stake location, a photo is taken of each stake and its associated location and azimuth are recorded.

Plot center is permanently marked with an 8-inch or 12-inch nail, often painted florescent orange for visibility, and tagged with the plot number. Plot numbers are either engraved on brass tags or hand pressed on

aluminum tags. Plot center is chosen in order to capture as many trees in all directions as possible. Descriptive data are recorded for the plot and include slope, aspect, elevation, light availability, landform, moisture regime, dominant vegetative lifeform cover, potential animal disturbance, and if time permitted, the soil type. Special attention is given to describing the location of the center nail.

Each planted seedling within the plot is located and assigned a number. For each seedling, the exact distance from plot center, in meters, and azimuth from plot center are recorded. The health of each tree is assessed and recorded, using the following scale: 1=dead, 2=missing (not found), 3=almost dead, 4=fair, 5=good (healthy). Comments that further describe the tree's health or may have a bearing on its ability to survive (e.g. growth, dead needles, presence and type of microsite, and whether or not a seedling was inoculated with ectomycorrhizal fungi) are recorded as well.

Plots are distributed throughout the entire planting site to avoid over sampling any given area. Monitoring plots attempt to capture 20% to 25% of the total seedlings planted at any given site. The number of seedlings captured per plot and plot radius varies between plots, but ideally plots contain 15 to 50 trees with a radius not much larger than 10 meters. It can become difficult to obtain accurate distances or see all seedlings in plots with radii greater than 10 meters.

Subsequent monitoring events entail locating each plot and each seedling within the plot, and utilizing the 5 point scale of health and survival assessment with comments as deemed necessary. Trees assigned a "2" (missing) were either previously dead and subsequently had disintegrated, or were not found. Many times a tree can be given a "2" one year and then be found alive and well the next. Additionally beginning in 2006, height and width of whitebark pine seedlings began to be measured (in cm). Size measurements are being recorded for trees at the Flattop Mountain, Caper Peak, Red Eagle, Hole-in-the-Wall and Divide Creek sites. Monitoring goals are for all plots to be monitored at years 1, 2, 3, 5, 10, 15 and 20 years after planting, as logistics permit.

2. *Whitebark Pine Seed Monitoring Transects*

There have been two methodologies used to install plots that monitor whitebark pine seed that is planted directly into the ground. On Caper Peak, two plots were installed in 2006 that resembled the whitebark and limber pine seedling plots. A center nail was installed and tagged, then documented with a GPS. Azimuth and distance from plot center measurements were then recorded for each seed cache, similar to the seedling plots described above. Multiple plantings occurred at each azimuth, at different distances from the center point. In this case, seed caches were interspersed with planted seedlings so that these two plots contain both seedlings and seed in the same plot. Plots ranged in size from 18 to 19 foot radius. Thirty eight and twenty nine caches of seed were installed in these respective plots with each cache containing 4 to 13 seeds (Table 48). Due to their remote location, these plots were not monitored in 2007 but were monitored in 2009, three years after seeding.

As stated above, a new methodology was used in 2007 near Siyeh Bend and Red Eagle Campground to monitor whitebark pine seed. In both locations, transects ranging from 20 to 30m were installed along relatively flat benches or mild slopes. These locations were chosen for their stability and the fact that large-scale snow movement that could take out both seedlings and monitoring stakes did not seem likely. Transects generally ran parallel to any slope that existed and were staked at the start and end of the transect line. GPS locations were recorded for these start and end points. A tape was laid out between these two points and then planting sites were haphazardly located at different distances either upslope or downslope originating from different lengths along the center line. Eight to thirteen caches of seed were then planted along the transect, with 3 to 5 seeds per cache at Siyeh Bend and 6 to 10 seeds per cache at Red Eagle (Table 48). The location of each cache was staked with a tagged nail and the distance along the transect line and direction and distance up or down from the transect line was recorded. Attempts were made to plant the seed caches in appropriate microsites for shade or to prevent erosion and snow damage. Attempts were also made to plant the seed caches within relatively open areas to reduce competition from other vegetation. Associated species, microsite slope, and description of the microsite were recorded for each cache site.

Table 48. Whitebark Pine Seed Transect Data

<i>Location</i>	<i>Plot Number</i>	<i>Length of Transect</i>	<i># Seeds Planted</i>	<i># Caches Planted</i>	<i># of Seeds Per Cache</i>	<i>Average Seed # Per Cache</i>
Caper Peak	1	18 ft.	227	38	4 to 10	6.0
	2	19 ft.	196	29	5 to 13	6.8
Siyeh Bend	1	20m	31	8	3 to 5	3.9
	2	30m	39	10	3 to 5	3.9
	3	20m	31	8	3 to 5	3.9
Red Eagle	1	25m	102	13	6 to 10	7.8
	2	20m	98	12	6 to 10	8.2

C. RESULTS

1. *Limber Pine Seedling Results*

Only one limber pine planting site was due to be revisited in 2010. Six plots at Scenic Point were monitored on August 30, 2010, five years after planting in 2005. Survival was determined based on all trees that were rated a 5 (good), 4 (fair), or 3 (almost dead).

No new seedlings have died in these plots in the last two years; the survival rate remains at 14% (Table 49). Three trees dropped in health rating, but six trees actually improved their health ratings. Seedlings that were rated as less healthy looked chlorotic or had thinning needles, while seedlings that improved in health had new growth.

Table 49. Health and Survival of Limber Pine Seedlings at Scenic Point, Monitored in 2010

<i>Site</i>	<i>Year Planted</i>	<i>Dead / Missing</i>	<i>Almost Dead</i>	<i>Fair</i>	<i>Good</i>	<i>Unk.</i>	<i># Survived</i>	<i># of Trees Monitored</i>	<i>% Survival</i>
Scenic Point	2005	126	1	9	11	0	21	147	14

Tables 50 to 53 recap survival at all established limber pine seedling monitoring sites over time. Overall survival of limber pine trees at all sites for all years is 6% (Table 50). Thirty three percent of the remaining live trees have been rated 'fair' and 63% of the trees have been rated 'good'. Overall, 94% of all planted limber pine trees have died, a 2% increase in mortality since 2008.

Table 50. Health and Survival of Remaining Live Limber Pine Seedlings to 2010

<i>Site</i>	<i>Year Planted</i>	<i>Last Year Monitored</i>	<i>Dead / Missing</i>	<i>Almost Dead</i>	<i>Fair</i>	<i>Good</i>	<i>Unk.</i>	<i># Survived</i>	<i># of Trees Monitored</i>	<i>% Survival</i>
Firebrand Pass	2002	2008	37	0	0	1	0	1	38	3%
Total 2002			584	0	0	1	0	1	585	0.2%
Two Med Camp Store	2003	2008	24	1	0	1	0	2	26	8%
Total 2003			24	1	0	1	0	2	26	8%
Baring Creek	2004	2009	71	0	7	13	1	20	91	22%
Base of Altyn Peak	2004	2009	28	0	7	5	0	12	40	30%
Sun Point	2004	2009	51	0	1	3	0	4	55	7%
Total 2004			150	0	15	21	1	36	186	19%
Scenic Point	2005	2010	128	1	5	15	0	21	149	14%
Total 2005			128	1	5	15	0	21	149	14%
Baring Creek	2006	2009	68	0	1	2	0	3	71	4%
Total 2006			68	0	1	2	0	3	71	4%
Subtotal			954	2	21	40	1	63	1017	6%
Percentage of Surviving Trees				3%	33%	63%	2%			
Percentage of Monitored Trees			94%	0.2%	2%	4%	0%	6%		6%

Table 51. Survival of Limber Pine Seedlings by Site, Planted in 2002

<i>Site</i>	<i>Monitoring Year</i>	<i>Total # Trees Monitored</i>	<i># Trees Survived</i>	<i>% of Trees Survived</i>
Apikuni Flats	2003	25	18	72%
	2004	25	0	0%
Base of Altyn Peak	2003	27	7	26%
(slope above Many	2004	27	1	4%
Glacier Hotel)	2006	27	1	4%
	2007	27	1	4%
	2009	27	0	0%
Dead Horse Point	2003	188	67	36%
	2004	188	0	0%
Firebrand Pass Trail	2003	38	27	71%
	2004	38	1	3%
	2006	38	1	3%
	2008	38	1	3%
Poia Lake Trail Head	2003	41	21	51%
	2004	41	0	0%
Rocky Point	2003	37	10	27%
	2004	37	0	0%
Scenic Point	2003	74	56	76%
	2004	74	0	0%
Sun Point	2003	53	24	45%
	2004	53	1	2%
	2006	53	1	2%
	2007	53	1	2%
	2009	53	0	0%
Two Medicine CG	2003	35	14	40%
	2004	35	0	0%
Two Medicine RS	2003	38	24	63%
	2004	38	0	0%
Wild Goose Island	2003	29	18	62%
Turnout	2004	29	0	0%
Total One Year Survival	2003	585	286	49%
Total Two Year Survival	2004	585	3	0.5%
Total Four Year Survival	2006	585	3	0.5%
Total Five Year Survival	2007	585	3	0.5%
Total Six Year Survival	2008	585	3	0.5%
Total Seven Year Survival	2009	585	1	0.2%

Table 52. Survival of Limber Pine Seedlings by Site, Planted in 2004

<i>Site</i>	<i>Monitoring Year</i>	<i>Total # Trees Monitored</i>	<i># Trees Survived</i>	<i>% of Trees Survived</i>
Baring Creek	2005	90	47	52%
	2006	90	39	43%
	2007	90	28	31%
	2008	90	20	22%
	2009	90	20	22%
Base of Altyn Peak	2005	40	23	58%
(slope above MG Hotel)	2006	40	13	33%
	2007	40	13	33%
	2009	40	12	30%
Dead Horse Point	2005	53	11	21%
	2006	53	4	8%
	2007	53	3	6%
	2009	53	0	0%
Sun Point	2005	55	28	51%
	2006	55	26	47%
	2007	55	16	29%
	2009	55	4	7%
Total One Year Survival	2005	238	109	46%
Total Two Year Survival	2006	238	82	34%
Total Three Year Survival	2007	238	60	25%
Total Five Year Survival	2009	238	36	15%

Table 53. Survival of Limber Pine Seedlings by Site, Planted in 2006

<i>Site</i>	<i>Monitoring Year</i>	<i>Total # Trees Monitored</i>	<i># Trees Survived</i>	<i>% of Trees Survived</i>
Baring Creek (2006)	2007	71	12	17%
	2008	71	3	4%
	2009	71	3	4%
Dead Horse Point	2007	20	0	0%
Total One Year Survival	2007	91	12	13%
Total Two Year Survival	2008	91	3	3%
Total Three Year Survival	2009	91	3	3%

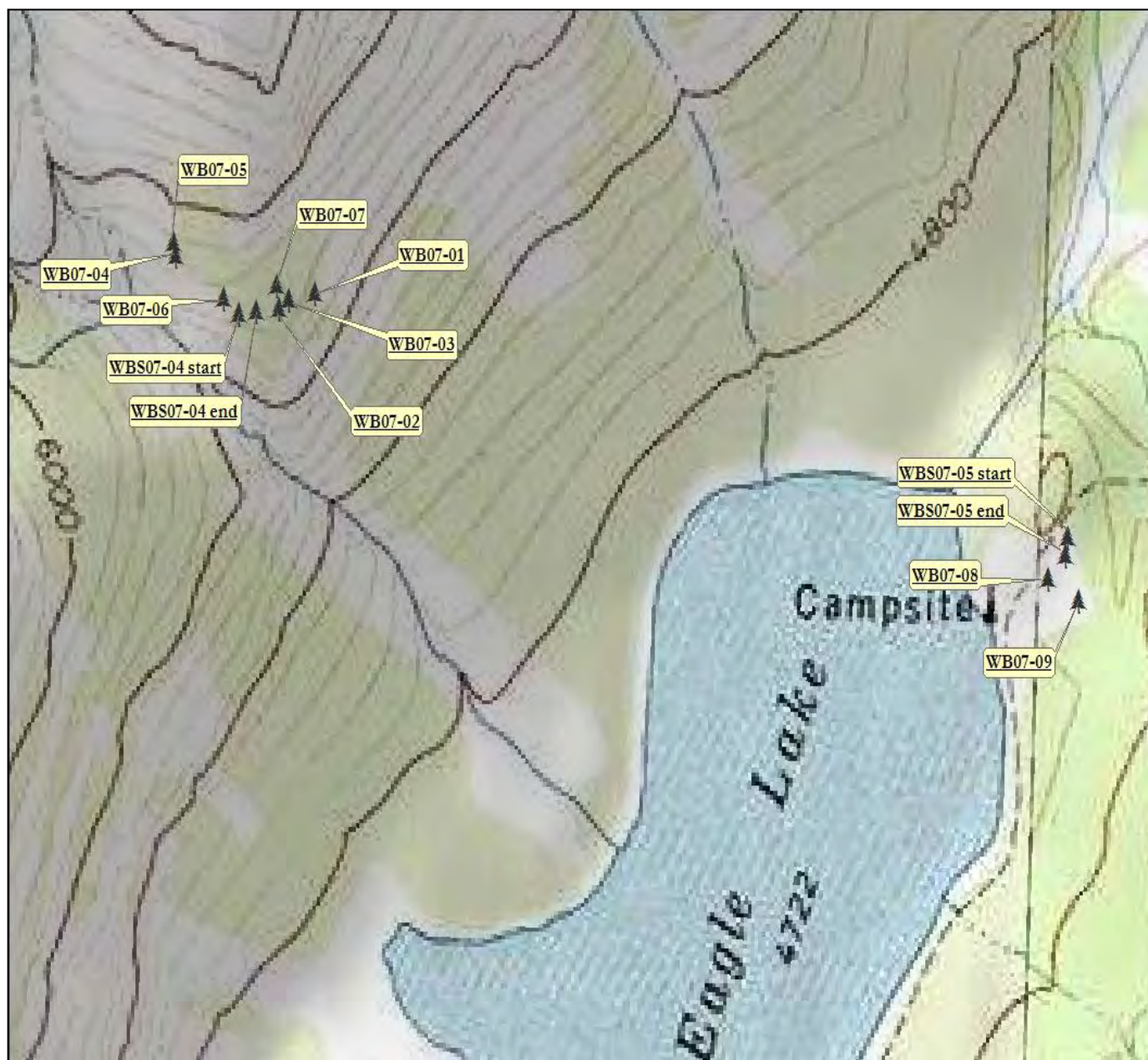
2. *Whitebark Pine Seedling Results*

One whitebark pine seedling site, Red Eagle Mountain, was monitored in 2010. Two new planting sites were established this year at Hole-in-the-Wall Campground and at Divide Creek.

a. *Red Eagle*

The Red Eagle site was monitored again in 2010 at year three after planting. Nine plots at Red Eagle were read in 2010, monitoring the success of 2,000 seedlings planted in 2007. Seven plots are located on the flanks of Red Eagle Mountain while two plots are located near Red Eagle Campground (Figure 38). Four hundred and twenty seedlings, or 21% of the planted material, are captured in these monitoring plots. The seed source of the seedlings was primarily Preston Park, however, some seedlings came from seed collected at Cobalt Lake and Scenic Point. Monitoring plots captured 1,690 seedlings (84.5%) from seed collected at Preston Park, 250 seedlings (12.5%) from seed collected at Cobalt Lake, and 60 seedlings (3%) from seed collected at Scenic Point. Due to their low numbers, no seedlings grown from Scenic Point seed were captured in monitoring plots (Table 54).

Figure 38. Location of Red Eagle Whitebark Pine Seedling and Seed Plots.



In addition, several planting amendments are being evaluated at Red Eagle. To test their impact on tree survival and growth, four planting treatments were tested: (1) Osmocote 13-13-13 fertilizer and watered in when planted; (2) Soil Moist¹ water polymer and watered in when planted; (3) both fertilizer and water polymer amendments as well as watered in; and (4) a few trees were solely watered in to serve as a control. While this is not a controlled experiment with equal numbers of trees under each treatment, it may be possible to make educated decisions concerning their effectiveness with monitoring data. The percent of trees monitored by site and treatment are presented in Table 54. Treatments by plot are presented with survival, heights and widths in Table 56.

¹ Soil Moist is a synthetic acrylic polyacrylamide with a potassium salt base. It allows initial rapid intake of water by a portion of the polymer followed by a slower absorption of water by a balance of the polymer. It contains a 5-5-5 fertilizer made from ammonium phosphate, sulfate, and muriate of potash.

Table 54. Red Eagle Whitebark Pine Seedlings: Percent of Trees Monitored by Site and Treatment

Site	% of trees monitored
Preston Park	61%
Cobalt Lake	39%
Treatment	% of trees monitored
Fertilizer + watered in	22.5%
Water polymer + watered in	22.7%
Fertilizer, water polymer + watered in	30.2%
Watered in only (control)	24.6%

Plots WB07-01 through WB07-07 are located on the flanks of Red Eagle Mountain (Figure 38). Survival remained relatively stable at these upper plots since last year. Average third year survival was 55%, a 3% decrease from the previous year. First year survival averaged 76.9% in these plots in 2008 (Table 55). Between years one and two, soil sliding and subsequent seedling burial on the steeper slopes caused high mortality in several plots, but no evidence of such activity was found during this monitoring event. Plot WB07-01 had the largest decline in survival between years one and two; declining from 95.9% to 30.6% (Table 55). This was due primarily to soil slides that buried many of the seedlings. This plot also had fewer microsites than other plots in flatter areas. Seedling survival has stabilized and remained the same for this plot between years two and three. Plots WB07-04, WB07-05, and WB07-06 were also affected by slides with several seedlings in each area buried by soil. Survival for the rest of the Red Eagle Mountain plots that were located in flatter areas with deeper soils and more microsites averaged 86% in 2009 and 79% in 2010. It should be noted that seven trees were not monitored in plot WB-07-02 in 2010, due to a missing data sheet in the field. Survival in this plot could have been as high as 81%, and therefore, survival in less disturbed sites could have been as high as 83% in 2010.

Table 55. Red Eagle Campground: Percent Survival and Dimensions of Whitebark Pine Seedlings by plot

Plot #	Seed Source	# Trees Planted	# Live Trees	2008 Survival	2009 Survival	2010 Survival	Planting Treatment	Avg Height (cm)	Avg Width (cm)
WB-07-01	Preston Park	49	15	95.9%	30.6%	30.6%	Water polymer + watered in	16.33	20.93
WB-07-07	Preston Park	44	32	88.6%	77.3%	72.7%	Water polymer + watered in	14.22	16.72
WB-07-02	Cobalt Lake	77	52	88.3%	83.1%	67.5%	Watered in only (control)	15.46	17.65
WB-07-03	Preston Park	55	51	96.4%	96.4%	92.7%	Fertilizer + watered in	19.39	20.02
WB-07-04	Cobalt Lake	40	18	52.5%	42.5%	45.0%	Fert, water polymer + watered in	13.17	13.39
WB-07-06	Cobalt Lake	46	13	63.0%	26.1%	28.3%	Fertilizer + watered in	13.54	14.23
WB-07-08	Preston Park	26	0	80.8%	0.0%	0.0%	Watered in only (control)	All Dead or Missing	
WB-07-05	Preston Park	48	11	39.6%	25.0%	22.9%	Fert, water polymer + watered in	12.82	14.36
WB-07-09	Preston Park	37	0	97.3%	0.0%	0.0%	Fert, water polymer + watered in	All Dead or Missing	
Subtotal Plots 01-07 (Flank RE Mtn.)				76.9%	57.7%	53.5%			
Subtotal Plots 08-0 (RE CG)				90.5%	0.0%	0.0%			
TOTAL		422	192	78.9%	49.1%	45.5%			

Average height of seedlings in the Red Eagle Mountain plots was 15.9 cm and average width was 17.6 cm (Table 56). This is an increase from 2009 when the average height was 12.3 cm and average width was 14 cm. It appears that certain planting amendments may be more successful than others, although many environmental variables may also be affecting growth and survival at each site making conclusions difficult. Preston Park seed that has been fertilized and watered in has the highest survival rate, height and width of all other treatments (Table 55). However, this trend does not hold for seed from Cobalt Lake. Seed from this source had the highest survival, height and width when watered in without additional soil amendments. Amending soil with water polymer at the time of planting may afford some advantage to seedlings, however. Seed from Preston Park produced broader seedlings in the presence of water polymer at the planting site, at least in plot WB-07-01. Seedlings with the largest average width by year three were planted with water polymer. Survival rates are somewhat deceiving, since plot WB07-01 lost many seedlings between years one and two due to soil slides and thus it is difficult to assess the effect of soil amendment on seedling survival.

Table 56. Average Height and Width of Whitebark Pine Seedlings at Red Eagle, 2008-2010.

Year	Height (cm)	Width (cm)
2008	8.92	9.57
2009	12.29	14
2010	15.87	17.55

Red Eagle plots WB07-08 and WB07-09 are located 85 to 150 meters northeast of the Red Eagle Campground (Figure 38). They are located in a very different habitat from the Red Eagle Mountain sites and thus survival is reported separately. First year survival for these plots was high, at 90.5%, where 86% of the surviving plants were in good condition (Tables 55). By 2009, year two after planting, all of the trees in both plots were either dead or missing. These plots were read again in 2010 to ensure that none of the missing trees were overlooked. Again, all trees were dead or missing in both plots resulting in removal of all center stakes. Some previously missing trees were relocated, all of which were dead. Overall, this rocky site with little soil and few microsites may not have been a good choice for planting whitebark pine. Additionally, some competition from regenerating herbaceous plants was also a potential factor. This site is also susceptible to more human disturbance. The rocky substrate, lack of good planting medium, lack of good microsites, human use, low elevation and competing vegetation likely all contributed to the failure of whitebark seedlings in this area.

Table 57. Red Eagle Campground: Health and Survival of Whitebark Pine Seedlings Monitored in 2010

<i>Plot</i>	<i>Dead/ Missing</i>	<i>Almost Dead</i>	<i>Fair</i>	<i>Good</i>	<i>Unk.</i>	<i># Survived</i>	<i># of Trees Monitored</i>	<i>% Survival</i>
WB-07-01	34		5	10		15	49	30.6%
WB-07-02	21		11	45	7	52	77	67.5%
WB-07-03	3	1	4	46		51	55	92.7%
WB-07-04	23		1	17		18	40	45.0%
WB-07-05	36		1	10		11	48	22.9%
WB-07-06	33		3	10		13	46	28.3%
WB-07-07	12	1	7	24		32	44	72.7%
			Total Flank of Red Eagle:			192	359	53.5%
WB07-08	26					0	26	0%
WB07-09	37					0	37	0%
			Total Red Eagle Campground			0	63	0%
			Total Red Eagle Entire Site:			192	422	45.5%

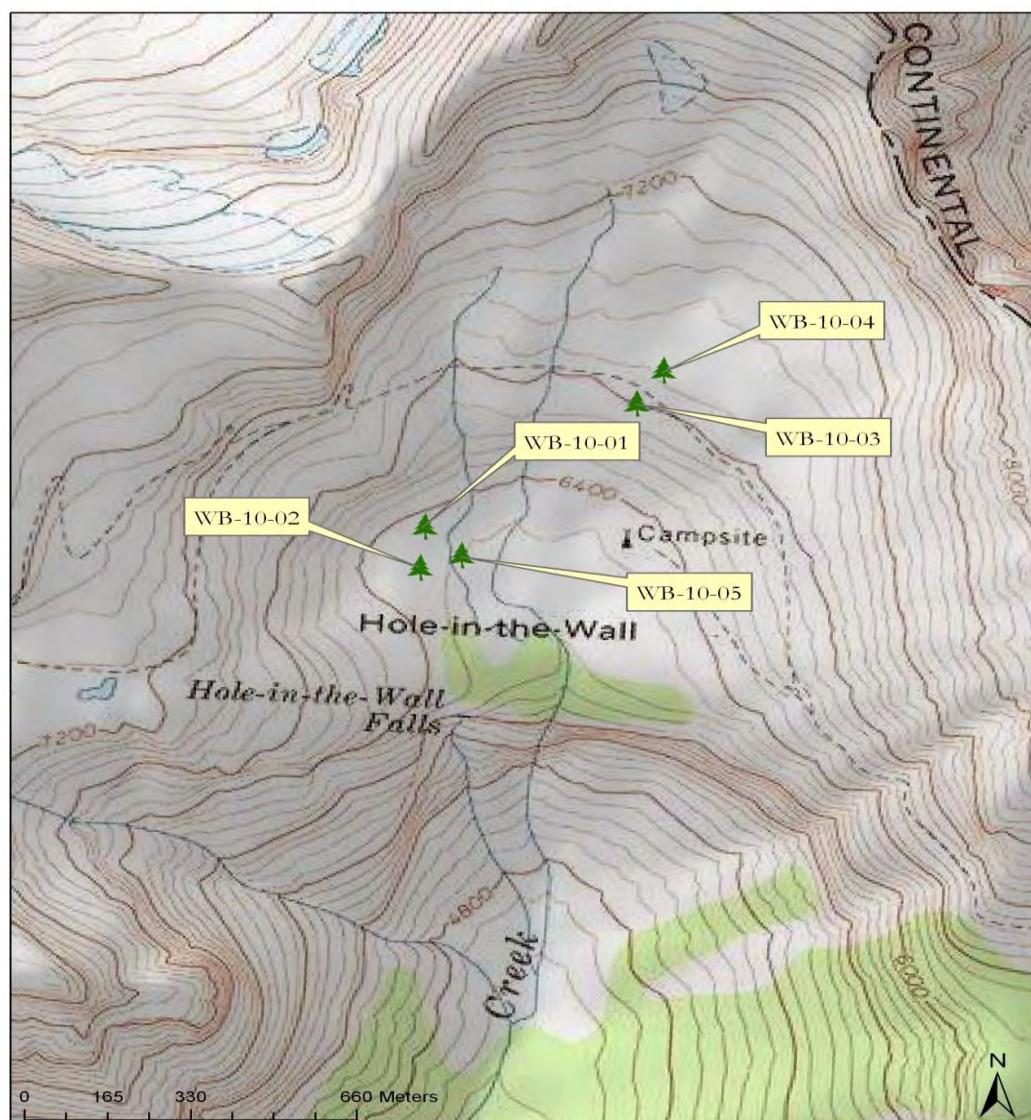
Overall first year survival for all plots in the Red Eagle area was 78.9% with 64% of the surviving trees in good health. Second year overall survival was 49.1% with all of the surviving trees rated as fair or good. By 2010, year three overall survival was 45.5% with most surviving trees rated fair or good (Table 57).

b. Hole-In-The-Wall Campground

A total of 830 whitebark pine seedlings were planted in the Hole-in-the-Wall campground area and in the cirque area above the campground. This is the first whitebark pine site that has not been burned and results from this experimental planting could direct planting site selection in the future. As stated above, an area of vegetation was “scalped” surrounding planting sites to reduce competition. Seedlings were preferentially planted near *Vaccinium scoparium*, *Luzula hitchcockii*, *Carex geyeri* and *Carex rossii*, since whitebark pine is disproportionately associated with these species (Izlar 2007). Microsites were utilized or provided for seedlings, when possible.

Five monitoring plots were established near the Hole-in-the-Wall Campground between August 23 and 25, 2010 (Figure 39). Plots contained 159 seedlings, monitoring 19% of planted trees. Of the monitored seedlings, 151 (95%) were given a “5” or “healthy” rating and 8 (5%) were assigned a “4” or “fair” rating. Average height of seedlings was 10.94 cm and average width was 9.42 cm.

Figure 39. Location of Whitebark Pine Seedling Monitoring Plots Established at Hole-in-the-Wall Campground, 2010.

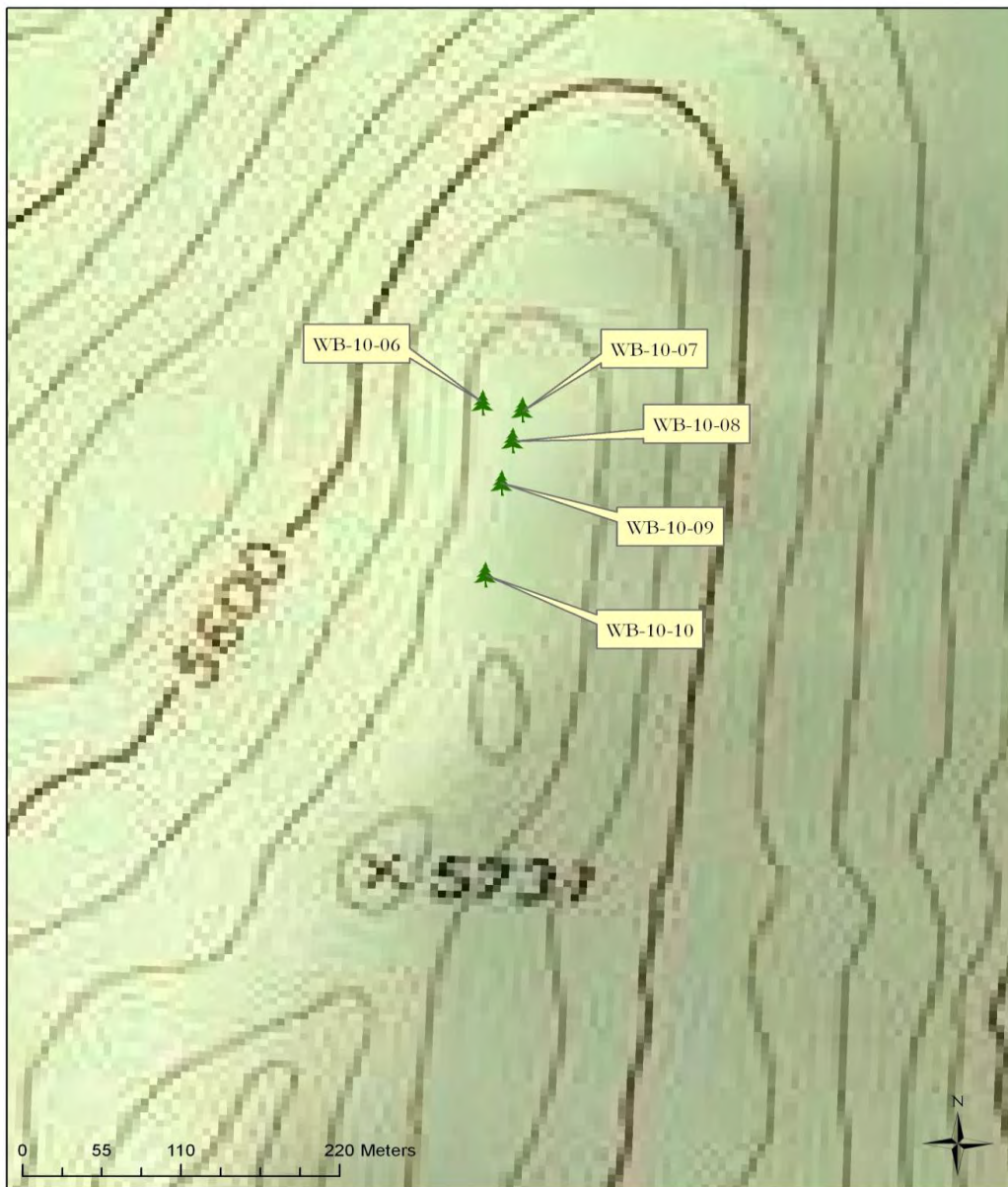


c. Divide Creek

On September 20-22, 2010, a total of 1,126 whitebark pine seedlings were planted on a ridge above Divide Creek (Figure 40). As stated above, this area burned in the Red Eagle fire of 2006 with moderate severity. An experimental planting occurred at this site where 300 of the planted seedlings had been inoculated by Cathy Cripps' lab from Montana State University. Inoculum was prepared from mushroom species known to have ectomycorrhizal relationships with whitebark pine. These were planted together in groupings of 3 seedlings per hole throughout the revegetation site.

Five monitoring plots were installed tracking 261 seedlings. This captured 21% of planted seedlings, 40 of which were inoculated. Of the monitored seedlings, 255 (98%) were given a "5" or "healthy" rating and 6 (2%) were assigned a "4" or "fair" rating. Average height of seedlings was 10.59 cm and average width was 10.12 cm.

Figure 40. Location of Whitebark Pine Seedling Monitoring Plots Established at Divide Creek, 2010.



3. *Whitebark Pine Seed Plot Results*

A total of seven whitebark pine seed plots have been installed to date to monitor the establishment of whitebark pine seedlings from seed planted directly into the ground. Two circular plots were installed in 2006 at Caper Peak. In 2007, two transects were installed in the Red Eagle area and three transects were installed at Siyeh Bend. Transects at Red Eagle and Siyeh Bend were monitored in 2010.

Two seedlings had germinated along transect WBS07-04 at the Red Eagle Mountain site in 2009. Both germinants were still alive in 2010 and grew in both height and width. In 2009, average height was 3.5cm and average width was 3cm. This year, average height was 5cm and average width was 5 cm. One germinant was rated healthy while the other germinant was only rated as fair.

In transect WBS07-05 at the Red Eagle campground site, one dead germinant was found in 2009. No germinants were found in this transect in 2010. The majority of the caches along this transect look to have been predated by animals. The probability of remaining seeds germinating at this point in time is fairly low for this site.

Similar to 2009, there were no germinants found along the Siyeh Bend transect, three years after seeding. Similar to the Red Eagle campground site, many small holes were observed at cache sites indicating animal predation.

D. CONCLUSIONS AND RECOMMENDATIONS

1. *Limber Pine*

Overall limber pine planting results in Glacier National Park are not very encouraging. Of the 1,089 trees that we have monitored in 13 different locations, only 64 trees, or 6%, remain in 2010. Of the remaining 64 trees, 62 trees are in good condition with a rating of fair or good and only 2 are rated as almost dead.

On the positive side, however, most of this overall low survival rate was due to a large planting event in 2002, preceding an extremely hot, dry summer in 2003, resulting in 0.5% survival by year two and 0.2% for year seven. Since then, survival rates of the limber pine trees planted in subsequent years is improving. Average survival for trees planted from 2003 to 2006 is 13%. The only limber pine seedlings scheduled to be monitored in 2010 were planted at Scenic Point in 2005. Survival rates for these trees have remained constant at 14% since the last monitoring event in 2008.

Results from a smaller planting of limber pine seedlings at Waterton Lakes National Park (WLNP) may shed some light on our results. It is interesting to note that the one cohort of planted limber pine trees (which came from the same source of seed as GNP limber pine seedlings) in WLNP that were planted in 2003 had an 85% survival rate at year one after planting, 76% survival rate at year two after planting, and 72% survival rate at year three after planting (Smith et al., 2007). While the number of monitored trees is lower than GNP's data set and only looked at one planting location, survival rates of this one trial in WLNP are significantly higher than results we have seen in GNP. In their study, they began to see three trends that may explain our lower survival rates and confirm some of our observations over the past few years. First, they found limber pine seedling survival was marginally better in seedlings planted near cover (Smith et al., 2007). Supporting our theory that seedlings may need some shade and some protection from wind to prevent desiccation, cover from microsites appears to increase survival of limber pine seedlings. As stated above, our planting technique has changed to incorporate microsites that offer cover, but did not during 2002 and in the 2006 Baring Creek planting when we had high mortality.

Smith et al. also found that survival and seedling health was improved when more seedlings were planted together in a clump. Singly-planted seedlings had the lowest survival rate at the end of three monitoring seasons while three- and five-clumped seedlings had higher survival rates. They argue that once emerged, seedling growth and survivorship are enhanced by the presence of other vegetation or seedlings (Powell 1996; Feldman et al. 1999) that may alleviate the abiotic effects of the surrounding environment, thus making the microclimate more suitable. The presence of other vegetation may promote growth since soil nutrients, density and moisture are retained, due to an established root system from the other plants. On the whole, a significant majority of limber pine trees planted in GNP were planted as single trees, possibly putting them at a disadvantage to retain soil moisture and nutrients, as well as to obtain protection from nearby vegetation. There is also conjecture that the survival benefit of being in a larger clump may not be a long-term effect. It is conceivable that the increased competition from being surrounded by more seedlings may result in lower survival once the seedlings are large enough to compete with one another (Smith et al., 2007).

Additionally, the WLNP study showed that seedling health was marginally better in burned areas than unburned areas within the experimental area. In general, burned soils carry a higher mineral load and more nutrients than unburned soils, thus having a positive effect on the growth of seedlings. To date, no limber pine seedlings have been planted in burned areas in GNP. Instead, they have been planted in unburned areas where limber pine is either present or has been present in the past. Some of those areas appear to be more amenable to limber pine survival, perhaps because they offer more soil nutrients and moisture, as well as appropriate microsites. These areas include the shadier areas of Baring Creek and Sun Point with moderate to low vegetation cover. Perhaps a site such as Scenic Point that is hot and exposed with little top soil or vegetation development offers too little protection, moisture, and nutrients.

To complicate results even further, there may be impacts from annual changes in precipitation and temperature. On the east side of GNP, where all of the limber pine sites are located, there was considerably low precipitation and in both 2002 and 2003 and higher temperatures in 2003. Increased rain and cooler temperatures since 2004 may be contributing to higher survival rates (Appendix A). Site differences surely account for differences in survival as well. Regular avalanche activity is certainly affecting tree survival, causing some sites to be less amenable for limber pine restoration.

Overall, we may need to be more critical about assessing a site as an appropriate limber pine planting site in GNP. The following factors should be considered when assessing a site:

- Microsite availability that provides some shade and wind protection.
- Some source of soil moisture and soil nutrients, including low to moderate vegetation and/or an area that has burned.
- Areas that have no on-going disturbance that would cause soil movement or trampling.

In addition, planting techniques of limber pine seedlings may want to address the following:

- Investigate growing seedlings in shorter containers to prevent the need for j-rooting in shallow soils.
- Investigate planting seedlings in groups of 3 to 5 seedlings to see if this increases survival.
- Assess the health of the seedlings prior to planting to assure that the healthiest material is being planted.

Finally, we recommend discontinuing the use of netting on limber pine trees, as it does not appear to be increasing their survival from our observations. If netting is still of interest, a more controlled experiment should be conducted to determine the benefits if its use to prevent seedling damage.

In 2011, limber pine trees planted in 2006 at Baring Creek are scheduled for monitoring (Table 58). If there is extra time available, Firebrand Pass may also be visited.

2. *Whitebark Pine*

To date, revegetation of whitebark pine seedlings is showing better progress than planted limber pine. Whitebark pine survival rates are higher than all of the limber pine sites for year two through year seven after planting. Third year survival was 47% for trees planted at Red Eagle in 2006, only a 2% reduction from 2009. Seedlings were not monitored this year at Flattop Mountain. In 2009, seven year survival was 41% and eight year survival was 31% for the trees planted at Flattop in 2001 and 2002. Both sites were planted using some of the recommendations learned from limber pine plantings, including planting in burned areas, planting in microsites, and not using shade netting.

These results are much more in keeping with results from other whitebark pine planting projects. Izlar (2007) compiled data from 37 whitebark planting events over the last 15 years in Montana, Wyoming, and Idaho. That summary reported that typical year one survival of planted whitebark seedlings is 74% (59-92% range), typical year three survival is 38% (31-47% range), and typical year 5 survival is 30% (19-42% range). While year one survival for the 2001 planting at Flattop Mtn. was slightly lower at 52%, five year survival of 34% is slightly higher than the average. Later plantings at GNP only improved. Trees planted in 2002 at Flattop Mtn. had 48% year three survival, remaining high at 46% at year four after planting. It is also important to remember that, currently, trees along Flattop Mtn., the oldest trees that have been planted, have had very little mortality after the first three to four years. Only 1%

to 2% mortality has occurred per year since year four after planting. The trees that remain are very healthy, have shown considerable growth, and show no signs of blister rust.

Year one survival at Red Eagle equaled the compiled average at 74% with 49% year two survival. If trees are removed from the Red Eagle Campground site that were likely planted in a poor location, year two survival for those trees planted on the flanks of Red Eagle Mtn. increases to 58%. If soil slides hadn't occurred in the area, survival would have even been higher. Overall seedling survival for year three at Red Eagle is higher than average and equals the high end of the range for Izlar's study, even including the lower campground site where all seedlings were dead.

As with limber pine plantings, we may need to be more critical about assessing a site as an appropriate whitebark pine planting site in GNP. The planting recommendations listed above for limber pine should also continue to be applied to whitebark pine plantings. In addition, there should be assessments made concerning the influence of slopes within planting areas, the possibility of falling bark of dead trees, and the impacts of competition from regenerating vegetation.

In 2011, Flattop seedling plots should be revisited (years 9 and 10). Siyeh Bend seed plots should also be monitored for year three results. Caper Peak is scheduled for 5-year monitoring in 2011 but due to logistics and lack of site information it may or may not be monitored (Table 58). Hole-in-the-Wall and Divide Creek should also be visited for first year data after planting. Since Hole-in-the-Wall is the first non-burned site which has been planted with whitebark pine seedlings, it will be interesting to compare survival results with burned sites.

Table 58. Whitebark and Limber Pine Monitoring Schedule

Plot(s)	Species	Location	Year Planted	Year Monitored: 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
None installed	Whitebark pine	Dutch Creek	2000?											X (year 10)		
GP00 -01 to -07	Whitebark pine	Grinnell Point	2000	X (year 0)						X (year 6)				X (year 10)		
FT01 -01 to -27	Whitebark pine	Flattop	2001		X (year 0)	X (year 1)			X (year 4)	X (year 5)			X (year 8)		X (year 10)	
FT02 -01 to -11	Whitebark pine	Flattop	2002			X (year 0)			X (year 3)	X (year 4)			X (year 7)		X (year 9)	
LP02 -01 to -25	Limber pine	Various	2002			X (year 0)	X (year 1)	X (year 2) ALL DEAD								
LP02-05	Limber pine	Many Glacier Hotel Slope	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE LEFT	X (year 5) 1 TREE LEFT		X (year 7) ALL DEAD			
LP02-22	Limber pine	Sun Point	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE LEFT	X (year 5) 1 TREE LEFT		X (year 7) ALL DEAD			
LP02-24	Limber pine	Firebrand Pass	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE LEFT		X (year 6)				X (year 10)
LP03-01	Limber pine	Two Med Camp Store	2003				X (year 0)	X (year 1)		X (year 3)		X (year 5)				
LP04 -01 to -05	Limber pine	Baring Creek	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)	X (year 4)	X (year 5)			
LP04 -06 to -07	Limber pine	Many Glacier Hotel Slope	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)			
LP04 -08	Limber pine	Sun Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5) ALL DEAD			
LP04 -09	Limber pine	Sun Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)			
LP04 -10	Limber pine	Dead Horse Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5) 1 TREE LEFT			
LP04 -11	Limber pine	Dead Horse Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5) ALL DEAD			
LP05 -01 to -06	Limber pine	Scenic Point	2005						X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)		
LP06 -02	Limber pine	Baring Creek	2006							X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)	
LP06 -01 & -03	Limber pine	Baring Creek	2006							X (year 0)	X (year 1)	X (year 2)	X (year 3) ALL DEAD		X (year 5)	
LP06 -04	Limber pine	Dead Horse Point	2006							X (year 0)	X (year 1)	Not done: all dead but 1 missing	X (year 3) ALL DEAD			
CP06 -01 to -02	Whitebark pine	Caper Peak (seeds + trees)	2006							X (year 0)		X (year 2)			X (year 5)	
WB07 -01 to -09	Whitebark pine	Red Eagle (seedlings)	2007								X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)
WBS07 -04 to -05	Whitebark pine	Red Eagle (seeds)	2007									X (year 1)	X (year 2)	X (year 3)		
WBS07 -01 to -03	Whitebark pine	Siyeh Bend (seeds)	2007								X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)
WB10-01-05	Whitebark pine	Hole-in-the-Wall	2010											X (year 0)	X (year 1)	X (year 2)
WB10-06-10	Whitebark pine	Divide Creek	2010											X (year 0)	X (year 1)	X (year 2)

Plot(s)	Species	Location	Year Planted	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2030
None installed	Whitebark pine	Dutch Creek	2000?			X (year 15)					X (year 20)							
GP00 -01 to -07	Whitebark pine	Grinnell Point	2000			X (year 15)					X (year 20)							
FT01 -01 to -27	Whitebark pine	Flattop	2001				X (year 15)					X (year 20)						
FT02 -01 to -11	Whitebark pine	Flattop	2002				X (year 14)					X (year 19)						
LP02 -01 to -25	Limber pine	Various	2002															
LP02-05	Limber pine	Many Glacier Hotel Slope	2002															
LP02-22	Limber pine	Sun Point	2002															
LP02-24	Limber pine	Firebrand Pass	2002					X (year 15)					X (year 20)					
LP03-01	Limber pine	Two Med Camp Store	2003	X (year 10)					X (year 15)					X (year 20)				
LP04 -01 to -05	Limber pine	Baring Creek	2004		X (year 10)					X (year 15)					X (year 20)			
LP04 -06 to -07	Limber pine	Many Glacier Hotel Slope	2004		X (year 10)					X (year 15)					X (year 20)			
LP04 -08	Limber pine	Sun Point	2004															
LP04 -09	Limber pine	Sun Point	2004		X (year 10)					X (year 15)					X (year 20)			
LP04 -10	Limber pine	Dead Horse Point	2004		X (year 10)					X (year 15)					X (year 20)			
LP04 -11	Limber pine	Dead Horse Point	2004															
LP05 -01 to -06	Limber pine	Scenic Point	2005			X (year 10)					X (year 15)					X (year 20)		
LP06-02	Limber pine	Baring Creek	2006				X (year 10)					X (year 15)					X (year 20)	
LP06 -01 & -03	Limber pine	Baring Creek	2006				X (year 10)											
LP06 -04	Limber pine	Dead Horse Point	2006															
CP06 -01 to -02	Whitebark pine	Caper Peak (seeds + trees)	2006				X (year 10)					X (year 15)					X (year 20)	
WB07 -01 to -09	Whitebark pine	Red Eagle (seeds + trees)	2007					X (year 10)					X (year 15)					
WBS07 -04 to -05	Whitebark pine	Red Eagle (seeds)	2007															
WBS07 -01 to -03	Whitebark pine	Siyeh Bend (seeds)	2007					X (year 10)					X (year 15)					
WB10-01-05	Whitebark pine	Hole-in-the-Wall	2010	X (year 3)		X (year 5)					X (year 10)					X (year 15)		X (year 20)
WB10-06-10	Whitebark pine	Divide Creek	2010	X (year 3)		X (year 5)					X (year 10)					X (year 15)		X (year 20)

XII. WHITEBARK AND LIMBER PINE PLUS TREE MONITORING

A. INTRODUCTION

Whitebark pine (*Pinus albicanlis*) and limber pine (*Pinus flexilis*) populations have declined dramatically in Glacier National Park, largely due to the introduction of a non-native fungus, white pine blister rust (*Cronartium ribicola*). White pine blister rust is a disease of five-needled pines and has been linked to the decline of all five-needled pines in the park. Spores from a secondary host infect trees through the needles and the fungus subsequently grows into the stem, producing fusiform cankers, almost always eventually killing the tree (Hoff 1992). Glacier National Park not only has a high mortality rate associated with blister rust, but it also has an extremely high blister rust infection rate of remaining live trees. Infection is estimated at 78% for both whitebark and limber pine trees that remain in the Park (Kendall and Keane 2001). A massive effort at removing secondary hosts for white pine blister rust in the Park was attempted between 1930 and 1970. Enormous numbers of *Ribes* species were removed by hand pulling and chemical control with no success at curtailing the disease (USGS 2003). Additionally, climate change may favor conditions that enhance distribution of blister rust spores. Recent climatic conditions produce frequent “wave years” that promote massive numbers of infections (Koteen 2002). Therefore, it does not appear that preventing the spread of blister rust is an effective strategy for preservation of whitebark or limber pine.

Taking advantage of natural blister rust resistance may be a more effective strategy for restoration of whitebark and limber pine. Natural genetic resistance has been found in several species of five-needled pines and there is preliminary evidence that whitebark pine may also exhibit natural resistance (Schwandt 2006). A protocol has been implemented by U.S. Forest Service nurseries whereby potential rust-resistant seedlings are tested for resistance. Preliminary tests have revealed resistance in some whitebark pine seedlings (Maholovich et al. 2006).

Glacier National Park has been attempting to utilize naturally resistant trees in its restoration program for the past 13 years. Cones have been collected from phenotypic-resistant whitebark pine trees since 1997. Phenotypic indicators of blister rust resistance include no or very few active blister rust cankers, no or very few inactive blister rust cankers, no to little impact to canopy cover of tree (no flags, dead branches, etc.), and the presence of cones. Wire cages are placed around cones during seed production for protection from predators with seed then collected later in the season. It is important to note that there has been no testing to date of blister rust resistance for any tree in Glacier National Park, so it is unknown whether or not the cone trees were truly resistant. In addition, despite best intentions, seed was combined so that it is now impossible to tell which seedlings were grown from which potential rust resistant cone tree. Beginning in 2007, seedlings were able to be tracked to a parent tree in a particular location in the park (i.e., Preston Park) but surviving seedlings have not been traceable with their seed source tree. Caging of trees in 2008 began a large scale collection for genetic testing, whereby all seed will be directly traceable to a specific tree.

Occasionally, trees were inadvertently caged that were infected with blister rust, and over time some of the potentially rust resistant trees have become infected. This influenced the decision to expand upon the initial purpose for monitoring potential plus trees purely as a seed source. Previously, cone trees have not been monitored over time for long-term health and resistance. Initially the purpose of this study was to identify and build baseline data for potential phenotypically rust resistant whitebark pine trees (“plus trees”) for field monitoring over time, as well as to identify potential cone collection trees for the future. Since whitebark pine often grow in very remote and isolated areas, this survey was also designed to reduce the amount of time and effort required when searching for cone trees to cage. Information is now being gathered concerning the trees’ ability to resist infection, how quickly the infection spreads and how long a tree may survive with infection. While this may aid in future cone collection, it may also help answer questions about resistance of specific trees in populations that are highly infected with blister rust, as well as the fate of trees that have mild blister rust infection.

B. METHODS

During August and September of 2007, whitebark pine tree populations were scouted for potential plus trees. Limber pine was also targeted in a few sites. For each population, trees were assessed for the presence of blister rust as well as overall health. Mostly blister rust canker-free trees were chosen for inclusion in the monitoring pool. Occasionally, trees that looked healthy but were mildly infected were also selected for monitoring to document the impacts of mild infestation on whitebark pine trees. Resistant trees can suppress cankers by a defense reaction whereby the tree builds a periderm around the infection (Hoff 1992). As cone production is variable by year, the presence of cones was not initially a determining factor for including a tree in the monitoring pool. Monitoring these plus trees on an annual to biannual basis should also provide information on cone production trends over time.

Potential plus trees were each numbered and their locations were recorded using a GPS unit. In 2007 and 2008, identification numbers were written on each tree bole with a waterproof marker to reduce impacts to the tree. By 2009, after realizing that this marking does not persist over time, some of the plus trees were marked with nails and flagging at the base of the tree to further assist with re-location. This method is working well for tree identification and will be continued for all plus trees in the future. Trees were assessed for percent live canopy and measured for DBH and height. Presence and number of cones was noted. A digital photograph was taken of each tree with the distance and azimuth from the tree recorded. Evidence of blister rust on the bole (labeled as bole cankers) or branches (labeled as stem or branch cankers) of the tree was recorded and categorized as active or inactive canker. Additional information about the site, such as the canopy cover of the surrounding forest, state of surrounding whitebark pine trees, whitebark regeneration in the area, and general site characteristics, was documented. Also noted were associated species, particularly any known or potential secondary hosts to blister rust, such as *Ribes* or *Castilleja* species. Presence of Clark's nutcrackers, whitebark pine seed dispersers, was also recorded.

Blister rust was identified in trees by the presence of active cankers, inactive cankers, or by old dead cankers evidenced by bark cracking or spindle-shaped branches (Hoff 1992). Signs of active (sporulating) cankers were orange-colored spore casings emerging from small cracks in the branches. Inactive cankers were identified by empty white fruiting bodies leftover from sporulation from the current year or spindle-shaped limbs characterized by extensive bark cracking. Early infections, prior to fruiting, were more difficult to identify but were recorded when recognized. Heavy sap flow and discoloration on the outside of the bark can be an early sign of blister rust (Hagle et al. 2003) and was also recorded when sighted. Yellow-orange patches on the stem and the beginnings of spindle-shaped stems may also be one of the only signs of blister rust infection for the first 4-5 years. Additionally, "bark stripping" was noted as possible evidence of cankers. High amounts of sugars are produced in cankers and animals such as rodents, ants and grasshoppers feed on them (Hoff, 1992) causing areas where bark has been scraped or chewed off. "Flagging", or ends of branches where needles have died that leave a red-needled branch tip, was also recorded as a potential sign of blister rust infection. Whenever signs were encountered that were most likely the early signs of blister rust, but could not be definitively called so, it was recorded as "probable".

C. RESULTS

To date, there are 82 whitebark pine trees that are monitored as part of the plus tree pool; 56 trees were identified in 2007, 4 trees were identified in 2008, 13 were identified in 2009, and 9 were identified in 2010 (Figure 41 and Table 59). Monitoring sites for whitebark pine established in 2007 include Numa Lookout (7 trees), Old Man Lake Trail (7 trees), Otokomi Lake (6 trees), Preston Park (20 trees), Rising Wolf (6 trees), Scenic Point (7 trees) and Siyeh Bend (3 trees). In 2008, only one site was added at Triple Divide with 4 trees. In 2009, 5 additional trees were added at Scenic Point, 5 additional trees were added at Numa Lookout and 3 additional trees were added at Preston Park. This year, 1 additional tree was added at Preston Park, 1 additional tree was added at Scenic Point, and 7 additional trees were added at White Calf, a new site for plus tree monitoring. The revegetation crew continued to take into consideration recommendations based on plus tree data for cone tree locations and areas that had the best cone tree pool. Cones were collected from trees at Scenic Point, Preston Park, and White Calf, whereby all the seed was put into the rust-

resistance genetics testing program with the USFS. Cone trees were monitored at all of these sites, as well as at Old Man Lake Trail, Otokomi Lake, and Triple Divide Trail. Two additional limber pine plus trees were added to the pool, one additional tree at Dead Horse Point and one tree at White Calf. These trees, plus the existing limber pine plus trees at Dead Horse Point and Scenic Point, were monitored this year.

Table 59. Whitebark Pine Plus Trees: Health and Cone Production, 2010.

<i>Site</i>	<i>Date</i>	<i># of Trees Monitored</i>	<i># of Healthy Trees¹</i>	<i># with Active Cankers</i>	<i># with Inactive Cankers</i>	<i># with Possible Cankers</i>	<i># With Cones</i>
Numa Lookout*	9/8/08	6	4	2	1	1	1
Numa Lookout*	8/4/09	6	2	3	3	0	6
Old Man Lake Tr*	9/15/10	7	4	3	3	2	2
Otokomi Lake*	9/2/10	6	3	2	3	4	3
Preston Park*	7/22/10	24	13	9	7	8	21
Rising Wolf*	9/24/09	6	2	3	4	1	3
Scenic Point*	7/21/10	13	2	8	8	3	13
Siyeh Bend*	8/14/08	3	0	3	3	0	1
Triple Divide	9/28/10	4	3	0	1	0	1
White Calf*	7/19/10	7	2	4	4	0	7
	TOTAL	82	35	37	37	19	58
% AS OF LAST SURVEY			43%	45%	45%	23%	71%

¹Trees are identified as healthy if there are no positively identified active or inactive cankers on any live part of the tree.

* Some of these trees have active, inactive and/or probable cankers on the same tree.

In 2010, of the 82 whitebark pine trees in the monitoring pool, 43% (35 trees) were healthy, 45% (37 trees) had active cankers, 45% (37 trees) had inactive cankers, and 23% (19 trees) had probable but unconfirmed inactive cankers (Table 59). This year's data supports a continuing trend of fewer healthy trees and a higher incidence of blister rust in some of the last remaining whitebark trees in Glacier. For comparison, in 2009, 48% (35 trees) were healthy, 32% (23 trees) had active cankers, 37% (27 trees) had inactive cankers, and 12% (9 trees) had probable but unconfirmed inactive cankers (Table 60). This was a fairly large increase in blister rust activity from 2008 when 60% of trees were healthy and only 27% of trees had active cankers and 22% had inactive cankers (Table 60). In 2007, 66% of plus trees were healthy with even lower blister rust infection rates (Table 60). Data from 2008 and 2009 was reused for sites that were not visited this year. It should be noted that many of these trees had active, inactive and/or probable cankers on the same tree.

On the positive side, the cycle of whitebark pine cone production is on the upswing with a higher percentage of cone producing trees in 2010 in comparison to 2008 and 2009. This year, 71% of whitebark pine plus trees had cones, a value nearing 2007 when 75% of plus trees had cones. In addition, the average cones per tree was up slightly from 2007 levels, currently estimated at 27 cones/tree for all monitored plus trees in 2010 (Table 61). First year cones were observed with great frequency this year, as well, indicating that 2011 could indeed be a true mast year. Very little is known about the frequency of mast years in whitebark pine, although it has been found that healthy stands of whitebark in the Greater Yellowstone area had moderate or large whitebark pine conecrop years 2 or 3 times from 1980-1990 (Morgan and Bunting 1990). It should be noted that the healthiest whitebark pine trees, now that they have been identified, are currently being targeted for cone collection. The actual cone production rate for the overall stand could indeed be much lower. A total of 673 cones were collected by the revegetation crew this year (Table 62).

Table 60. Whitebark Pine Plus Trees: Comparison of Health and Cone Production, 2007-2010.

<i>Site</i>	<i>Date</i>	<i># of Trees Monitored</i>	<i># of Healthy Trees¹</i>	<i># with Active Cankers</i>	<i># with Inactive Cankers</i>	<i># with Possible Cankers</i>	<i># With Cones</i>
Numa Lookout	2007	7	5	1	0	2	7
Numa Lookout	2008	7	4	3	2	1	1
Numa Lookout	2009	12	6	5	4	1	6
Old Man Lake Trail	2007	7	5	1	2	0	2
Old Man Lake Trail	2010	7	4	3	3	2	2
Otokomi Lake	2007	6	4	0	0	2	4
Otokomi Lake	2010	6	3	2	3	4	3
Preston Park	2007	20	13	5	4	1	20
Preston Park	2008	20	13	7	3	1	13
Preston Park	2009	23	12	4	8	3	18
Preston Park	2010	24	13	9	7	8	21
Rising Wolf	2007	6	5	0	0	1	2
Rising Wolf	2009	6	2	3	4	1	3
Scenic Point	2007	7	4	1	1	2	7
Scenic Point	2008	7	2	1	3	2	5
Scenic Point	2009	12	3	6	6	2	8
Scenic Point	2010	13	2	8	8	3	13
Siyeh Bend	2007	3	1	2	2	0	0
Siyeh Bend	2008	3	0	3	3	0	1
Triple Divide	2008	4	3	1	0	0	3
Triple Divide	2010	4	3	0	1	0	1
White Calf	2010	7	2	4	4	0	7
TOTAL 2007		56	37	10	9	8	42
TOTAL 2008		60	36	16	13	7	31
TOTAL 2009		73	35	23	27	9	45
TOTAL 2010		82	35	37	37	19	58
% 2007			66%	18%	16%	14%	75%
% 2008			60%	27%	22%	12%	52%
% 2009			48%	32%	37%	12%	63%
% 2010			43%	45%	45%	23%	71%

Table 61. Whitebark Pine Plus Trees: Cone Frequency, 2007 - 2010.

<i>Site</i>	<i># of Trees Monitored</i>	<i># of Cones in 2007</i>	<i>Avg Cones per Tree 2007</i>	<i># of Cones in 2008</i>	<i>Avg Cones per tree 2008</i>	<i># of Cones in 2009</i>	<i>Avg Cones per tree 2009</i>	<i># of Cones in 2010</i>	<i>Avg Cones per tree 2010</i>
Preston Park	20/20/23/24	925	46	176	9	267	12	718	30
Numa	7/7/6	165	24	5	1	52	9		
Old Man Tr	7	38	5					9	1
Otokomi Lk	6	14	2					25	4
Rising Wolf	6	16	3			89	15		
Scenic Point	7/7/10/11	237	34	10	1	109	11	599	54
Siyeh Bend	3	4	1	10	3				
Triple Divide	4			4	1			1	0.25
White Calf	7							232	33
TOTAL	56/41/45/59	1399	25	205	5	517	11	1584	27

Table 62. Caged Whitebark Pine Trees and Cones Collected, 2010.

Site	Trees Caged	Cones Collected
Preston Park	5	231
Scenic Point	5	252
White Calf	7	190
Total	17	673
Average Cones Per Tree		40

Lastly, four limber pine trees are present in the plus tree monitoring pool. Two trees, one at Dead Horse Point and one at Scenic Point, were identified in 2007, while two additional trees were identified in 2010, one at White Calf and a second tree at Dead Horse Point (Figure 41 and Table 63). All trees were monitored this year and are mostly healthy with the exception of the new limber pine at Dead Horse Point that had inactive cankers. All trees were producing cones this year, although the average number of cones per limber pine was less this year than in years past (Tables 63 and 64).

Table 63. Limber Pine Plus Trees: Health and Cone Production, 2010.

Site	Date	# of Trees Monitored	# of Healthy Trees ¹	# with Active Cankers	# with Inactive Cankers	# with Possible Cankers	# With Cones
Dead Horse Point	9/9/10	2	1	0	1	0	2
Scenic Point	7/21/10	1	1	0	0	0	1
White Calf	7/19/10	1	1	0	0	0	1
	TOTAL	4	3	0	1	0	4
	2007 PERCENT		100%	0%	0%	0%	100%
	2008 PERCENT		100%	0%	0%	0%	100%
	2009 PERCENT		100%	0%	0%	0%	50%
	2010 PERCENT		75%	0%	25%	0%	100%

Table 64. Limber Pine Plus Trees: Cone Frequency, 2007 - 2010

Site	# of Trees Monitored	# of Cones in 2007	Avg Cones per Tree 07	# of Cones in 2008	Avg Cones per tree 08	# of Cones in 2009	Avg Cones per tree 09	# Cones in 2010	Avg Cones per tree 10
Dead Horse Point	1/2	100	100	50	50	200	200	46	23
Scenic Point LP	1	10	10	20	20	0	0	15	15
White Calf	1							75	75
TOTAL	2/4	110	55	70	35	200	100	136	34

D. CONCLUSIONS AND RECOMMENDATIONS

The most predominant trend observed from 2008 to 2010 continues to be the increase in blister rust infection within the whitebark pine plus tree monitoring pool. As shown above, healthy whitebark pine plus trees have decreased from 66% in 2007 to 43% in 2010 with an increase of trees that currently have active and inactive blister rust cankers. It is possible that our ability to detect blister rust, especially the early stages, has been refined since 2007. Trees that were identified as healthy in 2007 may have had early signs of blister rust that were not detected and certain trees should possibly not have been included in the whitebark pine plus tree pool. While it is getting more difficult to find healthy trees in other areas, it is important that more plus trees are identified, not only in the stands listed above but also in new areas of the park. As the future of healthy whitebark pine trees is unknown, a larger pool of trees is imperative for seed collection and genetic

integrity of our seedling stock. Since 2008, limbs with active cankers have been removed or cut off, a recent practice that may prolong the life of certain whitebark pine plus trees in the monitoring pool.

Monitoring data is beginning to document the cyclic nature of cone production in whitebark pine trees. While 2008 and 2009 showed dramatic decline in whitebark pine cone production throughout the park, cone production was higher in 2010 with 71% of plus trees having cones. In addition, cones per tree appeared to be slightly higher this year and, with observations of first year cones in a number of trees this past summer, it could be a true mast year for cone production in 2011. It is important to note that overall cone production was likely lower, given that the healthiest trees were targeted for both cone collection and monitoring. Future monitoring will begin to document the local trends of cone production in the park, as well track the impacts of increasing blister rust on cone production of the plus tree pool.

As in years past, Preston Park has remained the best site for caging cones from healthy whitebark pine trees. This year there was a small rise in the amount of infected trees, but this area seems to have the largest population of live and healthy trees of all the sites monitored. Whitebark pine has historically dominated a large area in Preston Park. Many of these trees are dead and dying, but survivorship in this area seems to be much higher than most places within the park. It also seems to have some of the best cone production of all of our monitoring sites. Clark's nutcrackers were also observed on several visits to Preston Park in 2007, 2009, and 2010, indicating that this is an important habitat for the birds and potentially for grizzly bears as well. The entire Preston Park area has not been scouted for healthy whitebark pine trees so several more trees could be added to the monitoring pool in the future.

Numa Lookout and Scenic Point remain other areas with relatively healthy stands of whitebark pine, despite increases in blister rust infection within plus trees in that location. Whitebark pine trees, however, are smaller here compared to Preston Park and it appears that cone production is less reliable at both of these sites, despite an excellent cone crop at Scenic Point this year. Although the whitebark plus trees at both of these sites will need to be closely monitored, both sites will remain active cone collection areas.

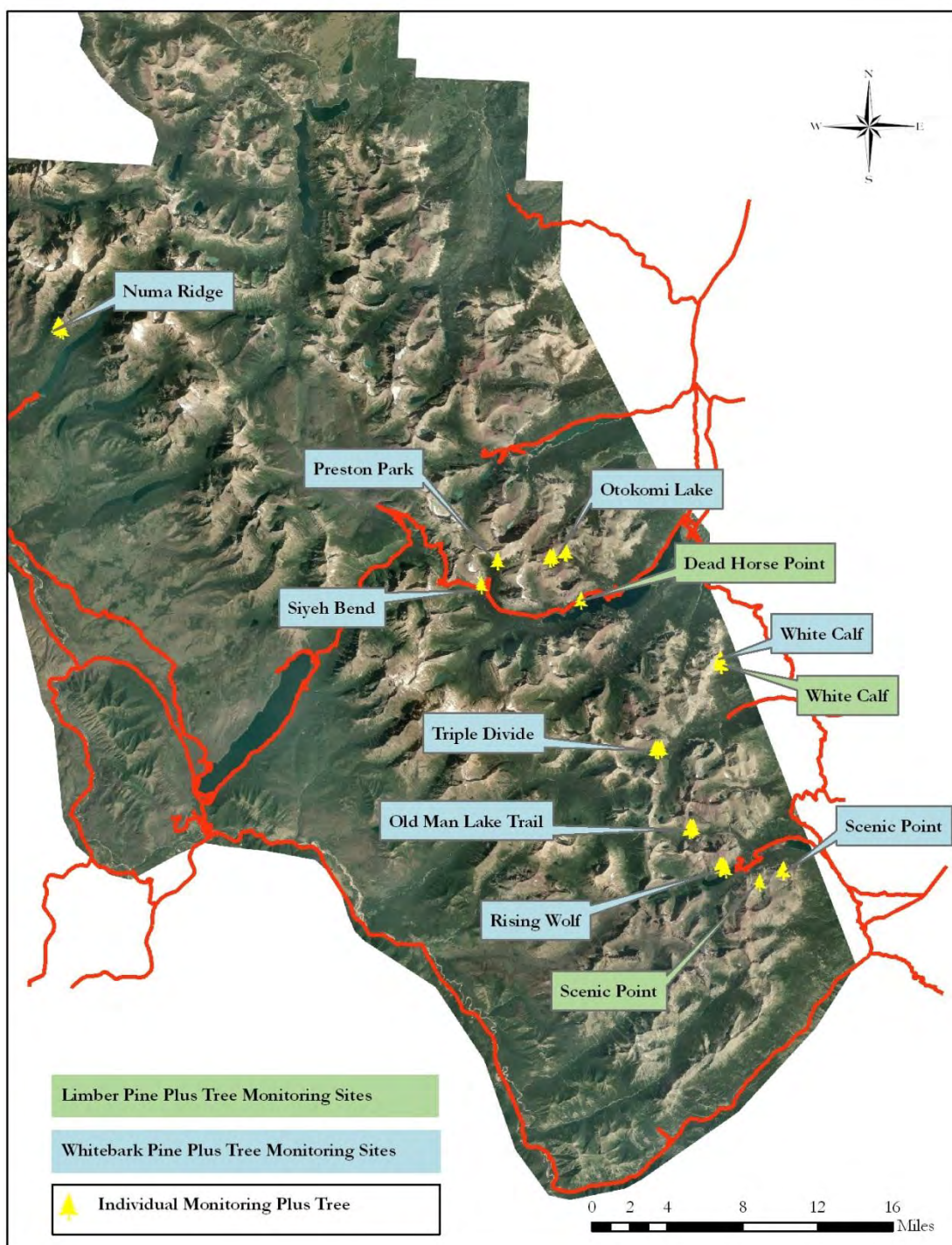
Healthy trees are present along the Dawson Trail (accessing Rising Wolf), the Old Man Lake Trail, the Otokomi Lake Trail, and the Triple Divide Pass Trail, although there are only a few trees at each site that also tend to have low cone production rates. Monitoring will continue at all four sites to assess cone production and tree health in the future. Trees at Rising Wolf, Otokomi Lake, and Triple Divide have had particularly low cone production since the start of plus tree monitoring, resulting in few if any trees being used for cone collection. Cones have been collected from trees along the Old Man Lake Trail in the past, and given the high frequency of first year cones that were observed at this site in 2010, trees in the area may provide good cone collection trees in 2011. Finally, all three trees at Siyeh Bend are now heavily infected with blister rust and have had minimal cone production in the last two years. Trees at Siyeh Bend will continue to be monitored, however, it is possible that this area may not be included as a seed collection site in the future. Other possible sites to search for healthy whitebark pine in 2011 include the Firebrand Pass Trail, trails in the Many Glacier subdistrict, the Morning Star Lake trail, and Bighorn Basin.

As mentioned in the introduction, Glacier is participating in a genetic resistance program with the U.S. Forest Service to test the resistance of whitebark pine plus trees to blister rust. We are aiming to have 25 plus trees tested to provide us with guidance for whitebark seed collection and protection of our plus tree pool. Until this information is clearer, our current strategy for collecting whitebark and limber pine seed is to collect seed from trees that either show no or very little sign of blister rust. With the amount of energy, time and money it takes to restore whitebark and limber pine trees in the park, it seems prudent to begin the process with seed that has the best chance of restoring healthy trees to the area. Gathering long-term data on these plus trees will help to ensure that the healthiest trees in the park are being used for seed collection.

Finally, as monitoring continues, data may help to answer whether some trees that exhibit mild blister rust infection can fend off lethal infection and remain healthy. It may also help us determine a timeline for survival of trees that succumb to infection. Data may also determine whether trees that appear healthy in the midst of dead and dying trees can remain blister rust free. Lastly, monitoring plus trees should provide data on cone production cycles that could help plan future seed collection efforts.

Whitebark and limber pine plus trees should be monitored each year if funding and time exists. Plus trees should, at a minimum, be monitored on a bi-annual basis to collect information on cone production and tree health.

Figure 41. Location of Whitebark and Limber Pine Plus Trees for Monitoring



XIII. OVERALL RECOMMENDATIONS FOR REVEGETATION AND REVEGETATION MONITORING

The revegetation and revegetation monitoring programs are making positive strides in restoring disturbed communities in Glacier National Park. One area in which we have made improvements is assessing appropriate species to use in specific revegetation areas. Listed below are recommendations for general plant species that are typically found in common forest, grassland, and subalpine meadow types. While these lists should not override the use of specific information found in site analysis data, these general lists should help to guide the nursery and restoration planners in common plants that we consistently see across the park in common habitats. Due to the complexity and site specific nature of wetland, shrubland, and alpine types, there are no general lists for these areas. A few additional recommendations are also listed that address communication and sampling design.

SPECIES SELECTION:

Certain plant species in Glacier National Park have a wide amplitude of habitats in which they grown and are quite common in the Park. From our observations, the following species are often present in these common plant communities. As a result, we have found that we recommend them frequently for revegetating areas. Adding to the complexity of the restoration process, many of these listed species are generally difficult to grow in the nursery. Species listed with a * are species that have been difficult to grow in the past and are species that are currently being experimented with in the nursery. Given their common presence in a number of plant communities, however, these species should be salvaged whenever possible.

Moist cedar-hemlock forest (montane - west side):

<u>Trees</u>	<u>Shrubs</u>	<u>Forbs/Ferns</u>	<u>Grasses</u>
<i>Betula papyrifera</i>	<i>Acer glabrum</i>	<i>Adenocaulon bicolor</i> *	<i>Bromus vulgaris</i>
<i>Larix occidentalis</i>	<i>Amelanchier alnifolia</i>	<i>Aralia nudicaulis</i> *	<i>Calamagrostis rubescens</i>
<i>Picea engelmannii</i>	<i>Linnaea borealis</i> *	<i>Athyrium filix-femina</i>	<i>Carex concinnoides</i>
<i>Pinus monticola</i>	<i>Lonicera utahensis</i>	<i>Chimaphila umbellata</i> *	<i>Carex rossii</i>
<i>Pseudotsuga menziesii</i>	<i>Menziesia ferruginea</i>	<i>Clintonia uniflora</i> *	<i>Elymus glaucus</i>
<i>Thuja plicata</i>	<i>Paxistima myrsinites</i>	<i>Cornus canadensis</i>	
<i>Tsuga heterophylla</i>	<i>Rosa acicularis</i>	<i>Disporum hookeri/ trachycarpum</i> *	
	<i>Rubus parviflorus</i>	<i>Dryopteris expansa</i>	
	<i>Spiraea betulifolia</i>	<i>Goodyera oblongifolia</i> *	
	<i>Vaccinium membranaceum</i> *	<i>Gymnocarpium dryopteris</i>	
		<i>Maianthemum stellatum</i> *	
		<i>Orthilia secunda</i> *	
		<i>Osmorhiza berteroi</i> *	
		<i>Thalictrum occidentale</i> *	
		<i>Tiarella trifoliata</i> *	
		<i>Viola orbiculata</i> *	
		<i>Xerophyllum tenax</i> *	

Engelmann spruce-subalpine fir forest (montane – east and west):

<u>Trees</u>	<u>Shrubs</u>	<u>Forbs/Ferns</u>	<u>Grasses</u>
<i>Abies lasiocarpa</i>	<i>Acer glabrum</i>	<i>Arnica cordifolia</i>	<i>Bromus vulgaris</i>
<i>Larix occidentalis</i>	<i>Amelanchier alnifolia</i>	<i>Clintonia uniflora</i> *	<i>Calamagrostis rubescens</i>
<i>Picea engelmannii</i>	<i>Linnaea borealis</i> *	<i>Disporum hookeri</i> *	<i>Elymus glaucus</i>
<i>Pinus contorta</i>	<i>Mahonia repens</i>	<i>Disporum trachycarpum</i> *	<i>Festuca occidentalis</i>
	<i>Paxistima myrsinites</i>	<i>Eurybia conspicua</i>	<i>Festuca subulata</i>
	<i>Salix scouleriana</i>	<i>Maianthemum racemosum</i> *	
	<i>Sorbus scopulina</i>	<i>Oryzopsis asperifolia</i>	
	<i>Spiraea betulifolia</i>	<i>Osmorhiza berteroi</i> *	
	<i>Symphoricarpos albus</i>	<i>Thalictrum occidentale</i> *	
	<i>Vaccinium caespitosum</i> *	<i>Viola orbiculata</i> *	
	<i>Vaccinium membranaceum</i> *	<i>Xerophyllum tenax</i> *	
	<i>Vaccinium myrtillus</i> *		

Engelmann spruce-subalpine fir forest (subalpine – east and west):Trees

Abies lasiocarpa
Picea engelmannii
Pinus contorta

Shrubs

Alnus viridis
Arctostaphylos uva-ursi
Menziesia ferruginea
Paxistima myrsinites
Ribes lacustre
Rubus parviflorus
Sorbus scopulina
Spiraea betulifolia
*Vaccinium membranaceum**
*Vaccinium myrtillus**
*Vaccinium scoparium**

Forbs/Ferns

Arnica cordifolia/latifolia
Erigeron peregrinus
*Erythronium grandiflorum**
Eucephalus engelmannii
Luzula glabrata var. hitchcockii
*Mitella breweri**
Pedicularis bracteosa
*Thalictrum occidentale**
Valeriana sitchensis
Veratrum viride
*Viola orbiculata**
*Xerophyllum tenax**

Grasses

Calamagrostis rubescens
Carex geyeri

Douglas fir forest (mesic montane – east and west):Trees

Abies lasiocarpa
Larix occidentalis
Pinus contorta
Pseudotsuga menziesii

Shrubs

Acer glabrum
Amelanchier alnifolia
*Linnaea borealis**
Lonicera utahensis
Mahonia repens
Menziesia ferruginea (higher)
Paxistima myrsinites
Rosa woodsii
Rubus parviflorus
Shepherdia canadensis

Forbs/Ferns

Achillea millefolium
Arnica cordifolia
*Clintonia uniflora**
Eurybia conspicua
*Goodyera oblongifolia**
*Orthilia secunda**
*Thalictrum occidentale**
*Xerophyllum tenax**

Grasses

Calamagrostis rubescens
Carex geyeri
Carex rossii
Festuca occidentalis

Douglas fir and/or ponderosa pine forest (drier montane – mostly west): species listed in Douglas fir forest above plus these additional speciesTrees

Pinus ponderosa

Shrubs

Arctostaphylos uva-ursi
Dasiphora floribunda
Juniperus communis
*Vaccinium caespitosum**

Forbs/Ferns

Antennaria rosea
Heuchera cylindrica
Penstemon confertus
Potentilla gracilis

Grasses

Festuca campestris
Danthonia intermedia
Pseudoroegneria spicata

Lodgepole pine and/or western larch forests (montane – mostly west):Trees

Larix occidentalis
Pinus contorta
Pseudotsuga menziesii

Subcanopy:

Abies lasiocarpa
Pseudotsuga menziesii
Thuja plicata
Tsuga heterophylla

Shrubs

Acer glabrum
Amelanchier alnifolia
*Linnaea borealis**
Mahonia repens
Rosa woodsii
Rubus parviflorus
Spiraea betulifolia
Symphoricarpos albus
*Vaccinium caespitosum**
*Vaccinium membranaceum**
*Vaccinium myrtillus**

Forbs/Ferns

Arnica cordifolia
Chamerion angustifolium
*Chimaphila umbellata**
*Clintonia uniflora**
Eurybia conspicua
Symphyotrichum laeve var. laeve
*Xerophyllum tenax**

Grasses

Calamagrostis rubescens
Carex concinnoides
Carex geyeri
Oryzopsis asperifolia

Quaking aspen (montane – east and west):Trees

Abies lasiocarpa
Picea engelmannii
Pinus contorta
Populus tremuloides

Shrubs

Acer glabrum
Amelanchier alnifolia
Mahonia repens
Prunus virginiana
Rosa acicularis
Rubus parviflorus
Salix scouleriana
Spiraea betulifolia
Symphoricarpos albus

Forbs/Ferns

Aster conspicuus
*Castilleja miniata**
Chamerion angustifolium
Equisetum arvense
Fragaria virginiana
Heracleum sphondylium
*Maianthemum racemosum**
*Maianthemum stellatum**
*Osmorhiza occidentalis**
*Thalictrum occidentale**
Veratrum viride
*Viola canadensis**

Grasses

Bromus carinatus
Calamagrostis canadensis
Calamagrostis rubescens
Carex geyeri
Elymus glaucus

Quaking aspen/black cottonwood/conifer (montane – east and west):Trees

Abies lasiocarpa
Betula papyrifera
Picea engelmannii
Pinus contorta
Populus tremuloides
Populus balsamifera

Shrubs

Alnus viridis
Amelanchier alnifolia
Cornus sericea
Lonicera utahensis
Ribes inerme
Rubus parviflorus
Spiraea betulifolia
Symphoricarpos albus/occidentalis

Forbs/Ferns

Actaea rubra
*Angelica arguta**
Chamerion angustifolium
*Disporum trachycarpum**
*Equisetum arvense**
Eurybia conspicuus
Fragaria virginiana
Geranium viscosissimum
Heracleum sphondylium
*Maianthemum stellatum**
*Osmorhiza occidentalis**
Pteridium aquilinum
*Thalictrum occidentale**
*Viola canadensis**

Grasses

Calamagrostis canadensis
Carex geyeri
Elymus glaucus
Melica smithii

Idaho Fescue/rough fescue (montane – east and west):Shrubs

Arctostaphylos uva-ursi
Dasiphora floribunda

Forbs/Ferns

Achillea millefolium
Agoseris glauca
Anemone multifida
Antennaria rosea
Antennaria umbrinella
Cerastium arvense
Eriogonum umbellatum
Fragaria virginiana
Gaillardia aristata
Galium boreale
Geranium viscosissimum
Geum triflorum
Hedysarum sulphurescens
Heuchera cylindrica
Lithospermum ruderales
Lomatium triternatum
Lupinus sericeus
Penstemon confertus
Potentilla glandulosa
Potentilla gracilis
Sedum lanceolatum

Grasses

Achnatherum occidentale
Achnatherum richardsonii
Carex obtusata
Carex petasata
Carex rossii
Danthonia intermedia
Elymus trachycaulus var. subsecundus
Elymus trachycaulus var. trachycaulus
Festuca campestris
Festuca idahoensis
Koeleria macrantha
Pseudoroegneria spicata

Subalpine meadow (subalpine – east and west):

Trees

Abies lasiocarpa

Shrubs

Dasiphora floribunda

Salix arctica

*Vaccinium caespitosum**

*Vaccinium scoparium**

Forbs/Ferns

Achillea millefolium

Agoseris glauca

Anemone occidentalis

Antennaria alpina/umbrinella

Arenaria capillaris

Arnica diversifolia/mollis

Castilleja spp.*

Chamerion angustifolium

Epilobium anagallidifolium

Erigeron compositus

Erigeron peregrinus

Eriogonum flavum

Galium boreale

Hedysarum sulphurescens

Heracleum sphondylium

Hypericum scouleri

Oxyria digyna

Pedicularis bracteosa

Phacelia hastata

Polygonum bistortoides

Potentilla diversifolia

Senecio cymbalarioides

Sibbaldia procumbens

Solidago multiradiata

Symphyotrichum foliaceum var. *foliaceum*

Symphyotrichum laeve var. *laeve*

Valeriana sitchensis

Veratrum viride

Veronica wormskejoldii

*Xerophyllum tenax**

Zigadenus elegans

Grasses

Agrostis variabilis

Carex haydeniana

Carex nigricans

Carex paysonis

Carex phaeocephala

Carex spectabilis

Deschampsia atropurpurea

Juncus drummondii

Juncus mertensianus

Juncus parryi

Luzula glabrata / *spicata*

Phleum alpinum

Poa alpina

Poa secunda

Trisetum spicatum

See 2008 Revegetation Monitoring Report to see suggestions about which species should be seeded or grown in containers, or both.

Road sides (montane – east and west):

Trees

various by site

Shrubs

Arctostaphylos uva-ursi

Juniperus communis

*Linnaea borealis**

Mabonia repens

Rosa woodsii

Spiraea betulifolia

Symphoricarpos albus

Forbs/Ferns

Achillea millefolium

Anaphalis margaritacea

Antennaria howellii

Antennaria rosea

*Aralia nudicaulis**

Arnica cordifolia/latifolia

Chamerion angustifolium

Eurybia conspicua

Fragaria virginiana/vesca

Geranium viscosissimum

Geum macrophyllum

Heracleum sphondylium

*Maianthemum stellatum**

*Osmorhiza berteroi**

Solidago canadensis

Symphyotrichum laeve var. *laeve*

*Xerophyllum tenax**

Grasses

Bromus carinatus

Bromus vulgaris

Calamagrostis rubescens

Carex concinnoides

Carex geyeri

Carex microptera

Carex rossii

Deschampsia elongata

Elymus glaucus

Elymus trachycaulus v.

trachycaulus

Festuca occidentalis

Festuca subulata

Oryzopsis asperifolia

Other generally good revegetation species to use that have wide ecological amplitude:

Achillea millefolium
Anaphalis margaritacea
Antennaria howellii
Fragaria virginiana/vesca
Symphytotrichum laeve var. *laeve*

Species to continue experimenting with in the nursery:

<i>Adenocaulon bicolor</i> *	<i>Maianthemum stellatum</i> *
<i>Angelica arguta</i> *	<i>Orthilia secunda</i> *
<i>Aralia nudicaulis</i> *	<i>Osmorhiza berteroi</i> *
<i>Castilleja</i> spp.*	<i>Osmorhiza occidentalis</i> *
<i>Chimaphila umbellata</i> *	<i>Thalictrum occidentale</i> *
<i>Clintonia uniflora</i> *	<i>Tiarella trifoliata</i> *
<i>Disporum bookeri</i> *	<i>Vaccinium</i> spp.*
<i>Disporum trachycarpum</i> *	<i>Viola canadensis</i> *
<i>Hieracium albiflorum</i> *	<i>Viola orbiculata</i> *
<i>Linnaea borealis</i> *	<i>Xerophyllum tenax</i> *
<i>Maianthemum racemosum</i> *	

COMMUNICATION:

- (1) Continue to conduct revegetation monitoring meetings for discussion about the monitoring data and evaluation of revegetation program. It may be more useful to hold several meetings that focus on certain revegetation issues. These issues could include: (1) use of fertilizers; (2) road shoulder revegetation strategies; (3) setting goals and objectives; (4) evaluation of monitoring techniques; (5) seed bank analysis and its impact on revegetation; and (6) research ideas for the field and for the nursery.

SAMPLING DESIGN:

- (1) Monitoring staff should consult with a statistician for assessment on monitoring design and appropriate statistical methods for past and future projects.
- (2) The types of monitoring methods that other parks/natural areas use should be investigated for comparison to our program. In particular, methods should be investigated as alternatives to ocular estimates used in Level II and in the site analysis.

XIV. MONITORING SCHEDULE: 1992 - 2014

1992

- 303-B - Level III (year 1)

1993

- 303-B - Level III, photomonitor (year 2)
- 303-B road shoulders - Level II (year 1)
- 303-C - Level II, photomonitor (year 1)
- Rob Tyser's Two Dog Flats plots - Level IV (year 1)
- 303-D - site analysis, photomonitor
- 303-E - site analysis, photomonitor
- Polebridge Developed Area - Level II, photomonitor
- Polebridge Bridge - Level II, photomonitor
- Bowman Creek Campground - Level II, photomonitor
- River Campground - Level II, photomonitor
- Swiftcurrent Apartments - Level II
- Three Bears Lake - Level II
- St. Mary Housing - Level II

1994

- 303-B - Level III, photomonitor (year 3)
- 303-B road shoulders - Level II, photomonitor (year 2)
- 303-C - Level II, photomonitor (year 2)
- 303-C road shoulders - Level II, photomonitor (year 1)
- 303-D - set up first series of shrub plots and established monitoring plots for Level IV experiment
- 303-F - site analysis along road corridor
- Granite Park Chalet - site analysis, photomonitor
- Two Medicine Housing Area - site analysis, photomonitor
- Camas Road - site analysis (2 sites)

1995

- 303-B road shoulders - Level II, photomonitor (year 3)
- 303-C - Level II, photomonitor (year 3)
- 303-C road shoulders - Level II, photomonitor (year 2)
- Rob Tyser's Two Dog Flats plots - Level IV (year 3)
- 303-D - Level IV, photomonitor (year 1)
- 303-E - photomonitor, wrote preliminary monitoring plans
- 303-F - continued site analysis along road corridor
- Camas Road - site analysis (10 sites)

1996

- 303-B - Level III, photomonitor (year 5)
- 303-D - Level IV, photomonitor (year 2)
- 303-D road shoulders - Level II, photomonitor (year 1)
- 303-E - photomonitor, set up Level IV experiments
- 303-F - Avalanche campground site analysis

1997

- Rob Tyser's Two Dog Flats plots - Level IV (year 5)
- 303-D - Level IV, photomonitor (year 3)
- 303-D road shoulders - Level II, photomonitor (year 2)
- 303-E - Level IV (year 1), photomonitor, set up additional experiments
- 303-F (Avalanche Picnic Area) - photomonitor (pre-disturbance)
- Camas Road - photomonitor (pre-disturbance)

1998

- 303-B road shoulders - Level II, photomonitor (year 6)
- 303-C - Level II, photomonitor (year 6)
- 303-C road shoulders - Level II, photomonitor (year 5)
- 303-E - Level IV, photomonitor (year 1 and 2)
- Polebridge Developed Area - Level II, photomonitor
- Polebridge Bridge - Level II, photomonitor
- Bowman Creek Campground - Level II, photomonitor
- River Campground - Level II, photomonitor

1999

- 303-D - Level IV, photomonitor (year 5)
- 303-E - Level IV, photomonitor (year 2 and 3)
- Camas Road - photomonitor (year 1)

2000

- 303-F - Level II, photomonitor (year 1)
- Camas Road - Level II, photomonitor (year 2)
- Three Bears Lake - Level II
- Oberlin Bend / Jones Flat Social Trail Assessment
- Logan Pass Visitor's Center Handicapped Access Trail Assessment
- Lunch Creek Social Trail Assessment

2001

- 303-B - Level III, photomonitor (year 10)
- 303-E - Level IV, photomonitor (year 4 and 5)
- 303-F - Level II, photomonitor (year 2)

2002

- Camas Road - Level II, photomonitor (year 4)
- Rob Tyser's Two Dog Flats plots - Level IV (year 10)
- 303-F – Level II, photomonitor (year 3)

2003

- 303-C - Level II, photomonitor (year 10)
- Camas Road - Level II, photomonitor (year 5)
- Hidden Lake – Level II (year 3)

2004

- 303-D – Level III, photomonitor (year 10)
- 303-F - Level II, photomonitor (year 5)
- GTSR Phase VII Site Analysis

2005

- 303D Shrub Monitoring – Level IV (year 11)
- Apgar-Headquarters Bike Path – Level II (year 1)
- Camas Road Hydromulch – Level II (year 1)
- Hidden Lake Social Trails – Level II (year 5)

2006

- 303-E - Level IV, photomonitor (year 10)
- Apgar Transit Center Site Analysis

2007

- Apgar-Headquarters Bike Path – Level II (year 3)
- Camas Road Hydromulch – Level II (year 3)
- Apgar Transit Center – Level II (year they were planted)
- Apgar Transit Center Experimental Plots - Level IV (year they were planted)
- GTSR Phase VI Site Analysis

2008

- Camas Road - Level II, photomonitor (year 10)
- Apgar Transit Center – Level II (year 1)
- Apgar Transit Center Experimental Plots - Level IV (year 1)
- Logan Pass Unit D: seed vs. seed & plant experimental plots (year 8)
- Above St. Mary Campground Weed/Reveg. (site analysis)
- Camas Creek Overlook Weed/Reveg. (site analysis)
- West Entrance (site analysis)

2009

- 303-F - Level II, photomonitor (year 10)
- Apgar-Headquarters Bike Path – Level II (year 5)
- Camas Road Hydromulch – Level II (year 5)
- Apgar Transit Center – Level II (year 2)
- Apgar Transit Center Experimental Plots - Level IV (year 2)
- Above St. Mary Campground Weed Rev. (year 1)
- Camas Creek Overlook Weed Rev. (year 1)
- West Entrance (year 1)
- Lake McDonald Dorms (site analysis)

2010

- Hidden Lake Social Trails – Level II (year 10)
- Apgar Transit Center – Level II (year 3)
- Apgar Transit Center Experimental Plots - Level IV (year 3)
- Above St. Mary Campground Weed Rev. (year 2)

- Camas Creek Overlook Weed Reveg. (year 2)
- West Entrance (repeat site analysis when construction is completed)
- Lake McDonald Dorms (year 1)
- GTSR – Phase 6 (year 1)

2011

- 303-B - Level III, photomonitor (year 20)
- 303-E – Level IV, photomonitor (year 15)
- West Entrance (year 3)
- Lake McDonald Dorm (year 2)
- GTSR – Phase 6 (year 2)
- St. Mary Visitor Center (year 1)

2012

- Rob Tyser's Two-Dog Flats (year 20)
- Apgar Transit Center – Level II (year 5)
- Apgar Transit Center Experimental Plots - Level IV (year 5)
- Lake McDonald Dorm (year 3)
- GTSR – Phase 6 (year 3)
- St. Mary Visitor Center (year 2)
- Above St. Mary Campground Weed Reveg. (year 1)
- Camas Creek Overlook Weed Reveg. (year 1)

2013

- 303-C - Level II, photomonitor (year 20)
- Above St. Mary Campground Weed Reveg. (year 5)
- Camas Creek Overlook Weed Reveg. (year 5)
- West Entrance (year 5)
- St. Mary Visitor Center (year 3)

2014

- 303-D – Level III, photomonitor (year 20)
- Apgar-Headquarters Bike Path – Level II (year 10)
- Camas Road Hydromulch – Level II (year 10)
- Lake McDonald Dorm (year 5)
- GTSR – Phase 6 (year 5)

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APPENDIX A. TEMPERATURE AND PRECIPITATION DATA *

WEST GLACIER

	April	May	June	July	August	September	October	November
Mean Temperature (degrees F) **								
1949-2010	41.5	50.7	57.5	63.7	62.4	53.1	42.3	31.3
1993	43.2	55.7	56.1	56.3	59.0	51.2	43.7	24.0
1994	43.8	53.4	56.8	65.7	65.4	55.5	42.5	28.4
1995	41.1	51.4	56.2	63.1	58.5	54.0	40.2	32.6
1996	42.0	46.3	58.5	65.0	61.5	51.0	40.2	26.4
1997	36.0	51.5	57.4	63.1	63.5	54.5	42.5	31.8
1998	44.0	54.9	56.4	68.4	64.5	59.4	42.3	36.0
1999	41.5	49.3	55.2	60.5	65.7	51.8	42.8	37.7
2000	43.0	50.2	56.7	63.4	63.0	51.0	42.8	28.3
2001	40.0	52.4	55.4	62.8	64.8	57.6	42.7	35.5
2002	39.7	47.8	57.4	67.0	60.3	54.1	37.5	33.2
2003	43.1	50.9	59.7	68.7	67.9	56.8	46.0	26.6
2004	45.8	51.5	58.5	66.7	64.9	52.4	43.2	33.7
2005	43.9	52.7	57.1	65.9	63.3	52.8	44.4	32.6
2006	44.4	53.7	61.8	68.5	64.2	55.3	43.3	30.7
2007	44.0	53.4	60.0	72.3	63.8	54.2	43.5	33.4
2008	37.4	51.3	56.6	65.4	64.2	52.9	43.4	36.4
2009	40.9	51.8	58.2	66.2	63.3	57.9	37.6	34.2
2010	42.2	47.3	56.5	62.7	60.3	53.4	45.1	28.7
Precipitation (inches)								
1949-2010	1.8	2.6	3.4	1.7	1.6	2.1	2.4	3.1
1993	3.2	1.9	4.5	5.1	2.2	2.3	1.0	0.7
1994	1.2	2.2	3.1	0.6	0.2	0.5	4.2	2.7
1995	1.7	1.2	6.9	3.4	2.1	1.4	5.2	7.5
1996	3.0	6.1	1.9	1.2	1.9	3.1	4.1	4.4
1997	2.0	1.8	3.0	1.5	1.4	3.0	3.0	1.6
1998	2.0	4.6	4.9	2.6	1.2	1.7	1.0	3.3
1999	0.9	1.2	3.1	1.8	1.1	0.5	3.8	3.2
2000	1.8	1.6	3.0	1.0	0.4	3.2	0.9	0.7
2001	3.0	1.3	4.0	0.6	0.1	1.2	3.8	2.3
2002	2.4	2.7	3.0	1.5	0.7	1.7	0.5	2.5
2003	1.4	1.9	1.8	0.04	0.1	2.0	2.7	4.1
2004	2.2	2.4	2.2	2.5	4.4	3.7	4.3	3.2
2005	1.7	2.1	7.5	0.5	1.1	4.4	4.6	3.0
2006	1.4	2.3	4.2	0.6	0.8	1.4	1.9	6.2
2007	1.4	2.6	2.4	0.6	0.2	2.1	2.5	0.6
2008	1.2	3.0	3.2	0.9	1.9	1.5	1.4	3.2
2009	1.0	4.0	1.4	2.7	1.6	0.3	3.3	1.4
2010	2.6	3.5	6.6	1.3	1.9	3.9	2.4	3.7

SAINT MARY

	April	May	June	July	August	September	October	November
Mean Temperature (degrees F) **								
1981 - 2010	40.3	48.5	55.7	62.7	62.1	53.3	43.3	31.7
1993	42.5	53.8	54.1	54.9	57.6	52.4	44.1	27.7
1994	42.1	52.0	56.9	62.8	63.1	58.9	43.0	27.6
1995	38.8	46.4	54.3	61.9	59.8	53.9	40.4	32.5
1996	43.2	45.0	56.6	64.7	64.0	50.2	42.0	21.0
1997	35.8	47.9	56.2	62.5	62.6	58.3	45.1	34.8
1998	42.1	53.8	53.0	67.8	62.3	58.5	45.8	33.1
1999	39.7	46.9	53.7	59.2	65.7	52.1	43.0	40.1
2000	43.7	50.1	65.3	65.7	65.5	52.6	43.9	28.0
2001	38.2	53.1	56.3	64.7	67.7	59.1	43.5	38.5
2002	34.4	43.9	52.7	63.8	56.6	50.3	36.1	38.2
2003	39.9	52.9	55.7	66.5	66.6	54.5	46.0	26.9
2004	42.5	43.5	52.7	62.6	59.3	49.8	41.1	35.8
2005	38.3	46.9	51.6	63.0	57.2	49.3	42.4	33.6
2006	40.5	48.7	55.8	65.8	59.2	52.5	39.0	26.4
2007	39.1	49.4	56.9	69.0	60.2	52.1	44.5	32.5
2008	35.4#	46.5#	53.0	#	#	#	44.4#	37.2
2009	34.8	47.2#	52.2#	62.0#	58.8#	#	34.7#	35.0
2010	36.0	38.7	48.3	56.6	53.0	#	45.8#	15.4#
Precipitation (inches)								
1981 - 2010	2.0	3.0	3.6	1.8	1.7	2.2	2.1	2.4
1993	0.8	1.9	3.1	6.3	3.6	3.1	0.9	2.0
1994	2.7	2.8	1.4	2.2	0.5	0.2	4.4	1.9
1995	1.9	5.5	7.2	3.3	1.2	3.2	4.2	5.1
1996	1.8	5.0	4.1	0.8	0.4	2.2	1.3	3.6
1997	1.4	3.6	4.1	0.9	2.6	1.1	1.6	0.8
1998	2.2	3.7	5.1	1.7	0.3	1.0	0.2	4.9
1999	1.5	1.5	1.8	0.9	2.2	1.7	3.1	4.1
2000	2.0	1.5	3.8	0.3	0.7	2.2	0.6	0.5
2001	3.8	1.2	3.9	0.7	0.03	0.8	2.3	0.5
2002	1.1	2.0	5.1	0.6	1.5	2.3	1.0	0.2
2003	1.5	1.2	1.6	0.1	0.0	1.0	1.0	2.2
2004	1.6	2.6	3.2	0.7	1.8	1.1	0.8	2.4
2005	1.6	1.3	7.4	0.2	2.0	3.8	2.0	2.0
2006	2.3	2.4	4.3	0.5	0.8	1.9	1.3	5.7
2007	1.5	2.7	1.1	0.4	0.7	2.8	2.0	1.8
2008	0.6#	6.7#	3.9#	#	#	#	0.6#	1.6#
2009	2.9	1.2#	1.4	4.9#	1.8#	#	2.7#	1.5#
2010	2.0	4.4	4.7	1.3	1.9#	#	0.1	2.1

* This data was obtained from U.S./NOAA weather stations operated by Glacier National Park, and from the Western Regional Climate Center.

** Mean temperature calculated by summing the daily maximum temperature and daily minimum temperature and dividing by two.

Missing data