

Glacier National Park: Restoration Monitoring Report

2009

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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	2007
Phase VII: Avalanche to West Tunnel section of GTSR	Site Analysis	2004
Apgar Transit Center	Site Analysis, Levels II & IV	2006, 2007, 2008, 2009
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
Herbicide / Revegetation Experimental Plots	Level IV	2008, 2009
Hidden Lake Social Trails	Level II	2003, 2005
Lake McDonald Lodge dorm site	Site Analysis, Level II	2007, 2009
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	2006
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		2009

The objectives of this report are to document the results of the 2009 season. The report includes: (1) data from six revegetation projects (Apgar Transit Center, Camas Road – Hydromulch, West Glacier Bike Path, Lake McDonald Lodge dorm site, West Entrance Station, and GTSR road project 303-F); (2) year one results of herbicide impacts at two sites in weed treatment-revegetation projects; (3) results from whitebark and limber pine restoration projects; (4) results from whitebark and limber pine plus tree monitoring; (5) summary of blister rust surveys conducted in the park; (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 (see Table 6 for list of salvaged material). 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 and Table 6). 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 7). 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 and 2009, one and two 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

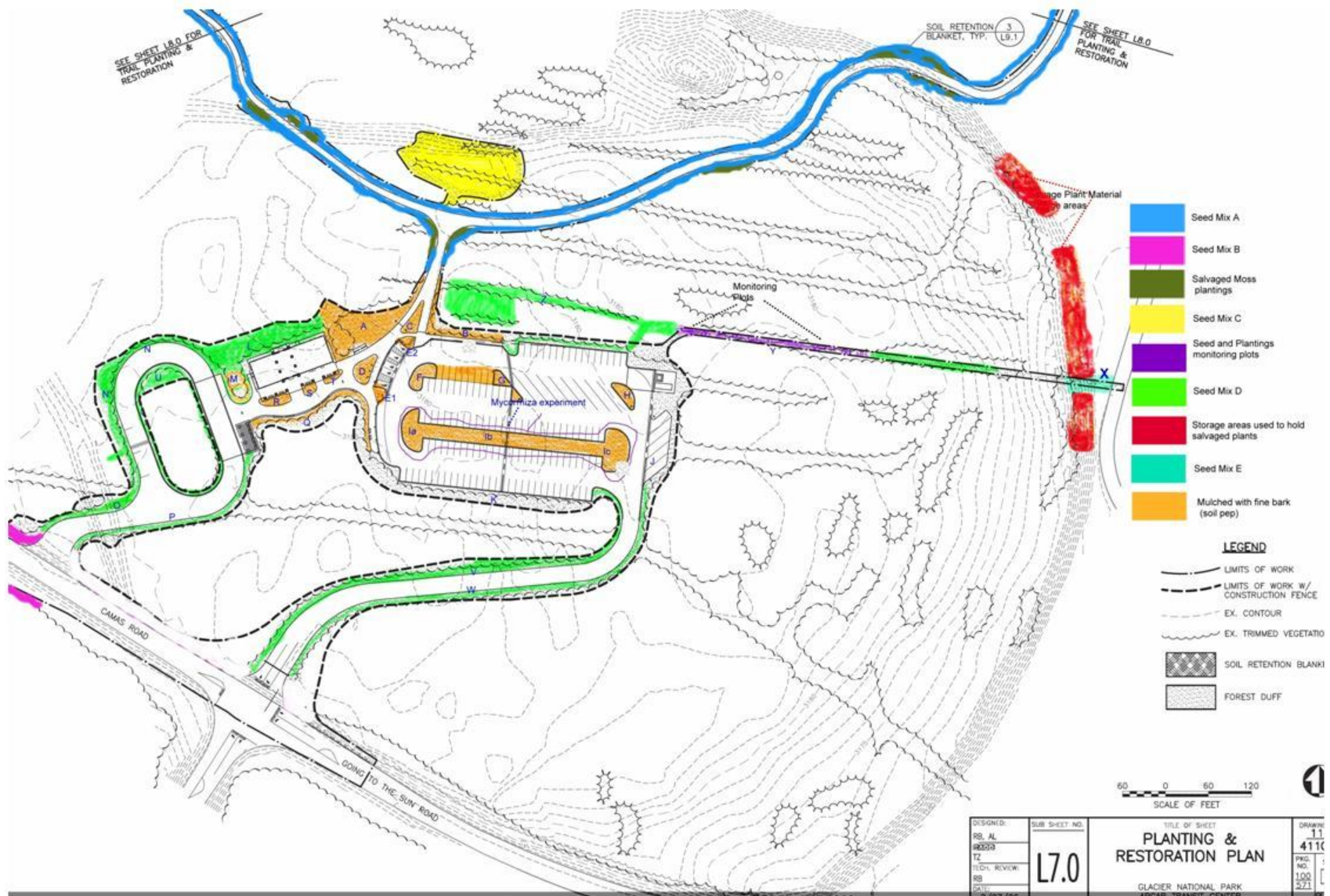
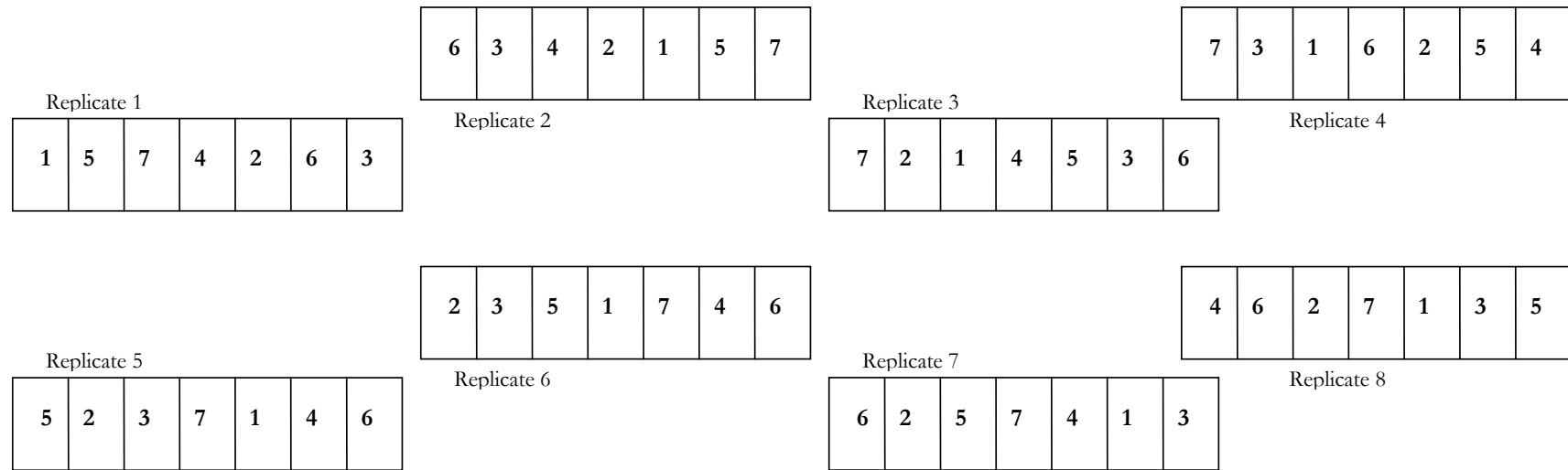


Figure 2. Apgar Transit Center: Schematic Layout of Research Monitoring Plots



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

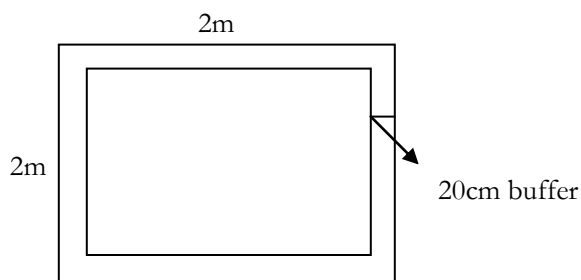


TREATMENTS:

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 and 2009. 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.

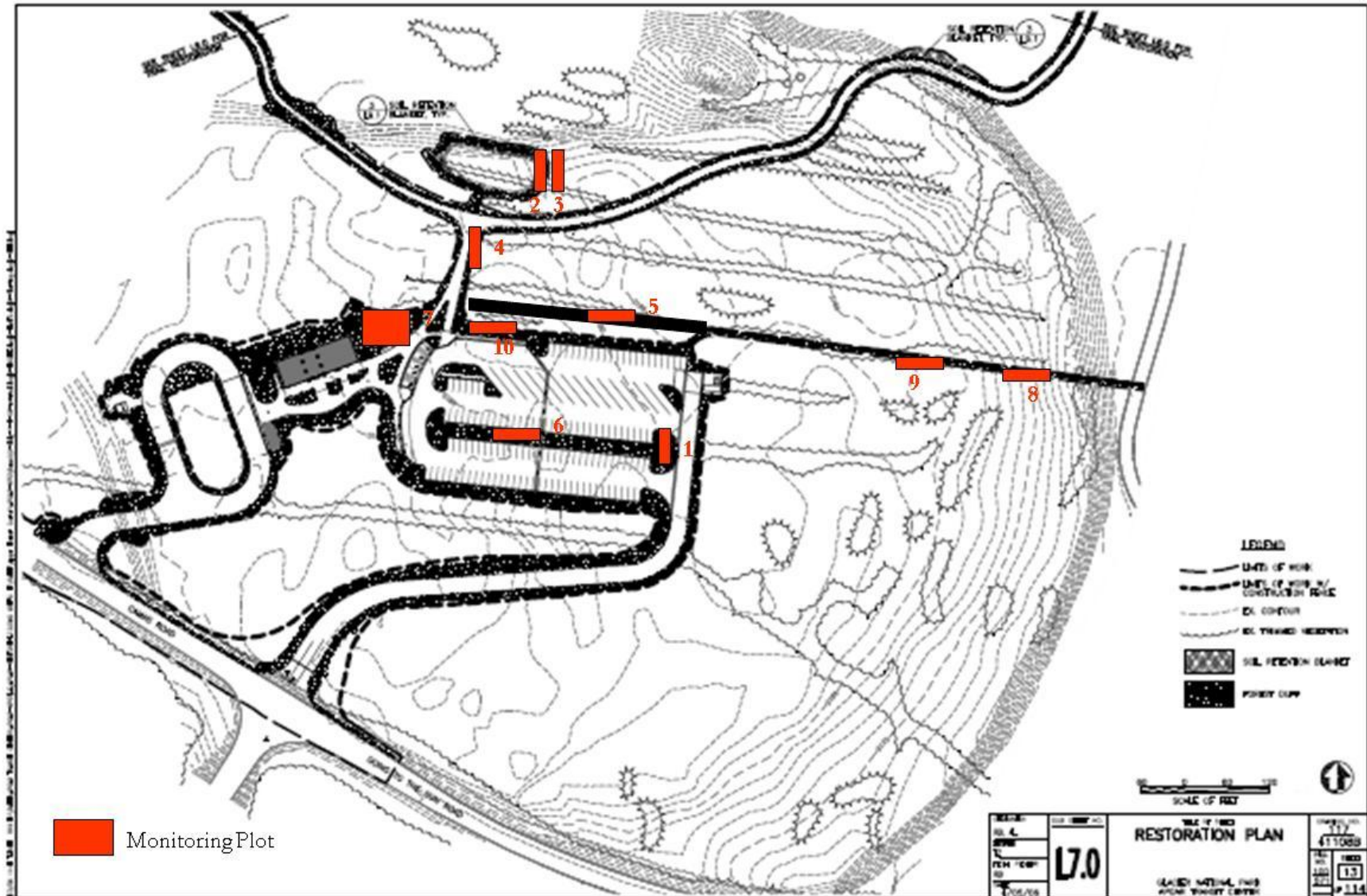
2. Revegetation Plots Monitored by Ocular Cover

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 July 2009, experimental plots were monitored, two 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 ¼ m² microplots were read per plot and percent cover was averaged per plot. Results are listed in Tables 4 and 5.

1a. Treatments

All treatments increased in native and exotic cover from 2008 to 2009. Curiously, the control plot had the largest % increase in native cover, increasing 613%. Plots seeded with *Rubus parviflorus* seeds had the second largest % increase in native cover with 558%. Plots seeded with *Xerophyllum tenax*, *Calamagrostis rubescens*, and *C. rubescens* or *Carex athrostachya* each with a forb and *Spiraea betulifolia* had relatively high % increases in cover, ranging from 220% to 440%. Plots planted with *C. rubescens* plugs had the lowest % increase in native cover at 59%.

The highest native cover two years after revegetation was produced by seeded *C. rubescens* with a forb and *S. betulifolia* mix. Overall native cover is 14.16%, a dramatic increase from 2.84% native cover last year. Native cover of planted *C. rubescens* plugs, which had the highest overall native cover last year, also has relatively high native cover at 12.32%. Additionally, cover of seeded *C. athrostachya* with a forb and *S. betulifolia* mix had relatively high native cover at 10.28%. All other treatments had relatively moderate covers ranging from 3.4% to 6.63%. Currently, seeding *X. tenax* alone has resulted in the lowest overall native cover at 3.4%. The control plot, where nothing was seeded or planted, ended up with the fourth highest native cover of the seven treatments at 6.63%.

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

All lifeforms except exotic grass significantly increased since 2008 under this treatment. As stated above, this resulted in the highest overall vegetative cover and highest native cover of any treatment this year. Of this overall cover, 77.4% was native cover, the third highest native to exotic ratio when comparing treatments. It should be noted that this treatment had the highest seed rate of any of the treatments at 925 seeds/m² (Table X), perhaps enhancing its success.

Native forb cover under this treatment had the biggest increase of any lifeform on any treatment. It increased from 1.2% in 2008 to 10.31% in 2009, making native forbs the dominant lifeform under this treatment. Increases were due to significant increases of all seeded forb species including *Achillea millefolium*, *Anaphalis margaritacea*, *Chamerion angustifolium*, *Geum macrophyllum*, *Solidago canadensis*, and *Symphytotrichum laeve*. *Achillea millefolium*, *Anaphalis margaritacea*, and *Symphytotrichum laeve* have the highest native forb cover on this treatment. Native forb cover was significantly higher than forb cover under all other treatments except seeded *C. athrostachya* with a similar seeded forb mix. Native forb cover under this treatment was slightly higher than the seeded sedge treatment with forbs but results were not statistically significant. Cover of all seeded forb species listed above were also significantly higher under this treatment than all other treatments except *A. millefolium* and *C. angustifolium* that had higher cover on the sedge/forb mix treatment.

Native grass cover more than doubled to 2.48% cover in 2009. This was due primarily to a significant increase of *Carex* spp., a small increase of *C. rubescens*, and the natural establishment of four additional native grasses within this treatment. This treatment has the third highest native grass cover behind *C. rubescens* plugs and *C. rubescens* seeding alone. Other than these pinegrass treatments, native grass cover is significantly higher on this mixed seed treatment than on the other treatments or the control. As you might expect, this is due to the fact that *C. rubescens* has significantly higher cover on this treatment than the other treatments where *C. rubescens* wasn't seeded or planted. It is interesting to note that cover of *C. rubescens* under this mixed seed treatment, while not statistically significant, is not as high as when *C. rubescens* is seeded alone. It is also not as high as cover of planted *C. rubescens* plugs.

Native shrub and tree cover also significantly increased since last year. Despite being statistically significant, the increase in shrub cover was small, resulting in only 0.41% shrub cover in 2009. This increase was due primarily to a significant increase in *S. betulifolia* cover. Treatments 4 and 5, where *S. betulifolia* was seeded in a mix, coincidentally

have the highest cover of *S. betulifolia*, covers that are not significantly different from each other. Tree cover was relatively the same throughout all treatments except on the seeded *X. tenax* treatment where it was significantly lower. Significant increases of *Pinus contorta* and other unidentified conifer seedlings, as well as small increases of *Populus balsamifera*, were the basis of most tree increases.

Finally, both exotic grass and exotic forb cover increased significantly under this treatment. Currently, exotic forb has third highest cover under this treatment, increasing from 0.19% in 2008 to 3.85% in 2009. Most of this increase was due to a significant increase of *Trifolium hybridum*, however, *Veronica officinalis*, *Trifolium* spp., and *Medicago lupulina* also had small increases in cover. The increase of exotic grass cover was due primarily to a significant increase of *Agrostis stolonifera* and a small increase of *Poa pratensis*.

ii. *Calamagrostis rubescens* plugs (Treatment 6)

While planted *Calamagrostis rubescens* plugs had at least double the vegetation cover at year one after planting, other treatments currently are catching up and surpassing the cover of this treatment. Currently, overall cover with planting of *C. rubescens* plugs is 14.71%, the third overall total cover, with 12.32% native cover, the second highest native cover of any treatment. It should be noted, however, that this treatment has the second lowest exotic cover of all the treatments, resulting in the highest percent native cover at 83.8%. It also had the highest percent native cover one year after planting at 98.4%. It is possible that this very high initial cover during the first year prevents 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 7.29% in 2008 to 10.43% in 2009, three to ten 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 9.54% this year. There is also almost 1% cover of *Carex* spp. that significantly increased under this treatment from last year. This may be natural regeneration or a result from windblown seed from nearby treatments.

While native forb cover under this treatment did significantly increase from 0.07% in 2008 to 0.98% in 2009, native forb cover remains the 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 over the past year to 0.62%. The lack of seeded forbs is clearly driving the low the forb cover, but naturally recruited forbs, like naturally recruiting weeds, may also have a difficult time getting established due to the higher grass cover.

Although tree cover has increased over the past year from 0.35% to 0.91%, this increase was not significant. This is the only treatment to not have a significant increase in tree cover since 2008. Like other treatments, most of the tree cover is due to low cover of *Populus balsamifera* and conifer seedlings. Currently there is no shrub cover under this treatment.

Lastly, as stated above, this treatment has the second lowest cover of exotic species. Currently, exotic grass is 0.04%, tied with the control plots for lowest overall grass cover. A small amount of *Agrostis stolonifera* accounts for this low cover. Exotic forb cover is also relatively low at 2.35% due primarily to a significant increase of *Trifolium hybridum* that happened in all treatments. *Veronica officinalis* and *Trifolium* spp. had smaller increases in cover over the last year.

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 second highest overall vegetation cover at 14.81% and the third highest native cover at 10.28%. These are significant increases in cover where overall cover was 2.90% and native cover was 2.50% last year. This treatment had the second highest seed rate of the project with 753 seeds/m² (Table X). Due to a dramatic increase in exotic forb cover and diversity since 2008, however, percent native cover is only at 69.4%, a large decline from 86.4% last year.

Except for slightly lower native forb and grass covers, overall results of this treatment are similar to treatment 4 where *C. rubescens* was seeded with a more diverse mix of forbs. Native forb cover had a dramatic significant increase, increasing from 1.61% in 2008 to 7.50% in 2009, similarly making native forbs the dominant lifeform under this treatment. Most of this cover was due to significant increases from the one seeded forb species, *Achillea millefolium*, and *Chamerion angustifolium*. *A. millefolium* had the most dramatic increase under this treatment, increasing from 1.53% to 6.13% cover this year. This is the second highest cover of any individual species on the project, other than the planted *C. rubescens* plugs. Other forb species are just becoming established under this treatment. As several

of them are seeded species under other treatments, windblown seed may again be confusing the results of this experiment. Native forb cover was the second highest forb cover compared to all other treatments except seeded *C. rubescens* with a more diverse forb mix (treatment 5). As stated above, native forb cover under treatment 5 was slightly higher than this seeded sedge treatment with forbs, but results were not statistically significant.

Native grass cover significantly increased in 2009, tripling from 0.28% to 0.94% cover. This was due primarily to a significant increase of *Agrostis scabra* and a small increase of *Carex spp.*, presumed to be *C. athrostachya*. Despite this increase, cover of total native grasses remains one of the lowest on the project. Although *C. athrostachya* had the same seed rate as *C. rubescens* on other treatment (323 seeds/m²), the germination rate of the sedge species over the last two years has been 2 to 3%, compared to 21.7 to 47.0% of *C. rubescens* (Table X). 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.

Like treatment 4, native shrub and tree cover also significantly increased since last year. Despite being statistically significant, the increase in shrub cover was small, resulting in only 0.67% shrub cover in 2009. This increase was due primarily to a significant increase in *S. betulifolia* cover. As stated above, treatments 4 and 5 that had *S. betulifolia* seeded in a mix, coincidentally have the highest cover of *S. betulifolia*, covers that are not significantly different from each other. While *Populus balsamifera* had the highest tree cover under this treatment, significant increases of *Pinus contorta* and other unidentified conifer seedlings were likely the cause for the overall increase in tree cover.

Finally, both exotic grass and exotic forb cover increased significantly under this treatment. Currently, exotic forb has second highest cover under this treatment, increasing from 0.33% in 2008 to 4.25% in 2009. Most of this increase was due to a significant increase of *Trifolium hybridum* and *Trifolium spp.*, however, *Veronica officinalis* also had an increase in cover. The increase of exotic grass cover was due primarily to a significant increase of *Poa pratensis*.

iv. Control plots (Treatment 7)

While the control plots did not have very high overall vegetation cover, control plots had the fourth highest total native cover of all the seven treatments and the highest percent native cover at 81.3%. Despite having no seed treatment, tree, native grass, and native forb cover significantly increased since last year. 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 1.15% to 8.16% since last year, while total native cover has increased from 0.93% to 6.63%.

Native forbs had the biggest increase in cover, significantly increasing from 0.36% to 2.57% and making native forbs the dominant lifeform of this treatment. The increase was due primarily to significant increases of *Anaphalis margaritacea* and *Chamerion angustifolium*, both species that may have naturally recruited to these plots or established from blown-in seed from other treatments. Smaller increases of *Epilobium brachycarpum* and *Hieracium albiflorum* added to the increase in forb cover. Native grasses also increased significantly, increasing from 0.18% in 2008 to 1.93% in 2009. This increase was due to a significant increase of *Carex spp.* that likely naturally recruited to the plots given that sedge was only seeded in one treatment and that all identified sedges within the control plots have been identified to *Carex rossii*, a sedge of the adjacent forest. Three other naturally recruited grasses, *Festuca occidentalis*, *Danthonia intermedia*, and *Agrostis scabra*, have also had small increases in cover, adding to the overall increase of native grasses within the control plots.

While tree cover dramatically increased on the control plots, shrub cover remained negligible. Compared to other treatments, tree cover is currently the highest in the control plots, significantly increasing from 0.38% to 2.04% this year. This increase was due to significant increases in cover of *Populus balsamifera* and *Pinus contorta*, as well as unidentified conifer seedlings. For unknown reasons, cover of *P. balsamifera* is at least double on the control plots in comparison to all other treatments. Cover of *P. contorta* seedlings is also higher on the control plots than any other treatment.

Interestingly, cover of exotic species has remained the lowest of any treatment. Cover of exotic grasses is very small with only 0.04% of *Agrostis stolonifera*, while cover of exotic forbs is the lowest of all the treatments. Like all other treatments, cover of exotic forbs did significantly increase since last year, but the control plots had the smallest increase in 2009. Also like other treatments, most of the exotic forb cover is due to a significant increase of *Trifolium hybridum* and smaller increases of *Trifolium spp.* and *Medicago lupulina*.

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

While seeding *Calamagrostis rubescens* seed alone resulted in the third highest overall vegetation cover at 10.3%, nearly half of this cover is due to exotic forbs. Only 51.3% of the vegetation is from native cover, the second lowest percentage of native cover of any treatment. Despite the high exotic forb cover, overall native cover significantly increased from 1.65% to 5.29% this year, including significant increases of trees, native grass, and native forbs.

As you might expect, native grasses are showing the most success. Native grass cover was the second highest compared to the other treatments, second only to planted *C. rubescens* plugs. Native grass cover significantly increased from 1.08% to 3.07% in 2009 due to increases of *C. rubescens* that was seeded as well as *Carex* spp. that is 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. While results are not statistically significant, it is interesting to note that *C. rubescens* seeded alone had slightly higher cover at 2.7% than *C. rubescens* seeded with a forb/shrub mix that had 1.63% cover. Although more time is needed to assess these results, literature and past revegetation experiments have suggested that *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.

Native forb cover also significantly increased from 0.13% to 1.17% this year. Most of this cover is due to a small increase of *Chamerion angustifolium* in addition to the establishment of several new, naturally recruiting forb species on this treatment. Overall diversity of forb species on this treatment is actually quite good 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 the increases of *Pinus contorta*, *Populus balsamifera*, and unidentified conifer seedlings. With no shrub species seeded on this treatment, shrub cover remains negligible.

Finally, as stated above, exotic forb cover dramatically increased from 0.16% to 4.47% in 2009, making exotic forbs the highest lifeform cover of this treatment. This is almost exclusively due to a significant increase of *Trifolium hybridum* on this treatment. *Veronica officinalis* had a small increase in cover. Exotic grass cover remains relatively low at 0.26% with *Agrostis stolonifera* comprising most of that cover.

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

Treatment 2, where *Rubus parviflorus* was seeded alone, and Treatment 1, where *Xerophyllum tenax* was seeded alone, had similar results. While having significant increases in native cover, both treatments had the lowest overall vegetation and native covers of the project. Treatment 2 with seeded *R. parviflorus* had slightly higher cover than plots with seeded *X. tenax*. Total vegetation cover significantly increased on the *R. parviflorus* treatment from 0.87% to 7.88% in 2009 due primarily to a significant increase in exotic forbs. Total native cover also significantly increased from 0.69% to 4.54% due to smaller yet significant increases of trees, shrubs, and native forbs and grasses. This treatment had a relatively low percent native cover at 57.6%. This is third lowest percent native cover of all the treatments.

In keeping with seeding only a shrub species, treatment 2 had the highest shrub cover of any treatment at 1.45%. This is a significant increase from last year when cover was only 0.21% and is significantly greater (at least double to more than triple) 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 1.45% cover. Tree cover also significantly increased from 0.20% to 0.87% due to significant increases in cover of *Pinus contorta* and unidentified conifer seedlings, as well as a small increase in cover of *Populus balsamifera*.

Native forbs had a moderate increase in cover, significantly increasing from 0.20% to 1.43% in 2009. This increase was due almost exclusively to a significant increase in cover of *Chamerion angustifolium*, a forb that has naturally regenerated on several treatments. A small increase in cover of *Anaphalis margaritacea* and the establishment of several new native forb species also added to the increase in native forb cover. Although native grass cover significantly increased from 0.05% to 0.78% this year, this treatment continues to have the lowest native grass cover of any of the treatments. Hopefully this will change in the future as *Carex* spp. significantly increased this year and at least three new native grass species became established within this treatment in 2009.

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 0.11% to 3.12% this year due mostly to significant increases in cover of *Veronica officinalis* and *Trifolium hybridum*, in addition to smaller increases of *Trifolium* spp.

and *Medicago lupulina*. For unknown reasons, this is the only treatment where *V. officinalis* had a significant increase in cover, jumping from 0.06% to 1.44%, resulting in the highest cover of this species on any treatment. As this exotic forb spreads rhizomatously and can persist in shade, it is concerning that this species has established so quickly. Conversely, exotic grasses did not significantly increase in cover. *Agrostis stolonifera* and *Elymus repens* were documented on this treatment for the first time, however, with low cover.

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

Although total vegetation cover significantly increased from 1.25% to 7.67% and total native cover significantly increased from 0.63% to 3.4% since last year, seeding *Xerophyllum tenax* alone resulted in the lowest overall vegetation cover, the lowest native cover, and the lowest percent native cover of all the treatments. Total native cover is 1% to 11% lower than all other treatments and 44.4% relative native plant cover is 7% to 19% lower than all other treatments.

The main success of treatment 1, however, is to show that seeding *X. tenax* by itself at a seed rate of 269 seeds/m² can result in 0.61% cover and approximately 36 plants/m² at only year two. 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. 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 0.25% to 1.75%, due to significant increases of *Anaphalis margaritacea* and *Chamerion angustifolium*, as well as smaller increases of *X. tenax* and the natural establishment of seven new native forb species. Currently, *C. angustifolium* and *X. tenax* have the highest native forb covers within this treatment and cover of *X. tenax* is significantly higher on this treatment than all other treatments. Native grass also significantly increased since last year from 0.11% to 1.17%. This was due to significant increases of *Carex spp./Carex rossii* and the establishment of three new native grass species.

Like other treatments, tree cover significantly increased from 0.18% to 0.47%, although this is the lowest tree cover of any treatment. Significant increases of *Pinus contorta* and unidentified conifer seedlings resulted in the higher tree cover. Shrub cover did not change since last year, remaining extremely low at 0.01%

Also like other treatments, cover of exotic forbs increased significantly from 0.38% to 4.03% making exotic forbs the lifeform with the highest cover on this treatment. This increase in cover was due primarily to an approximate 3% increase of *Trifolium hybridum* and the establishment of five new exotic forb species. Exotic grass cover did not change since 2009, remaining at a low 0.21% that is similar to other treatments. Only *Agrostis stolonifera* has become established within this treatment.

1b. Success of individual species

Two years after seeding, cover of several individual seeded species greatly increased with a few species attaining cover over 1%. Due to the fact that most germination rates did not significantly change over time (Table X), the increased cover is primarily due to plants growing larger in size since 2008. Successful of individual species are described by lifeform below.

i. Native Forbs

Treatments 4 and 5, where native forbs were seeded, coincidentally had significantly higher covers of native forbs at 10.31% and 7.5%, respectively. These increased significantly from 1.20% and 1.61% covers last year. Covers of other treatments where either no forbs were seeded or *Xerophyllum tenax* was seeded remain between 0.98% and 2.57% cover.

Achillea millefolium remained the most successful seeded species under both treatments with significant increases in cover since last year, currently having 3.56% cover for treatment 4 and 6.13% cover for treatment 5. This is the highest cover of any native species other than the planted *Calamagrostis rubescens* plugs. Interestingly, treatment 4, where *A. millefolium* was sown at only 86 seeds/m², had 66.8 *A. millefolium* plants/ m², a very high 77.7% germination rate. *A. millefolium* was sown at a higher rate of 215 seeds/m² on treatment 5, and while this species currently has 81.0 plants/m² and slightly higher cover (not statistically significant) on this treatment, the overall germination rate was much lower at 37.7%. It may be that there is a 'point of no return' with *A. millefolium* that is closer to the seed rate on treatment 4.

Other successful seeded forbs on treatment 4 include *Anaphalis margaritacea* that significantly increased from 0.16% to 2.54% cover and *Symphytotrichum laeve* that significantly increased from 0.13% to 2.12% cover. Coincidentally,

these two species had notable increases in their germination rates this year in comparison to last year. Both seeded at 86 seeds/m², *A. margaritacea* had a 77.7% germination rate with 66.8 plants/m² and *S. laeve* had a 52.5% germination rate with 45.2 plants/m². Higher cover of these species is due to growth of plants that germinated last year as well as additional density of plants that germinated this year. *Geum macrophyllum*, *Solidago canadensis*, and *Chamerion angustifolium* also increased significantly in cover under treatment 4, however, their covers remain at a lower range of 0.31% to 0.88%. These three species were seeded at the same rate as *A. margaritacea* and *S. laeve* but have far lower germination rates. While germination rates for all three plants are approximately 5% higher than they were last year, indicating greater density of each species, they only range from 10-20%. The overall lower density is likely preventing these species from greater increases in cover. Covers of *A. margaritacea*, *S. laeve*, *G. macrophyllum*, and *S. canadensis* are significantly 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* was 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. The highest cover of *C. angustifolium* was under treatments 7 (control), 2 (*R. parviflorus* seed), and 3 (*C. rubescens* seed) where it was not seeded.

In general, many species are naturally recruiting 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 are naturally recruiting in new plots and may show greater cover in the future include *Chamerion angustifolium* on treatments 1, 2, 3, 5, 6, and 7, *Anaphalis margaritacea* on treatments 1, 2, 3, 5, 6, and 7, *Hieracium albiflorum* and *Epilobium brachycarpum* on all treatments, and *Viola orbiculata* on treatments 1, 2, 4, 5, and 6. In addition, a few new species have naturally recruited to certain project plots this year including *Adenocaulon bicolor* in treatment 1, *Antennaria howellii* in treatments 1 and 2, *Campanula rotundifolia* in treatment 7, *Osmorhiza berteroi* in treatments 3 and 5, *Penstemon confertus* in treatment 3, and *Hieracium albiflorum* in all treatments.

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* is low, remaining the same as last year at approximately 14%, illustrating that, while possible, it is difficult to get this species to grow from seed. Cover of this species is increasing over time, 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 two remains to plant *Calamagrostis rubescens* plugs. This treatment resulted in 10.43% native grass cover in 2009, significantly higher than all other treatments and much higher than seeding *C. rubescens* alone, the treatment with second highest native grass cover at 3.07%. Cover of *C. rubescens* plugs increased significantly from 2.31% in 2007 to 7.29% in 2008, year one of planting. This year, cover of *C. rubescens* plugs increased to 10.43%, although these results are not statistically significant. Despite having the highest native grass cover of all the treatments, this treatment was the only one that did not significantly increase in 2009.

The long term question of these treatments is whether grass seed cover will eventually ‘catch up’ to planted grass cover. Currently, native grass cover in all treatments other than planted plugs, whether they were seeded or not, significantly increased in cover. *Calamagrostis rubescens* that was seeded alone had the highest grass seed rate at 538 seeds/m², resulting in 3.07% cover this year and significantly increasing from 1.08% cover last year. Interestingly, this cover is not significantly different from *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 2.48% cover, significantly increasing from 1.01% cover last year. Overall, *C. rubescens* at this lower seed rate currently has higher densities at 148.5 plants/m² and a higher germination rate at 46% in comparison to *C. rubescens* seeded alone with a higher seed rate that had only 116.8 plants/m² and a 21.7% germination 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 32 plants per macroplot (almost 4m²) when *C. rubescens* is planted in comparison to 116 to 148 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* that was evident, most sedges were necessarily lumped as *Carex* sp. In 2009, all treatments had similar cover of *Carex* sp. (no significant differences) even though only treatment 5 was seeded with *Carex athrostachya*. In addition, cover of *Carex* sp. increased on all treatments in 2009 except for treatment 5 where it was seeded. This leads us to believe that other sedges, particularly *C. rossii*, are successfully naturally regenerating across the project, perhaps at a greater rate than the seeded *C. athrostachya*. Where it was seeded within treatment 5 at a rate of 323 seeds/m², cover of *Carex* sp. has only reached 0.52%. This is substantially lower than the 2.48% cover of *Calamagrostis rubescens* seen in the treatment where it was seeded at the same rate. Differences are even more dramatic when comparing density data. Density of *C. athrostachya* was only 6.37 plants/m² (2% germination, the lowest in the project), while density of *C. rubescens* was 148.5 plants/m² (46% germination) when combined with a forb seed mix.

Finally, natural regeneration of native grasses continued in all treatments throughout the project. *Danthonia intermedia* and *Festuca occidentalis* were each observed in five new treatments, now present in six of the seven treatments. *Agrostis scabra* was also observed for the first time in 2009 in four treatments. 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. *Elymus glaucus*, present in one treatment last year, was not observed this year. Finally, *C. rubescens*, newly observed in two treatments this year, is now 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, shrubs remain negligible on the project unless seeded. *Symphoricarpos albus* and *Shepherdia canadensis* recruited into three plots at very low rates but otherwise no non-seeded shrubs were found. 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 significantly increased from last year from 0.21% to 1.45% while the germination rate of this shrub decreased to a low 9.9%. It appears that *R. parviflorus* may be difficult to grow from seed in the field given its low germination rate for both years and die-off of year-one germinants may occur given the decline in density at year two. However, those germinants that do survive seem to grow dramatically, providing significant cover. At year two after reseeded, it seems as if *R. parviflorus* is even quicker at establishing higher shrub cover than *S. betulifolia*.

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 32.7% germination rate at year two, while *S. betulifolia* was seeded at 215 seeds/m² on treatment 5 with a 25.4% germination rate at year two. 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. *S. betulifolia* significantly increased under both treatments, and although cover of this shrub is slightly higher on treatment 5, cover is not significantly different for treatments 4 and 5. Cover of *Spiraea* may be increasing on treatment 4 due to increased germination and growth of existing germinants, while cover of this shrub on treatment 5 has to be solely to growth of existing germinants due to the decline in germination rate this year. 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 0.4% to 0.65% in comparison to 1.45% cover of *Rubus*.

In contrast, tree species demonstrated high recruitment rates in the project. No trees were planted in the project but total native tree cover significantly increased under all treatments this year. This is due to significant increases of *Pinus contorta* seedlings under all treatments, significant increases of unidentified conifer seedlings under most treatments, and notable increases of *Populus balsamifera* under all treatments. Currently, *Populus balsamifera* accounts for most of the tree cover at 0.54% average cover across all plots, doubling the 0.22% average cover last year. While tree covers between treatments are generally not significantly different from each other, it is interesting

that the highest native tree cover was found in the control plots. Overall, treatment 1 (seeded *X. tenax*) had significantly lower tree cover than all other treatments. In addition, tree cover on the control plots (treatment 7) was significantly higher than treatment 2 (seeded *R. parviflorus*).

Although there are still unidentified conifer seedlings, several seedlings were identified this year giving rise to new covers of *Pinus contorta* and *Larix occidentalis*. These tree species are not new in 2009 but were merely in the generic conifer seedling group last year.

iv. Exotic Species

Unfortunately, much of the natural regeneration in the project came from exotic species. This year, the biggest concern is that exotic forb cover significantly increased under all treatments, now ranging in cover from 1.48% to 4.74%. Exotic forbs now have the highest lifeform cover on treatment 1, 2, and 3 and the second highest lifeform cover on treatments 4, 5, and 6. Ironically, exotic forb cover has remained the lowest on the control plots.

Veronica officinalis and *Trifolium* species, primarily *Trifolium hybridum* but including *Trifolium agrarium* and *Trifolium pratense*, consistently have the highest cover of any exotic forb species. *Trifolium hybridum* significantly increased under all treatments, while *Trifolium* spp. and *Veronica officinalis* each significantly increased under one treatment and notably increased under most other 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 0.06% to 1.44%. *Trifolium* spp. may be more ephemeral and may potentially be less of a problem than other weeds. Other weed species that are becoming established but currently have low cover include *Medicago lupulina*, *Taraxacum officinale*, *Lactuca serriola*, *Filago arvense*, and *Cirsium* spp. Other than *Cirsium* spp. that could turn out to be noxious weed *Cirsium arvense*, most of these other weeds are not overly aggressive and do not displace native vegetation.

Overall exotic grass cover is much lower, ranging from 0.04% to 0.30%. Exotic grass cover remained the same as last year except on treatments 4 and 5 where it significantly increased by a minor amount. Despite the increases on these treatments, all exotic grass cover is statistically the same at this point in time. Currently, *Agrostis stolonifera* is the most consistent exotic grass on the project, present under all treatments. It only significantly increased, however, on treatment 4 where it went from 0% cover last year to 0.22% this year. *Agrostis stolonifera* is of concern due to its rhizomatous nature and inability to be controlled with herbicide.

Three new exotic grasses became established on the project this year as well: *Elymus repens* on treatment 2, *Poa compressa* on treatment 5, and *Poa pratensis* on treatments 4 and 5. *Triticum aestivum* (regreen) remains present with extremely low cover on treatment 3, having already disappeared from treatments 2 and 7 where it was present last year. It is uncertain how this sterile wheatgrass became introduced to the project.

1c. Conclusions for Experimental Plots

At year two 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. Last year, *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. This year, the treatments are becoming more complicated. One on hand, *C. rubescens* plugs are still providing by far the highest native grass cover over any other treatment. At the same time, however, they do not have the highest overall native cover, no longer have the lowest exotic cover, and are the treatment with the lowest native diversity. Seeding *C. rubescens* with a forb and shrub mix is currently the treatment with the highest overall cover and highest native cover. Native forbs clearly dominate this treatment and it has the second highest native diversity of any treatment. 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 three treatments. Exotic grass cover remains fairly low on all treatments, despite significantly increasing on two treatments.

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* will likely not attain 49% cover next year as 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% 10 years after planting under that scenario.

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 decline in density by year two. 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 two after planting, the highest native cover and diversity is achieved by 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 similar when seeded with a forb/shrub mix as it is when seeded alone. The forb/shrub mix results in much higher native forb cover than no forb seed at all.
- Planting *Calamagrostis rubescens* plugs remains the quickest way to achieve a high cover of native grass. Two years after replanting, cover of native grass was three to ten times as high on the *C. rubescens* plug treatment than on other treatments. This treatment also has the second lowest exotic cover of all the treatments, resulting in the highest percent native cover at 83.8%. It also had the highest percent native cover one year after planting at 98.4%. It is possible that this very high initial cover during the first year prevents 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.
- If forb cover is not as important, seeding *Calamagrostis rubescens* alone remains a good option to achieve high native grass cover. While results were not significantly different, cover of *C. rubescens* was slightly 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 32 plants per macroplot (almost 4m²) when *C. rubescens* is planted in comparison to 116 to 148 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 do not appear to naturally regenerate. 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. *Populus balsamifera* has colonized in each treatment and currently provides 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: 2010 (year 3), 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, 2008-2009 (3 microplots per plot x 8 reps, averaged per treatment). * = Seeded species. Orange cells indicate that cover per treatment are significantly different (90% CI) between 2008 and 2009.

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	2008	2009	2008	2009	2008	2009	2008	2009	2007	2008	2009	2008	2009
Basal vegetation	0.10	0.50	0.10	0.45	0.10	0.91	0.22	0.97	0.10	0.88		0.63	1.15	0.10	0.47
Litter/Duff	47.75	64.25	44.54	61.04	53.29	70.50	52.33	65.50	58.96	70.25		31.71	55.67	62.88	79.33
Moss	0.12	5.08	0.18	5.77	0.13	2.48	0.96	4.01	0.07	2.31		0.02	1.98	0.56	4.58
Bare Soil	24.58	9.54	22.71	10.58	21.58	9.33	20.25	7.29	17.08	9.38		26.88	14.75	17.50	6.29
Gravel	25.42	18.63	32.29	22.29	23.96	16.63	24.71	21.67	23.38	16.63		38.29	25.26	18.63	9.21
Rock	1.00	0.25	0.29	0.00	1.08	0.25	1.04	0.50	0.54	0.38		2.67	1.25	0.46	0.13
Wood	1.17	1.88	0.00	0.42	0.00	0.00	0.63	0.13	0.00	0.25		0.00	0.00	0.00	0.13
Other	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
TOTAL NATIVE TREE	0.18	0.47	0.20	0.87	0.33	1.04	0.22	0.96	0.31	1.16		0.35	0.91	0.38	2.04
Generic conifer seedlings	0.05	0.23	0.03	0.26	0.16	0.26	0.05	0.17	0.06	0.25		0.05	0.29	0.07	0.28
<i>Larix occidentalis</i>						0.08							0.13		0.04
<i>Pinus contorta</i>		0.19		0.10		0.22		0.11		0.40			0.10		0.59
<i>Populus balsamifera</i>	0.13	0.05	0.18	0.51	0.17	0.48	0.18	0.68	0.26	0.51		0.30	0.39	0.31	1.13
TOTAL NATIVE SHRUB	0.01	0.01	0.21	1.45	0.004	0.01	0.05	0.41	0.19	0.67		0.00	0.00	0.00	0.08
<i>Rubus parviflorus</i> *	0.01		0.21	1.45				0.01		0.01					
<i>Shepherdia canadensis</i>		0.01													
<i>Spiraea betulifolia</i> *				0.01		0.01	0.05	0.40	0.19	0.65					0.08
<i>Symphoricarpos albus</i>			0.004		0.004		0.004			0.01					
Unknown, hairy toothed															0.02
TOTAL NATIVE GRASS	0.11	1.17	0.05	0.78	1.08	3.07	1.01	2.48	0.28	0.94	2.31	7.29	10.43	0.18	1.93
<i>Agrostis scabra</i>						0.01		0.09		0.27					0.21
<i>Carex albmstachya</i> *															
<i>Carex rossii</i>		0.17		0.13				0.09		0.04			0.13		0.08
<i>Carex sp.</i>	0.11	0.73	0.05	0.49	0.08	0.29	0.05	0.50	0.27	0.52		0.12	0.76	0.13	0.74
<i>Calamagrostis rubescens</i> *		0.07	0.004	0.10	1.08	2.70	1.01	1.63	0.03	0.03	2.31	7.21	9.54		0.02
<i>Danthonia intermedia</i>		0.10		0.04		0.03		0.08	0.004	0.08				0.004	0.29
<i>Ehymus glaucus</i>												0.004			
<i>Festuca occidentalis</i>		0.10		0.02	0.004	0.04		0.08				0.004	0.01	0.04	0.58
<i>Festuca sp.</i>				0.01											
TOTAL NATIVE FORB	0.25	1.75	0.20	1.43	0.13	1.17	1.20	10.31	1.61	7.50		0.07	0.98	0.36	2.57
<i>Achillea millefolium</i> *		0.04	0.05	0.04			0.95	3.56	1.53	6.13			0.04		
<i>Adenocaulon bicolor</i>		0.05													
<i>Anaphalis margaritacea</i> *	0.03	0.15	0.01	0.15	0.02	0.08	0.16	2.54	0.01	0.11			0.05	0.01	0.36
<i>Antennaria howellii</i>		0.08		0.04											
<i>Campanula rotundifolia</i>														0.004	0.05
<i>Chamerion angustifolium</i> *	0.08	0.65	0.12	1.09	0.12	0.83	0.09	0.31	0.15	1.08		0.06	0.62	0.31	1.79
<i>Conyza canadensis</i>				0.01		0.04				0.01					0.01
<i>Epilobium brachycarpum</i>		0.01	0.04	0.04	0.01	0.04	0.01	0.06	0.004	0.04		0.01	0.09	0.004	0.17
<i>Gnaphalium macounii</i>						0.08		0.04							0.04
<i>Geum macrophyllum</i> *							0.07	0.68		0.01					
<i>Hieracium albidiflorum</i>		0.06		0.04		0.02		0.09		0.04			0.13		0.10
<i>Melampyrum linare</i>														0.04	0.04
<i>Osmorhiza berteroi</i>						0.01				0.04					
<i>Penstemon confertus</i>						0.04									
<i>Solidago canadensis</i> *		0.04			0.004		0.06	0.88		0.04					
<i>Symphyotrichum laeve</i> *		0.01					0.13	2.12					0.01		
Unknown						0.01				0.01					
<i>Viola orbiculata</i> (?)	0.02	0.05		0.02			0.004	0.04	0.01	0.01			0.04		
<i>Xerophyllum tenax</i> *	0.21	0.61				0.01						0.004			

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

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	2008	2009	2008	2009	2008	2009	2008	2009	2007	2008	2009	2008	2009
TOTAL EXOTIC GRASS	0.21	0.21	0.05	0.21	0.18	0.26	0.004	0.30	0.00	0.28		0.04	0.04	0.01	0.04
<i>Agrostis stolonifera</i>	0.21	0.21		0.13	0.17	0.25	0.004	0.22		0.05		0.04	0.04	0.004	0.04
<i>Elymus repens</i>				0.08											
<i>Phleum pratense</i>			0.004												
<i>Poa compressa</i>					0.004					0.04					
<i>Poa pratensis</i>								0.08		0.19					
<i>Triticum aestivum</i>	0.004		0.05		0.01	0.01								0.004	
TOTAL EXOTIC FORB	0.38	4.03	0.11	3.12	0.16	4.74	0.19	3.85	0.33	4.25		0.06	2.35	0.20	1.48
<i>Cirsium sp.</i>		0.03				0.01				0.01			0.01		
<i>Filago arvensis</i>		0.05		0.03	0.004	0.01			0.004	0.02			0.05		0.08
<i>Lactuca serriola</i>		0.01							0.04						
<i>Medicago lupulina</i>		0.13	0.004	0.21	0.004			0.13	0.004	0.08			0.04	0.01	0.15
<i>Taraxacum officinale</i>		0.02		0.03		0.01			0.01	0.09			0.03	0.13	0.05
<i>Trifolium agrarium</i>						0.04		0.01	0.004			0.004	0.04		
<i>Trifolium hybridum</i>		3.13		0.51		4.38	0.08	2.59		1.63			1.42		0.77
<i>Trifolium pratense</i>													0.08		
<i>Trifolium sp.</i>	0.37	0.31	0.06	0.92	0.14	0.08	0.02	0.15	0.06	1.34		0.05	0.54	0.05	0.38
<i>Veronica officinalis</i>	0.03	0.38	0.06	1.44	0.02	0.20	0.10	0.96	0.22	1.08		0.01	0.13	0.01	0.06
UNKNOWN ORIGIN GRASS	0.01	0.01	0.00	0.00	0.004	0.00	0.00	0.00	0.01	0.00		0.01	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	0.03	0.02	0.03	0.00	0.05	0.01		0.02	0.00	0.01	0.01
<i>Hieracium sp.</i>				0.01			0.004					0.004		0.01	
unknown forb	0.01	0.02	0.01		0.03	0.02	0.02		0.05	0.01		0.02		0.004	0.01
TOTAL PLOT NATIVE VEG COVER	0.63	3.40	0.69	4.54	1.65	5.29	2.84	14.16	2.50	10.28		7.77	12.32	0.93	6.63
TOTAL PLOT VEG COVER	1.25	7.67	0.87	7.88	2.03	10.30	3.07	18.31	2.90	14.81		7.90	14.71	1.15	8.16
% NATIVE COVER	50.0%	44.4%	79.2%	57.6%	81.1%	51.3%	92.4%	77.4%	86.4%	69.4%		98.4%	83.8%	81.1%	81.3%

Table 5. Apgar Transit Center Experimental Plots: Statistical comparison of canopy cover between treatments. Upper table shows cover values that have significant differences (90% CI) between treatments. Lower tables shows how treatments are significantly different from each other. * = 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	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
TOTAL NATIVE TREE	0.18	0.47	0.20	0.87	0.33	1.04	0.22	0.96	0.31	1.16	0.35	0.91	0.38	2.04
<i>Populus balsamifera</i>	0.13	0.05	0.18	0.51	0.17	0.48	0.18	0.68	0.26	0.51	0.30	0.39	0.31	1.13
TOTAL NATIVE SHRUB	0.01	0.01	0.21	1.45	0.004	0.01	0.05	0.41	0.19	0.67	0.00	0.00	0.00	0.08
<i>Rubus parviflorus</i> *	0.01		0.21	1.45				0.01		0.01				
<i>Spiraea betulifolia</i> *				0.01		0.01	0.05	0.40	0.19	0.65				0.08
TOTAL NATIVE GRASS	0.11	1.17	0.05	0.78	1.08	3.07	1.01	2.48	0.28	0.94	7.29	10.43	0.18	1.93
<i>Agrostis scabra</i>						0.01		0.09		0.27				0.21
<i>Calamagrostis rubescens</i> *		0.07	0.004	0.10	1.08	2.70	1.01	1.63	0.03	0.03	7.21	9.54		0.02
TOTAL NATIVE FORB	0.25	1.75	0.20	1.43	0.13	1.17	1.20	10.31	1.61	7.50	0.07	0.98	0.36	2.57
<i>Achillea millefolium</i> *		0.04	0.05	0.04			0.95	3.56	1.53	6.13		0.04		
<i>Anaphalis margaritacea</i> *	0.03	0.15	0.01	0.15	0.02	0.08	0.16	2.54	0.01	0.11		0.05	0.01	0.36
<i>Chamerion angustifolium</i> *	0.08	0.65	0.12	1.09	0.12	0.83	0.09	0.31	0.15	1.08	0.06	0.62	0.31	1.79
<i>Geum macrophyllum</i> *							0.07	0.68		0.01				
<i>Solidago canadensis</i> *		0.04			0.004		0.06	0.88		0.04				
<i>Symphyotrichum laeve</i> *		0.01					0.13	2.12				0.01		
<i>Xerophyllum tenax</i> *	0.21	0.61				0.01					0.004			
TOTAL EXOTIC FORB	0.38	4.03	0.11	3.12	0.16	4.74	0.19	3.85	0.33	4.25	0.06	2.35	0.20	1.48
<i>Trifolium hybridum</i>		3.13		0.51		4.38	0.08	2.59		1.63		1.42		0.77

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
<i>Populus balsamifera</i>	2008	No significant differences between treatments
	2009	2=3=4=5=6=7; 1=4, 7 > 1
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
<i>Rubus parviflorus</i>	2008	2 > 1=3=4=5=6=7
	2009	2 > 1=3=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
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
<i>Agrostis scabra</i>	2008	No significant differences between treatments
	2009	1=2=3=4=6; 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
TOTAL NATIVE FORB	2008	4=5 > 1=2=3=6=7
	2009	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
<i>Anaphalis margaritacea</i>	2008	4 > 1=2=3=5=6=7
	2009	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
<i>Geum macrophyllum</i>	2008	No significant differences between treatments
	2009	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
<i>Symphyotrichum laeve</i>	2008	4 > 1=2=3=5=6=7
	2009	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
TOTAL EXOTIC FORB	2008	No significant differences between treatments
	2009	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
TOTAL EXOTIC GRASS	2008	No significant differences between treatments
	2009	No significant differences between treatments

Table 6. Apgar Transit Center Experimental Plots: Density (# plants/0.25m²) of seeded plants, 2008-2009. * = Seeded species. Orange indicates significant difference (90% CI) between treatments.

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	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
NATIVE SHRUB	0	0	10.08	6.67	0	0	2.96	7.04	17.33	13.67			0	0
<i>Rubus parviflorus</i> *			10.08	6.67										
<i>Spiraea betulifolia</i> *							2.96	7.04	17.33	13.67				
NATIVE GRASS	0	0	0	0	42.67	29.21	38.00	37.33	2.46	1.58	4.00	3.875	0	0
<i>Carex sp.</i> (assumed <i>athrostachya</i> *)							0.04		2.42	1.58				
<i>Calamagrostis rubescens</i> *					42.67	29.21	37.96	37.13	0.04					
CALRUB plugs/microplot											4.00	3.875		
CALRUB plugs total per macroplot												32		
NATIVE FORB	9.75	8.96	0	0	0	0	39.21	54.63	20.13	21.17			0	0
<i>Achillea millefolium</i> *							14.08	16.71	19.67	20.25				
<i>Anaphalis margaritacea</i> *							9.46	16.71		0.92				
<i>Chamerion angustifolium</i> *							0.79	2.13	0.46					
<i>Geum macrophyllum</i> *							2.54	3.58						
<i>Solidago canadensis</i> *							3.08	4.21						
<i>Symphotrichum laeve</i> *							9.25	11.29						
<i>Xerophyllum tenax</i> *	9.75	8.96												
TOTAL DENSITY OF SEEDED SPECIES	9.75	8.96	10.08	6.67	42.67	29.21	80.17	99.00	39.92	36.42		0	0	0

Table 7. Apgar Transit Center Experimental Plots: Density (# plants/m²) and percent germination for seeded species, 2008-2009.

Treatment #	1						2						3						4						5					
Treatment Type	XERTEN seed						RUBPAR seed						CALRUB seed						CALRUB seed with forb						CARATH seed with forb					
	density per m ²		seed rate per m ²	germ. rate		density per m ²		seed rate per m ²	germ. rate		density per m ²		seed rate per m ²	germ. rate		density per m ²		seed rate per m ²	germ. rate		density per m ²		seed rate per m ²	germ. rate						
	2008	2009		2008	2009	2008	2009		2008	2009	2008	2009		2008	2009	2008	2009		2008	2009	2008	2009	2008	2009		2008	2009			
NATIVE SHRUB						40.3	26.7	269	15.0%	9.9%						11.8	28.2	86	13.8%	32.7%	69.3	81.0	215	32.2%	25.4%					
<i>Rubus parviflorus</i> *						40.3	26.7	269	15.0%	9.9%																				
<i>Spiraea betulifolia</i> *																11.8	28.2	86	13.8%	32.7%	69.3	54.7	215	32.2%	25.4%					
NATIVE GRASS											170.7	116.8	538	31.7%	21.7%	152.0	148.5	323	47.0%	46.0%	9.9	6.3	323	3.0%	2.0%					
<i>Carex</i> sp.(assumed <i>albrostachya</i> *)																0.2					9.7	6.3	323	3.0%	2.0%					
<i>Calamagrostis rubescens</i> *											170.7	116.8	538	31.7%	21.7%	151.8	148.5	323	47.0%	46.0%	0.2									
NATIVE FORB	39.0	35.8	269	14.5%	13.3%											156.8	218.5	516	30.4%	42.3%	80.5	84.7	215	36.6%	37.7%					
<i>Achillea millefolium</i> *																56.3	66.8	86	65.5%	77.7%	78.7	81.0	215	36.6%	37.7%					
<i>Anaphalis margaritacea</i> *																37.8	66.8	86	44.0%	77.7%		3.7								
<i>Chamerion angustifolium</i> *																3.2	8.5	86	3.7%	9.9%	1.8									
<i>Geum macrophyllum</i> *																10.2	14.3	86	11.8%	16.7%										
<i>Solidago canadensis</i> *																12.3	16.8	86	14.3%	19.6%										
<i>Symphotrichum laeve</i> *																37.0	45.2	86	43.0%	52.5%										
<i>Xerophyllum tenax</i> *	39.0	35.8	269	14.5%	13.3%																									
TOTAL SEED RATE/TREATMENT	269						269						538						925						753					

2. **Revegetation Plots Monitored by Ocular Cover**

In August 2009, monitoring plots were read two 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 6). 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.

2a. **Trees**

Tree cover continued to show little change. Currently, tree cover ranges from 0.3% to 6% depending on the density and size of planted trees. This does not differ much from last year when tree cover ranged from 0.1% to 5.7%. Most plots remained the same in tree cover or increased by less than 1% cover. Plot 9 was the only plot to increase by 2% cover due to an increase in cover of salvaged *Tsuga heterophylla*. 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* seedlings were observed in eight new plots while unknown conifer seedlings recruited to five new plots. *Populus tremuloides*, seen for the first time on this project this year, was observed in three plots.

2b. **Shrubs**

Similar to last year, most plots did not experience large changes in shrub cover. Currently, the range of shrub cover is 0.3% to 4.1%, up from 0.1% to 2% cover last year. Most plots have maintained their cover or increased by less than 1%.

Plots 8 and 9 were the only plots to have a 2% increase in cover this year. On plot 8, this increase was due primarily to an increase of *Arctostaphylos uva-ursi* that had been salvaged, *Linnaea borealis* that was naturally moving into the plot from the adjacent forest, and *Spiraea betulifolia* that had been seeded. On plot 9, the increase was due primarily to an increase of salvaged *Vaccinium myrtilloides*, a Montana Natural Heritage Program Species of Concern, in addition to the establishment of two additional shrub species. Although there was some concern at the start of this project that this rare *Vaccinium* would not transplant successfully, so far our plot data has tracked several healthy and thriving plants. This year those healthy plants actually increased in cover, producing new growth and fruit. It was also noted that other salvaged *Vaccinium* species were thriving.

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. Shrub species that appear to be expanding into new areas throughout the project include naturally regenerating *Alnus viridis* that was observed in four new plots, *Rubus parviflorus* and *Spiraea betulifolia* that were each observed in three new plots from natural regeneration and/or seed, and naturally occurring *Rubus idaeus* that was observed on two new plots.

2c. **Native Forbs**

Native forb cover increased on all plots throughout the project. Native forb cover ranges from 2.2% to 12%, up dramatically from 0.2% to 4% cover last year. Native forb cover is the dominant or co-dominant lifeform on two of the plots.

Plots 1, 3, 6, and 10 exhibited the largest increases in forb cover, increasing by 4% to 9% since last year. *Antennaria howellii* and *Anaphalis margaritacea* have each increased on three of these plots. *A. margaritacea* has shown the biggest increases in cover, increasing by 2% to 5% since last year, while *A. howellii* has typically increased by 0.5% cover. Other species that have had notable increases on one or two plots include *Chamerion angustifolium*, *Epilobium brachycarpum*, *Achillea millefolium*, and *Geum macrophyllum* with smaller increases from *Penstemon confertus*, *Hieracium albiflorum*, and *Symphyotrichum laeve*. Overall, five species consistently dominate native forb cover: *Anaphalis margaritacea*, *Antennaria howellii*, and *Geum macrophyllum* from nursery stock, as well as *Chamerion angustifolium* and *Achillea millefolium* from seed and/or natural regeneration. Most other species have 0.1% to 0.2% 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. An average of 4 native forb species were newly found in each plot, all of them already present in other areas. The most common include: *Geum macrophyllum* and *Anaphalis margaritacea* (each newly found in 5 plots), *Chamerion angustifolium* and *Viola orbiculata* (each newly found in 4 plots), and *Fragaria virginiana* and *Campanula*

rotundifolia (each new to 3 plots).

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 some *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. Native grass cover currently ranges from 2.2% to 40% cover, a notable increase from last year when cover ranged from 0.3% to 25%. Plots 1, 2, 3, 4, 6, 9, and 10 had the biggest increases in cover, increasing from 5% to 15% this year. In total, native grass was the most dominant or co-dominant lifeform on three of the plots.

Similar to last year, *Elymus glaucus* remained the native grass that continued to exhibit the largest increases in cover. *E. glaucus* increased by 10% cover on plot 2, by 15% cover on plot 3, and by 4% cover on plot 9. All three of these plots were seeded with *E. glaucus*. 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 0.5% to 3% increases on plots 1, 2, 4, 6, and 10, significantly adding to the overall native grass cover of these plots. While some of this cover was present in salvage mats, most sedge species are naturally regenerating throughout the project. Other native grasses that increased in cover on three or more plots included *Danthonia* spp. that increased 1% to 2% on plots 1, 6, and 10 and *Festuca occidentalis* (presumed since not all plants had seed heads) that increased 0.5% to 3% on plots 1, 4, 6, 9, and 10. Finally, grass species *Calamagrostis rubescens*, *Agrostis scabra*, and *Bromus carinatus* had smaller increases on one plot each with *C. rubescens* providing consistent cover in many of the plots. 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, naturally regenerating *Carex rossii*, *Calamagrostis rubescens* from seed, salvage, and nursery stock, and *Festuca occidentalis* from salvage and natural regeneration are the dominant native grasses on the project with the highest covers. All other native grass species have 0.1% to 0.2% cover.

Species that have been present within one area of the project are also beginning to establish in other revegetation areas of the project. This year, naturally regenerating *Carex concinnoides* and *Danthonia* spp. each moved into three new plots, while *Calamagrostis rubescens* and *Carex athrostachya* moved into two new plots. 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

Exotic forb cover increased in all plots in 2009, currently ranging from 1.5% to 21% cover. This is a big increase from last year when exotic forb cover ranged was 0.2% to 7%. Plots 1, 2, 3, 6, 7, and 10 had the biggest increases in exotic forb cover, typically increasing 10% to 14%.

Similar to last year, the increase in exotic forb cover is due mostly to increased cover of clover species *Trifolium agrarium*, other *Trifolium* spp. (almost exclusively *T. hybridum* and *T. repens*), *Medicago lupulina*, and *Melilotus alba*. Cover of these species typically increased by 1-9%. In addition, *Veronica officinalis* increased by 1-4% this year in most plots. The result is that exotic forbs are the dominant lifeform on six out of ten plots and the second most common lifeform on two additional plots, typically dominated by these six exotic forb species. While there has been a hand weeding effort in the transit center area that has targeted clovers and other weeds, currently these efforts are not enough to reduce cover of these weed species. That said, hand pulling efforts should continue, as they remain the best option to keep exotic forbs from increasing even further. Other weed species to watch include *Artemisia absinthium*, *Cirsium arvense*, and *Rumex acetosella* that had notable increases in a few plots.

Recruitment of new exotic forb species added to the increase of this lifeform over the past year. While there were fewer overall new exotic forbs species introduced to the project area this year, existing exotic forb species tend to be expanding to new areas throughout the project. In terms of noxious weed species, *Centaurea maculosa* was found

in two additional plots while *Leucanthemum vulgare* was found in one additional plot. Overall, *Cirsium arvense* can be found in almost half of the revegetation plots, while *C. maculosa* and *L. vulgare* are found in about a third of the plots. *Potentilla recta* and *Hieracium piloselloides* remain each in one plot, while *Tanacetum vulgare* disappeared from one plot and colonized in another plot. In terms of other exotic forbs, *Taraxacum officinale* was the most common recruit, found in five new plots this year. Other species that are spreading into new areas include *Galium aparine*, *Medicago lupulina*, *Tragopogon dubius*, *Digitalis purpurea* (new to the project this year), and *Veronica officinalis*. Currently, all ten plots have low to moderate 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 may be 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, while *Chenopodium album*, *Erodium cicutarium*, and *Lactuca serriola* have disappeared from one-third to one-half of their previous sites. 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 last year, most plots have not experienced great changes in exotic grass cover over the last year with the notable exception of three plots. Currently, exotic grass cover is 0.1% to 5.6%, generally similar to the range of 0.1% to 10% cover last year. In actuality, only two plots have exotic grass cover of 3.5% and 5.6% in 2009 while the remaining plots have exotic grass cover of less than 1%.

Plots 1 and 9 were the only plots to show notable increases in exotic grass cover. This increase in cover was due mostly to increases of *Agrostis stolonifera* that not only increased on these two plots, but also increased on plots, 2, 7, and 8. The result is that *A. stolonifera* has the highest and most consistent cover of all exotic grasses within this project. While it has been hand pulled in several locations, *A. stolonifera* is an aggressive perennial rhizomatous grass that can quickly dominate herbaceous areas. *Elymus repens* and *Poa compressa*, other aggressive grasses, also had notable increases on plot 1.

Plot 3, adjacent to the retention pond, had a 10% decrease in exotic grass cover this year, the only plot to show a large decrease in exotic grass cover. This was due exclusively to a 10% decrease of *Bromus commutatus*, which coincidentally increased by 10% in 2008. Similarly, *B. commutatus* decreased by 1% on plot 2 (adjacent to plot 3) this year while increasing by 1% in 2008. While it is uncertain what is happening with this grass, *B. commutatus* is an annual brome that may fluctuate from year to year in its ability to reseed itself. Its cover may have been high last year when there was less vegetation to compete with but decreased this year as other vegetation became established. Future monitoring will document whether this grass will continue to have fluctuating cover or if its high cover last year was a temporary event.

Generally, exotic grass cover has remained the same for plots 2, 4, 5, 6, 7, 8, and 10. While certain grasses could increase over time, hand pulling exotic grasses throughout the project has seemed to keep them in check and should continue in the future on an annual basis. Currently, native grass cover is far higher than exotic grass cover, a excellent sign for the future success of this project.

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, species within these mats maintained their cover, died back significantly or disappeared. Some of the larger declines last year were seen in *Arctostaphylos uva-ursi*, *Carex rossii*, *Festuca occidentalis*, *Fragaria virginiana*, *Hieracium albidiflorum*, and *Linnaea borealis*. This year, most salvaged species are maintaining their cover since 2008. 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. Salvaged trees are still doing well in the project after two 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. Shrub species that appear to be expanding into new areas throughout the project include naturally regenerating *Alnus viridis* and *Rubus idaeus*, as well as *Rubus parviflorus* and *Spiraea betulifolia* that are naturally regenerating and/or germinating from seed.
- Although there was some concern at the start of this project that the Species of Concern *Vaccinium myrtilloides* would not transplant successfully, so far our plot data has tracked several healthy and thriving plants. This year those healthy plants actually increased in cover, producing new growth and fruit. It was also noted that other salvaged *Vaccinium* species were thriving.
- Native forb cover increased on all plots throughout the project becoming the dominant or co-dominant lifeform on two of the plots. Overall, five species consistently dominate native forb cover: *Anaphalis margaritacea*, *Antennaria howellii*, and *Geum macrophyllum* from nursery stock, as well as *Chamerion angustifolium* and *Achillea millefolium* from seed and/or natural regeneration.
- An average of 4 native forb species were newly found in each plot, all of them already present in other areas. The most common species that are spreading throughout the project include: *Geum macrophyllum*, *Anaphalis margaritacea*, *Chamerion angustifolium*, *Viola orbiculata*, *Fragaria virginiana* and *Campanula rotundifolia*.
- Like native forbs, native grass cover increased on all plots throughout the project becoming the dominant or co-dominant lifeform on three of the plots. Similar to last year, *Elymus glaucus* remained the native grass that continued to exhibit the largest increases in cover. Naturally regenerating *Carex rossii*, *Carex pachystachya*, *Carex concinnoides*, *Danthonia* spp. and *Festuca occidentalis* also consistently increased. Currently, *Elymus glaucus* from seed, naturally regenerating *Carex rossii*, *Calamagrostis rubescens* from seed, salvage, and nursery stock, and *Festuca occidentalis* from salvage and natural regeneration are the dominant native grasses on the project with the highest covers.
- Also like native forbs, species that have been present within the project are beginning to establish in other revegetation areas of the project. The most common species that are spreading include: *Carex concinnoides*, *Danthonia* spp., *Calamagrostis rubescens* and *Carex athrostachya*. 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.
- Exotic forb cover increased dramatically in all plots in 2009, typically increasing 10% to 14%. Similar to last year, the increase in exotic forb cover is due mostly to increased cover of clover species *Trifolium agrarium*, T.

hybridum and *T. repens*, *Medicago lupulina*, and *Melilotus alba*. In addition, *Veronica officinalis* increased this year in most plots. The result is that exotic forbs are the dominant lifeform on six out of ten plots.

- Recruitment of new exotic forb species added to the increase of this lifeform over the past year. Although fewer new exotic forbs became established this year, existing exotic forb species tend to be expanding to new areas throughout the project. In terms of noxious weed species, *Cirsium arvense* can be found in almost half of the revegetation plots, while *Centaurea maculosa* and *Leucanthemum vulgare* are found in about a third of the plots. *Potentilla recta* and *Hieracium piloselloides* remain each in one plot, while *Tanacetum vulgare* disappeared from one plot and colonized in another plot. In terms of other exotic forbs, *Taraxacum officinale*, *Galium aparine*, *Medicago lupulina*, *Tragopogon dubius*, *Digitalis purpurea* (new to the project this year), and *Veronica officinalis* are other weed species that are spreading into new areas.
- In keeping with trends from last year, exotic grass cover has not changed dramatically over the last year. In addition, native grass cover is far higher than exotic grass cover, a excellent sign for the future success of this project. Any exotic grass increases are due to increases of *Agrostis stolonifera* that now has the highest and most consistent cover of all exotic grasses within this project.
- *Bromus commutatus*, present near the retention pond, is the only exotic grass on the project to exhibit large annual fluctuations in cover. This grass decreased in cover by 10% this year, after increasing in cover by 10% in 2008. While it is uncertain what is happening with this grass, *B. commutatus* is an annual brome that may fluctuate from year to year in its ability to reseed itself. Its cover may have been high last year when there was less vegetation to compete with but decreased this year as other vegetation became established. Future monitoring will document whether this grass will continue to have fluctuating cover or if its high cover last year was a temporary event.
- While there has been a hand weeding effort in the transit center area that has targeted clovers and other weeds, currently these efforts are not enough to reduce cover of these weed species. That said, hand pulling efforts should continue, as they remain the best option to keep exotic and noxious weeds from increasing even further. Other weed species to watch include *Agrostis stolonifera*, *Elymus repens*, *Artemisia absinthium*, *Cirsium arvense*, and *Rumex acetosella* that had notable increases in a few plots. Hand pulling does seem to be reducing the cover of *Amaranthus retroflexus*, *Thlaspi arvense*, *Spergularia rubra*, *Capsella bursa-pastoris*, *Myosotis macrantha*, *Chenopodium album*, *Erodium cicutarium*, and *Lactuca serriola*. 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.
- 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: 2010 (year 3), 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 - 2009.

		ATC-07-01			ATC-07-02			ATC-07-03			ATC-07-04			ATC-07-05		
Ground Cover		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Basal veg				3			3			5			3			5
Bare Ground				7			20			38			4			15
Gravel				1			8			15			5			15
Litter				87			67			40			81			60
Moss				2			2			2			6			1
Rock													0			0.1
Wood													1			8
Species	source	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Trees		5.7	5.7	6	0.1	0.1	0.3	0	0.1	0.6	0.1	0.1	0.6	0.1	0.1	1
<i>Larix occidentalis</i>	nursery?	0.5	0.5	0.5												
<i>Betula papyrifera?</i>	regen												0.2			
<i>Picea engelmannii</i>	salvage	3	3	3											0.1	0.2
<i>Pinus contorta</i>	salvage?													0.1	0.1	0.2
<i>Pinus contorta</i>	regen			0.2					0.1	0.2			0.2			0.2
<i>Populus balsamifera</i>	regen	0.2	0.2	0.2	0.1	0.1	0.2			0.2	0.1	0.1	0.2		0.1	0.2
<i>Populus tremuloides</i>	regen			0.1												
<i>Pseudotsuga menziesii</i>	salvage	2-	2	2(budworm)												
<i>Unknown conifer seedlings</i>	regen						0.1			0.2			0.2		0.1	0.2
Shrubs		1	1	1.2	0.2	0.4	0.5	0.1	0.2	0.3	4	1	1	2	1	1.9
<i>Acer glabrum</i>	nursery	0.2	0.2													
<i>Alnus viridis</i>	nursery	0.1	0.1	0.1												
<i>Alnus viridis</i>	regen			0.1												
<i>Amelanchier alnifolia</i>	nursery	0.1														
<i>Amelanchier alnifolia</i>	regen				0.1											
<i>Arctostaphylos uva-ursi</i>	salvage										3	0.5	0.5			
<i>Arctostaphylos uva-ursi</i>	nursery			0.1 (creeping in)												
<i>Cornus sericea</i>	salvage														0.1	0.1
<i>Holodiscus discolor</i>	nursery	0.2	0.2	0.1					0.1							
<i>Linnaea borealis</i>	salvage					0.1	0.1				1+			0.2	0.2	0.2
<i>Linnaea borealis</i>	regen/seed?											0.1	0.2			
<i>Paxistima myrsinites</i>	nursery	0.2	0.2			0.1										
<i>Paxistima myrsinites</i>	salvage													0.1	0.1	
<i>Rubus idaeus</i>	regen			0.2			0.1		0.1							
<i>Rubus parviflorus</i>	nursery		0.1			0.1	0.1									
<i>Rubus parviflorus</i>	regen/seed?															0.1
<i>Shepherdia canadensis</i>	nursery	0.1	0.1													
<i>Spiraea betulifolia</i>	nursery	0.2	0.2													
<i>Spiraea betulifolia</i>	regen/seed?			0.2	0.1	0.1	0.2	0.1	0.1	0.2			0.1		0.1	0.2
<i>Spiraea betulifolia</i>	salvage										0.2	0.1	0.1	0.5	0.2	0.2
<i>Symphoricarpos albus</i>	nursery	0.2	0.2	0.2												0.2
<i>Symphoricarpos albus</i>	regen/seed?															0.2
<i>Vaccinium caespitosum?</i>	salvage													0.1		
<i>Vaccinium caespitosum</i>	regen															0.2
<i>Vaccinium membranaceum</i>	regen	0.1?		0.2				0.1	0.1	0.1	0.2	0.1	0.1			
<i>Vaccinium membranaceum</i>	salvage													1-	0.5	0.5
<i>Vaccinium myrtilloides</i>	salvage													0.1	0.1	

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2009.

		ATC-07-01			ATC-07-02			ATC-07-03			ATC-07-04			ATC-07-05		
		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Native Forbs		1	3+	12.2	0.1	0.2	2.3	0.2	0.2	4.3	5	5	8.2	1	0.5	3.3
<i>Achillea millefolium</i>	regen/seed?					0.1	1-	0.1	0.1	2						0.2
<i>Achillea millefolium</i>	salvage													0.1	0.1	0.2
<i>Anaphalis margaritacea</i>	nursery	0.2	1	6								0.1	0.1			
<i>Anaphalis margaritacea</i>	salvage													0.1		
<i>Anaphalis margaritacea</i>	regen/seed?						0.1						0.1			0.2
<i>Antennaria bonellii</i>	nursery	0.5	0.5	1												0.1
<i>Antennaria bonellii</i>	regen/seed?					on edge	0.1	0.1	0.1	0.5						0.1
<i>Apocynum andromisaeifolium</i>	regen	0.1?	0.1	0.1					0.1							
<i>Arabis divaricarpa</i>	regen		0.1	0.1								1.5				
<i>Aster laevis</i>	nursery		0.1	0.2												
<i>Aster laevis</i>	seeded															0.2
<i>Campanula rotundifolia</i>	regen						0.1									
<i>Chamerion angustifolium</i>	regen/seed?		1.5	2			0.1			0.2		0.5	0.5			0.1
<i>Chimaphila umbellata</i>	salvage											0.1	0.1	0.2	0.1	0.1
<i>Clintonia uniflora</i>	regen/seed?														0.1	
<i>Conyza canadensis</i>	regen		0.1	0.2												
<i>Epilobium brachycarpum (thin lvs)</i>	regen		0.1	1								2	3			
<i>Epilobium brachycarpum (wider lvs)</i>	regen			0.2												
<i>Fragaria virginiana</i>	salvage										2+	0.2	1			
<i>Fragaria virginiana</i>	regen/seed?									0.2						
<i>Galium boreale</i>	regen			0.1												
<i>Geranium bicknellii</i>	regen/seed?	0.1	0.1	0.1								0.1	0.2		0.1	
<i>Geum macrophyllum</i>	nursery	0.2	0.2	0.2												
<i>Geum macrophyllum</i>	regen/seed?						0.2			0.2						
<i>Gnaphalium macounii</i>	regen			0.1		0.1	0.1						0.2		0.1 P	
<i>Hieracium albiflorum</i>	regen		0.1	0.1	0.1	0.1	0.2		0.1	0.5						0.2
<i>Hieracium albiflorum</i>	salvage										3	1	2	0.5	0.2	0.2
<i>Hieracium sp. (yellow)</i>	regen												0.2			
<i>Lathyrus ochroleucus</i>	regen		0.1	0.1												
<i>Lupinus sericeus</i>	regen									0.2						
<i>Maianthemum stellatum</i>	regen/seed?			0.2			0.1	0.1	0.1	0.2		0.1	0.2		0.1	0.2
<i>Melampyrum lineare</i>	salvage												0.2	0.1	0.1	0.1
<i>Osmorhiza brevipes</i>	regen															0.1
<i>Penstemon confertus</i>	nursery	0.2	0.2	0.1		0.1										0.2
<i>Penstemon lyallii?</i>	nursery	0.2														
<i>Penstemon spp.</i>	nursery	0.1	0.1													
<i>Pteridium aquilinum</i>	nursery	0.2	0.2	0.2		0.1										
<i>Ranunculus sp.</i>	regen			0.2												
<i>Solidago sp. can?</i>	seeded					0.1	0.2		0.1	0.2						0.2
<i>Viola adunca?</i>	regen							0.1								
<i>Viola orbiculata</i>	salvage					0.1	0.1		0.1	0.1	0.2		0.2	0.1	0.1	0.1
<i>Viola orbiculata</i>	regen															0.2
<i>Xerophyllum tenax</i>	nursery?	0.2	0.1													
<i>Xerophyllum tenax</i>	seeded											0.1	0.2			0.5
<i>Xerophyllum tenax</i>	salvage													0.1	0.1	0.1
<i>Xerophyllum tenax</i>	regen				0.1											
unknown forb	regen														0.1	

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2009.

		ATC-07-01			ATC-07-02			ATC-07-03			ATC-07-04			ATC-07-05		
		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Native Grasses		0.5	2	9.6	3	15	26	5	25	40.4	8	4	9.2	1	1+	2.2
<i>Agrostis scabra</i>	nursery		0.5	0.5		0.1										
<i>Bromus carinatus</i>	seeded															0.2
<i>Calamagrostis rubescens</i>	nursery	0.5	0.2	0.5		0.1										
<i>Calamagrostis rubescens</i>	seeded															0.5
<i>Calamagrostis rubescens</i>	salvage										1+	1	1	0.2	0.5	0.2
<i>Carex athrostachya</i>	nursery			0.2												
<i>Carex concinnoides</i>	salvage		0.1	0.2		0.1	0.5				3	1	1+		0.1	0.2
<i>Carex pachystachya</i>	regen		0.5													
<i>Carex pachystachya</i>	nursery			2												
<i>Carex rossii</i>	regen		0.2	3								0.5	2		0.1	
<i>Carex</i> spp.	salvage										0.2			0.5	0.5	0.1
<i>Carex</i> spp.	regen					0.1	0.5			0.2						
<i>Danthonia intermedia?</i>	seeded?							0.1*								
<i>Danthonia spicata?</i>	?		0.5	2+						0.1						0.1
<i>Elymus glaucus</i>	seeded				3	15	25	5	25	40					0.1	0.2
<i>Elymus glaucus</i>	salvage										0.2					
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>	?	0.1														
<i>Festuca idahoensis</i>	regen			0.2												
<i>Festuca occidentalis</i>	salvage		0.1								3	1	1	0.5	0.2	0.5
<i>Festuca occidentalis</i>	regen/seed?			1									4+			
<i>Hordeum jubatum</i>	regen?								0.1			0.1	0.1			
<i>Oryzopsis asperifolia</i>	regen		0.1							0.1					0.1	0.1
<i>Poa</i> spp.	?	0.1														
<i>Trisetum cernuum</i>															0.1	
<i>Trisetum canescens</i>													0.1			0.1
unknown	?				0.1				0.1		0.2			0.1	hairy sheath)	
Exotic Forbs		0.5	5	18.9	0.2	1	11.1	0.5	3	12.5	1	2	10.4	0.1	0.2	1.5
<i>Amaranthus retroflexus</i>	regen		0.1									0.1				
<i>Arenaria serpyllifolia</i>	regen		0.1	0.1												
<i>Artemisia absinthium</i>	regen		0.2	0.5												
<i>Centaurea maculosa</i>	regen			0.1												
<i>Chenopodium album</i>	regen		0.1									0.1				
<i>Chrysanthemum leucanthemum</i>	regen		0.1 P													0.1
<i>Cirsium arvense</i>	regen	0.1	0.1 P	0.2												
<i>Cirsium vulgare</i>	regen	0.2	0.1	0.2												
<i>Convolvulus arvensis</i>	regen			0.1												
<i>Erodium cicutarium</i>	regen							0.1			0.1	0.1	0.2			
<i>Filago arvensis?</i> / <i>Gnaphalium palustre</i>	regen		0.1	0.1							0.1	0.1	0.2		0.1	
<i>Galium aparine</i>	regen		0.1	0.1											0.1	0.2
<i>Lactuca serriola</i>	regen		0.1	0.1		0.1							0.2		0.1	
<i>Madia glomerata</i>	regen											0.1	0.1			
<i>Medicago lupulina</i>	regen		1	7								0.1	2-			
<i>Melilotus alba</i>	regen			1												

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 1-5, 2007 - 2009.

		ATC-07-01			ATC-07-02			ATC-07-03			ATC-07-04			ATC-07-05		
Exotic Forbs con'd		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
<i>Melilotus officinalis</i>	regen												0.2			
<i>Melilotus</i> spp.	regen		0.1	0.1												
<i>Plantago major</i>	regen	0.2	0.1 P	0.1												
<i>Potentilla argentea</i>	regen		0.1	0.2								0.1	0.2			
<i>Potentilla norvegica</i>	regen			0.1												
<i>Prunella vulgaris</i>	regen										0.2					
<i>Taraxacum officinale</i>	regen		0.1	0.2			0.1						0.1	0.1		
<i>Thlaspi arevense</i>	regen											0.1				
<i>Tragopogon dubius</i>	regen		0.1	0.2								0.1				
<i>Trifolium agrarium</i>	regen		1	1								0.1				
<i>Trifolium</i> spp. (<i>hybridum</i> , <i>repens</i> + <i>pratense</i>)	regen	0.2	3		0.2	1	10	0.5	3	12	1	1	5+	0.1	0.1	1-
<i>Trifolium hybridum</i>	regen			5												
<i>Trifolium pratense</i>	regen			0.2												
<i>Trifolium repens</i>	regen			1												
<i>Verbascum thapsus</i>	regen	0.1	0.1	0.2												
<i>Veronica officinalis</i>	regen		0.1	1		0.1	1-			0.5		0.1	1		0.1	0.2
<i>Veronica serpyllifolia</i>	regen		0.1	0.1								0.1	0.2			
<i>Verbena bracteata</i>	regen												0.5			
unknown	regen	0.1									0.1					
unknown mustard (ascending pods)	regen												0.5			
Exotic Grasses		0.2	4	5.6	0	1	0.5	0	10	0.2	0	0.2	0.5	0.5	0.2	0.1
<i>Agrostis stolonifera</i>	salvage		2	3		0.1	0.5		0.1			0.1		0.5	0.1 P	
<i>Agrostis stolonifera</i>	regen												0.2			
<i>Bromus commutatus</i>	regen					1			10	0.1						
<i>Bromus inermis</i>	regen		0.1	0.2												
<i>Dactylis glomerata</i>	regen	0.1	0.1													
<i>Elymus repens</i>	regen		0.5	1												
<i>Phleum pratense</i>	regen		0.1	0.2												
<i>Poa annua</i>	regen		0.1									0.1	0.1			
<i>Poa compressa</i>	regen	0.1	1	1						0.1			0.2			
<i>Poa pratensis</i>	regen	0.2	0.2											0.1		0.1
<i>Triticum aestivum</i>	?					0.1						0.1		0.1	0.1	
<i>Annual Brome</i>				0.2												

P= pulled

*= likely mis-ID: BROCOM

2009: BROMCOM 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 - 2009.

		ATC-07-06			ATC-07-07			ATC-07-08			ATC-07-09			ATC-07-10		
Ground Cover		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Basal veg				3			5			2			2			3
Bare Ground				10			20			1			5			25
Gravel				5			10			10			5			5
Litter				81			64			80			70			67
Moss				1			0.2			1			2			0
Rock				0			1			3			1			0.2
Wood				0			0			3			15			0
Species	source	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Trees		3	3	2.65	2	3	3.7	2	3	3.5	1	1	3.1	1+	2+	2.8
<i>Abies lasiocarpa</i>	salvage	1	1	1										1	1.5	0.2
<i>Larix occidentalis</i>	nursery?	0.5	0.25	0.25	0.2	0.2	0.2							0.2	0.5	1
<i>Picea engelmannii</i>	salvage				1	2	2									
<i>Pinus contorta</i>	nursery	0.2	0.2	0.2	0.5	1	1	0.5	(N + I)	1				0.2	0.2	0.2
<i>Pinus contorta</i>	salvage?							0.5								
<i>Pinus contorta</i>	regen			0.2			0.2			0.2			0.2			1
<i>Pinus monticola</i>	salvage							0.2	0.2	0.2						
<i>Populus balsamifera</i>	regen				0.1	0.1	0.1		0.1	0.2		0.1	0.5	0.1	0.1	0.1
<i>Populus balsamifera</i>	salvage									0.2	0.1	0.1	0.1			
<i>Populus tremuloides</i>							0.1						0.1			
<i>Pseudotsuga menziesii</i>	nursery													0.1	0.1	0.2
<i>Tsuga heterophylla</i>	salvage	1	1	1				1	1.5	1.5	1	1	2			
Unknown conifer seedlings	regen		0.1			0.1	0.1			0.2			0.2		0.1	0.1
Shrubs		1	2	1.7	1+	2	2.6	0.5	2	4.1	0.2	0.3	2.2	1	2	2.8
<i>Acer glabrum</i>	nursery	0.2	0.2	0.2	0.1	0.1	0.2							0.1	0.1	0.1
<i>Alnus viridis</i>	nursery/regen?				0.1	0.1	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
<i>Amelanchier alnifolia</i>	regen									0.2						
<i>Arctostaphylos uva-ursi</i>	salvage								0.5	1-						
<i>Arctostaphylos uva-ursi</i>	nursery	0.1	0.1	0.2												
<i>Cornus sericea</i>	nursery				0.2	0.2	0.2									
<i>Holodiscus discolor</i>	nursery				0.2	0.2	0.2							0.1	0.1	1-
<i>Linnaea borealis</i>	regen							0.1	0.1	0.5		0.1	0.1			
<i>Mahonia repens</i>	nursery	0.1	0.1	0.2	0.2	0.1	0.2									
<i>Paxistima myrsinites</i>	nursery	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						
<i>Rubus idaeus</i>	regen		0.1	0.2		0.1	0.2		0.1	0.2					0.1	0.1
<i>Rubus parviflorus</i>	nursery		0.1	0.2	0.1	0.1	0.2							0.2	0.2	0.1
<i>Rubus parviflorus</i>	salvage								0.1	0.2						
<i>Rubus parviflorus</i>	seeded									0.2			0.2			
<i>Salix</i> sp.															0.1	
<i>Sorbus scopulina</i>	salvage								0.1	0.2						
<i>Spiraea betulifolia</i>	nursery	0.2	0.2	0.2	0.2	0.2	0.2							0.2	0.2	0.1
<i>Spiraea betulifolia</i>	seeded							0.1	0.1	0.5	0.1	0.1	0.1			
<i>Spiraea betulifolia</i>	salvage											0.1	0.2			
<i>Symphoricarpos albus</i>	nursery	0.2	0.5	0.2	0.5	0.5	1-		0.5	0.5				0.2	0.5	1
<i>Symphoricarpos albus</i>	seeded												0.2			
<i>Vaccinium membranaceum</i>	regen							0.1	0.2	0.1						
<i>Vaccinium membranaceum</i>	salvage										0.1	0.1	0.2			
<i>Vaccinium myrtilloides</i>	salvage							0.2	0.1	0.2	0.2	0.1	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 - 2009.

		ATC-07-06			ATC-07-07			ATC-07-08			ATC-07-09			ATC-07-10		
		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Native Forbs		0.5	4	10	0.5	1	2.2	0.5	1	4	0.1	0.5	2.8	0.5	2	8
<i>Achillea millefolium</i>	regen						0.2	0.1	0.1	0.2						
<i>Achillea millefolium</i>	seeded											0.1	0.2			
<i>Achillea millefolium</i>	salvage												0.2			
<i>Anaphalis margaritacea</i>	nursery	0.1	1	5	0.2	0.2	0.2							0.1	1	3
<i>Anaphalis margaritacea</i>	seeded												0.2			
<i>Anaphalis margaritacea</i>	salvage									0.2						
<i>Antennaria bonellii</i>	nursery	0.1	0.1	0.2											0.1	0.5
<i>Antennaria bonellii</i>	seeded											0.1	0.1			
<i>Antennaria rosea?</i>	regen/seed?			0.2												
<i>Apocynum androsaefolium</i>	regen					0.1	0.1		0.1				0.1	0.1	0.1	0.1
<i>Arabis divaricata?</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								0.1	0.2						
<i>Aster laevis</i>	nursery	0.1	0.1	0.2					0.1	0.2				0.1	0.1	0.5
<i>Aster laevis</i>	seeded												0.2			
<i>Aster spp.</i>	nursery													0.1		
<i>Campanula rotundifolia</i>	regen		0.1	0.2			0.1	0.1	0.1	0.2			0.1			
<i>Cerastium arvense</i>	regen															1?
<i>Chamerion angustifolium</i>	regen/seed?		2	2		0.1	0.2		0.1	0.2			0.2		0.1	0.1
<i>Chimaphila umbellata</i>	salvage							0.1	0.1	0.2	0.1	0.1	0.1			
<i>Coryza canadensis</i>	regen		0.1	0.2		0.1	0.1						0.1		0.1	0.2
<i>Dracocephalum parviflorum</i>	regen									0.1						
<i>Dryas drummondii</i>	nursery		0.1	0.2										0.1	0.1	0.5
<i>Epilobium brachycarpum</i>	regen		0.1	0.2		0.1	0.1								0.1	0.1
<i>Epilobium brachycarpum (wider lvs)</i>	regen			0.2												
<i>Fragaria vesca</i>	nursery				0.1											
<i>Fragaria virginiana</i>	nursery				0.1	0.1	0.2									
<i>Fragaria virginiana</i>	regen						0.2									
<i>Galium boreale</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						0.1									1-
<i>Geum macrophyllum</i>	nursery	0.1	0.1	0.2	0.2	0.2	0.2							0.2	0.2	
<i>Geum macrophyllum</i>	seeded												0.1			
<i>Gnaphalium macounii</i>	regen		0.1	0.2		0.1	0.1		0.1			0.1	0.1		0.1	1-
<i>Hieracium albiflorum</i>	regen		0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2			0.2		0.1	0.1
<i>Hieracium albiflorum</i>	salvage										0.1	0.1	0.2			
<i>Maianthemum stellatum</i>	regen					0.1										
<i>Melampyrum lineare</i>	salvage								0.1	0.1						
<i>Penstemon albertinus</i>	nursery	0.1	0.1													
<i>Penstemon confertus</i>	nursery	0.2	0.2	0.2		0.1			0.1					0.1	0.1	0.5
<i>Polemonium pulcherrimum</i>	regen									0.2						
<i>Sagina saginoides</i>	regen		0.1												0.1	0.1
<i>Solidago canadensis</i>	regen/seed?		0.1	0.2								0.1	0.2		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	0.1	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			
<i>Xerophyllum tenax</i>	salvage							0.1	0.1	1-		0.1	0.2			
<i>Xerophyllum tenax</i>	regen							0.1	0.1	0.2		0.1		0.1	0.1	0.1
<i>unknown forb</i>	regen								0.1	0.2						

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2009.

		ATC-07-06			ATC-07-07			ATC-07-08			ATC-07-09			ATC-07-10		
		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
Native Grasses		0.2	0.5	4.9	1+	4	5.6	0.2	0.3	2.4	0.2	1	6.4	0.2	4	9.8
<i>Agrostis scabra</i>	nursery					0.1	0.2						0.2	0.1	0.1	1+
<i>Bromus carinatus</i>	regen/seed?											0.1?	0.2		0.1	0.5
<i>Calamagrostis rubescens</i>	nursery	0.1	0.1	0.2										0.1	1	1+
<i>Calamagrostis rubescens</i>	seeded								0.1			0.1	0.5			
<i>Calamagrostis rubescens</i>	salvage							0.1	0.1	0.2	0.1	0.1	0.2			
<i>Calamagrostis rubescens</i>	regen				1+	3	3+			0.5						
<i>Carex athrostachya</i>	nursery?			0.2												
<i>Carex concinnoides</i>	salvage		0.1	0.2		0.1	0.2			0.2		0.1	0.2		0.1	1
<i>Carex concinnoides</i>	regen			0.2			0.5			0.2						
<i>Carex (deweyana?)</i>	regen			0.2		0.1										
<i>Carex rossii</i>	regen		0.1	1+		0.1	1-			1-					1	4
<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?							0.1	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									0.2			
<i>Deschampsia elongata?</i>	nursery													0.1	1	0.2
<i>Elymus glaucus</i>	seeded											0.5	4+		0.1	0.1
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>	?		0.1	0.2												
<i>Festuca occidentalis</i>	salvage							0.1	0.1		0.1					
<i>Festuca occidentalis</i>	regen/seed?		0.1	0.7		0.1	0.4			0.2		0.1	0.5		0.1	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 cernuum</i>													0.2			
unknown	?	0.1									0.1	0.1		0.1	0.1	
Exotic Forbs		0.2	7	17.6	0.5	3	15.7	0.2	0.3	2.3	0.1	0.1	7.7	0.1	4	21.4
<i>Arenaria serpyllifolia</i>	regen					0.1	0.1									
<i>Artemisia absinthium</i>	regen		0.1 P			0.1	0.1									
<i>Capsella bursa-pastoris</i>	regen														0.1	
<i>Centaurea maculosa</i>	regen			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							0.1 P	0.1 P	0.1
<i>Cirsium arvense</i>	regen		0.1 P	0.2					0.1	0.2					0.1	0.5
<i>Cirsium vulgare</i>	regen					0.1	0.1		0.1 P	0.2					0.1	0.1
<i>Cirsium</i> sp.	regen			0.2												
<i>Digitalis purpurea</i>	regen			0.1												
<i>Erodium cicutarium</i>	regen														0.1	0.5
<i>Filago arvensis?</i> / <i>Gnaphalium palustre</i>	regen		0.1	0.2			0.5			0.2			0.1			0.1
<i>Galium aparine</i>	regen						0.1			0.2					0.1	
<i>Hieracium floribundum?</i>	regen		0.1 P													
<i>Hieracium</i> sp. (nativity?)	regen						0.1									
<i>Hieracium</i> sp. (white, glab, hairy marg)	regen			0.2												
<i>Lactuca serriola</i>	regen		0.1	0.2		0.1	0.2									0.1
<i>Madia glomerata</i>	regen					0.1	0.2									

Table 8. con't. Apgar Transit Center: Ocular Canopy Cover by Species for Plots 6-10, 2007 - 2009.

		ATC-07-06			ATC-07-07			ATC-07-08			ATC-07-09			ATC-07-10		
Exotic Forbs, con'd		2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
<i>Medicago lupulina</i>	regen	0.1 P	1	3	0.2	1	3			0.2			0.2		0.1	1
<i>Melilotus alba</i>	regen			3			1							0.1	0.1	0.1
<i>Melilotus officinalis</i>	regen			0.2			0.2									0.1
<i>Melilotus</i> spp.	regen	0.1 P	1			0.2										
<i>Myosotis micrantha</i>	regen		0.1													
<i>Plantago major</i>	regen					0.1	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												
<i>Potentilla argentea</i>	regen		0.1				0.2									
<i>Potentilla recta</i>	regen					0.2 (P 5)	0.1 (P)									
<i>Prunella vulgaris</i>	regen		0.1	0.1												
<i>Rumex acetosella</i>	regen														0.1	5
<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			
<i>Tragopogon dubius</i>	regen			0.2			0.1									
<i>Trifolium agrarium</i>	regen			0.5		0.5	1			0.2			0.2			0.5
<i>Trifolium pratense</i>	regen						0.2									
<i>Trifolium</i> spp. (hybridum, repens + pra)	regen		3	3+		0.2	6	0.1	0.1	0.2	0.1	0.1	6	0.1	1.5	12
<i>Verbascum thapsus</i>	regen		0.1	0.2	0.1 P	0.1 P			0.1	0.2					0.1	0.1
<i>Veronica officinalis</i>	regen	0.1 P	0.5	5		0.1	1-		0.1	0.5	0.1 P	0.1	1		0.1	1+
<i>Veronica serpyllifolia</i>	regen					0.1	0.2	0.1 P							0.1	0.1
Exotic Grasses		0.1	0.1	0.3	0.1	0.1	0.7	0.2	0.2	0.6	0.2	1	3.5	0	1	0.6
<i>Agrostis stolonifera</i>	salvage		0.1			0.1	0.2	0.2	0.2	0.5	0.2	1	2		0.5	0.5
<i>Agrostis stolonifera</i>	regen			0.2			0.2						0.5			
<i>Dactylis glomerata</i>	regen								0.1							
<i>Festuca arundinacea</i>	regen												1			
<i>Phleum pratense</i>	regen	0.1 P			0.1				0.1 P		0.1					
<i>Phleum pratense</i>	salvage										0.1				0.1	
<i>Poa annua</i>	regen														0.1	
<i>Poa compressa</i>	regen		0.1	0.1		0.1	0.2					0.1				
<i>Poa pratensis</i>	regen	0.1													0.1	0.1
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 spp.</i>					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 spp.</i>					4.28g	unk
<i>Bromus carinatus</i>					1379g	80.38
<i>Calamagrostis rubescens</i>	186g	177.15			638g	691.61
<i>Carex/ forb mix</i>			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 spp.</i>			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 spp.</i>	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. HEADQUARTERS-APGAR VILLAGE BICYCLE PATH

A. BACKGROUND AND PURPOSE

In 2004, a water line was replaced between the Headquarters Area and Apgar Village. A paved bike path, used by both visitors and park staff, was re-built and widened significantly subsequent to water line installation, following the route of this water line. Restoration activities began in 2004 to revegetate areas that had been disturbed by replacement of the water line and/or resurfacing of the bike path. Minor amounts of soil were imported to provide fill in a few low areas along the route of the bike path/water line. Restoration activities included hydroseeding and hydromulching disturbed soil (either native or imported) on either side of the path and planting shrubs in a few areas. Hydroseeding and hydromulching was done in May 2004 by Agrotech, a hydroseeding-hydromulching contractor. The hydroseed/hydromulch application contained 20 lb/acre of a native seed mixture that included at least seven grass species, seven forb species, and four shrub species (Lapp and Turecek 2004, Table 10). Shrubs were planted in a few areas to deter foot and bicycle traffic and for aesthetic purposes; these areas were not monitored.

Revegetation and monitoring objectives are as follows:

- To restore native vegetation to areas of bare ground, thus preventing soil erosion and exotic plant invasion.
- To enhance the aesthetics of these areas and begin to blend into the adjacent undisturbed vegetation.
- To document changes in species composition and cover over time.
- To photomonitor progress at each site.

Table 10. Bike Path Revegetation Project: Species Seeded in 2004

Grasses	Forbs:	Shrubs:
<i>Bromus carinatus</i>	<i>Achillea millefolium</i>	<i>Cornus sericea</i>
<i>Carex athrostachya</i>	<i>Anaphalis margaritaceae</i>	<i>Rosa woodsii</i>
<i>Carex species</i>	<i>Aster sp.</i>	<i>Spiraea betulifolia</i>
<i>Elymus glaucus</i>	<i>Chamerion angustifolium</i>	<i>Symphoricarpos albus</i>
<i>Elymus trachycaulus</i>	<i>Penstemon confertus</i>	
<i>Festuca idahoensis</i>	<i>Solidago canadensis</i>	
<i>Festuca ovina</i>	<i>Solidago sp.</i>	
<i>Pseudoroegneria spicata</i>	<i>Symphyotrichum laeve var. laeve</i>	
	<i>Xerophyllum tenax</i>	

B. METHODS

Five non-permanent plots were established along the bike path between Headquarters and Camas Road (Figure 5) and evaluated with Level II protocol in August 2005. This included ground cover estimates and canopy cover estimates for all species present. Plot locations were selected to sample representative vegetation zones along the bike path. No permanent markers were placed at the plots, but UTM data and written descriptions of plot locations were recorded. Plots were 20 square meters each. Plots were either 20m x 1m or 10m x 2m, dependent on the linear nature of the site.

Plots were revisited on August 2, 2007 and on July 9, 2009. Percent cover of each species present and ground cover was recorded. Exact locations of plots were not able to be repeated either year, as the plots were not permanently marked. GPS coverage in this area is notably poor, and GPS errors were often high, contributing to the difficulty of repeating exact plot locations.

Figure 5. Bike Path Revegetation Project: Location of Monitoring Plots.

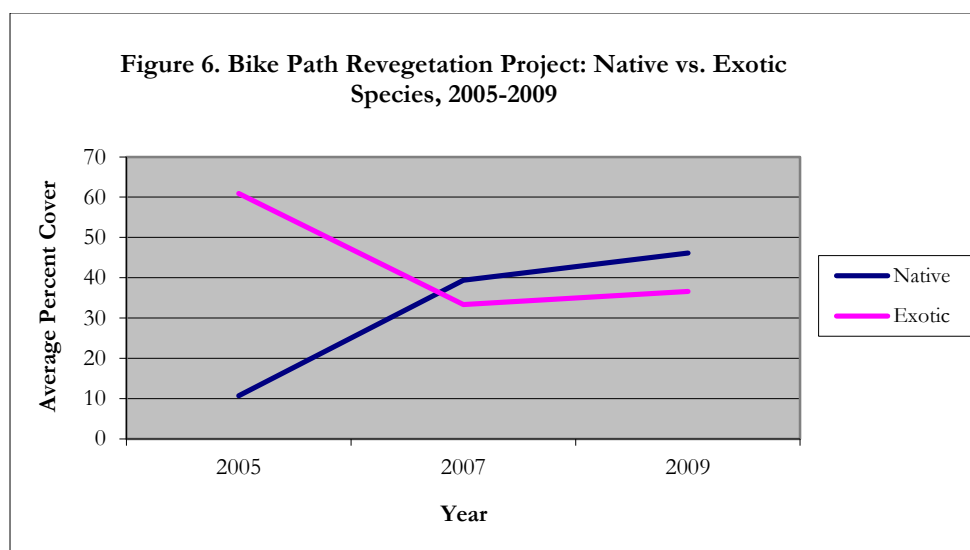


C. RESULTS

1. Meeting Revegetation Objectives

- a. **To restore native vegetation to areas of bare ground, thus preventing soil erosion and exotic plant invasion.**

Overall vegetative cover has increased 10% since 2007, from an average of 73% in 2007 to 83% in 2009. Additionally, gravel cover across plots has decreased from an average of 9% in 2007 to 0.2% in 2009. Bare ground cover has always been low in these plots (1% or less), thus gravel better represents unvegetated surface area. Furthermore, most of the increase in vegetative cover has been due to native species. An initial spike of *Trifolium agrarium* in 2005, originally dominating the site, plummeted in subsequent years and opened habitat for seeded native species. While exotic cover has increased slightly since 2007 from 33% to 36%, native cover has made a larger increase from 39% to 46% (Figure 6). Exotic forbs are actively being controlled with herbicide treatments thus reducing the impacts of exotic forb invasion. Exotic grasses, however, are very difficult to control. Compared to many roadside revegetation projects, however, exotic grass cover on this project is quite low at this point in time and has not increased, on average, in the last two years. Future monitoring will track whether invasive grasses, often the largest threat to the success of revegetation projects, increase over time.



- b. **To enhance the aesthetics of these areas and begin to blend into the adjacent undisturbed vegetation.**

The dominance of native grass *Elymus glaucus* creates a taller profile than the understory in the adjacent community, resulting in a visual vegetation break between the revegetated area and the undisturbed adjacent forest. As trees and shrubs establish within the revegetation site, this disparate break will hopefully become reduced. Observations of the bike path project area in October 2009 revealed that some succession of natives may be already occurring. Some areas have quite a few *Pinus contorta* seedlings encroaching. In other areas where *Pteridium aquilinum* dominates the forest understory, this species is also moving into the revegetation swath. Hopefully, dominant trees in the adjacent forest, such as *P. contorta*, *Larix occidentalis*, and *Pseudotsuga menziesii*, will continue to establish over time in addition to dominant understory species *Xerophyllum tenax*, *Arctostaphylos uva-ursi* and *Vaccinium* species. *E. glaucus* is thought to function as a “nurse grass”, establishing quick cover while other slower-growing native species become established. Cover of *E. glaucus* then decreases over time as cover of later seral species increases. Future monitoring will document the change in *E. glaucus* over time, determine whether seeded species or adjacent native species continue to become established within the revegetation area, and document if the visual vegetation break between the existing forest and the replanted swath begins to diminish.

c. **To document changes in species composition and cover over time.**

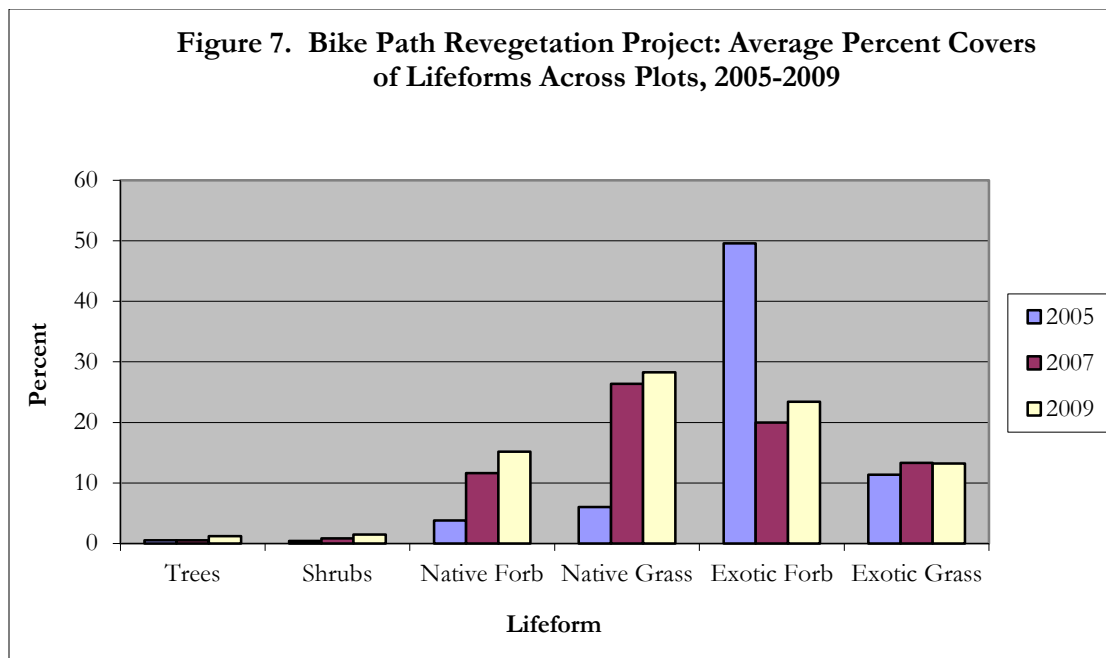
Results below describe percent covers of all species found in plots for all years.

d. **To photomonitor progress at each site.**

Photos of plots are located in Appendix B.

2. Results by Lifeform

Native grasses continued to be the dominant lifeform in 2009, exhibiting a small increase in the last two years of 2% (Figure 7 & Table 11). Average cover of all lifeforms has been relatively stable since 2007, with the largest change being a nearly 4% increase in the cover of native forbs. Exotic forb cover also increased by 3%, while average cover of exotic grasses has essentially stayed the same over the last two years. While tree and shrub covers continue to be less than 2%, both have increased slightly since 2007.



2a. Native Forbs

Total native forb cover across the five plots averaged 15.2% (Table 11), 3.6% higher than in 2007. Increases were mainly due to a fairly large increase (1-10%) in cover of *Achillea millefolium* which increased in all plots. *Anaphalis margaritacea* also increased in cover in two plots by 1-3%. While these species were both seeded on the project and are good colonizers, both are vulnerable to herbicide. In plot 2 that had been recently sprayed, *A. millefolium* had 16% cover but was shriveled and some was in the process of dying. Another seeded species, *Symphytotrichum laeve* var. *laeve*, has not been as affected by herbicide. This species had only trace cover in four of the five plots in 2007, but increased 1-2% in two plots while remaining the same in two plots. It is uncertain why this species has not been as impacted by herbicide in this project, as it has been negatively impacted by herbicide in other projects. Members of the Aster family, a target family for many herbicides, are often negatively impacted by herbicide application.

Other seeded species are showing sporadic success. *Penstemon confertus* has increased to 3% cover in one plot and remains in two plots with trace cover. Conversely, *Solidago canadensis* has disappeared from three plots this year and remained stable in the other two plots, despite being found in all plots in 2007 with trace cover. Additionally, *Chamerion angustifolium* disappeared from two plots and decreased from trace cover in one plot, while recruiting into another. *Xerophyllum tenax*, although seeded in the project, has never been observed within monitoring plots.

A few naturally regenerating native forb species were present with more than 1% cover in 2007. *Antennaria racemosa*, present with 1% cover in one plot, could prove to be a good ground cover once established. *Apocynum androsaemifolium*, a species that colonizes open spaces, had 1% cover in two plots but was affected by herbicide in at least one of these areas. *Equisetum arvense*, *Galium triflorum*, *Pteridium aquilinum*, *Senecio pseud aureus* and *Maianthemum stellatum* each were present with 1-2% cover in at least one plot. The most notable decline was found in *Cerastium arvense* which decreased from 5% to 1% in one plot and from 4% to 0% in another plot.

2b. Native Grasses

As in 2007, native grasses provided the highest cover of all lifeforms in 2009, averaging 28.3%. This is a small increase over 26.4% native grass cover in 2007 but remains much higher than 6% native grass cover in 2005. It appears that native grasses took advantage of open habitat left behind by the decline of *Trifolium agrarium* after 2005. Fortunately, exotic grasses did not colonize these areas as their cover remains relatively low.

Although *Elymus glaucus* remains the native grass with the highest cover, due primarily to a 50% increase in 2007, it began to decrease in certain areas of the project in 2009. While cover of *E. glaucus* increased in cover by 5-14% on two plots, cover of this grass species declined by 5-15% on three plots. As observed in other monitoring projects, this is a typical trend for this nurse grass to see a large increase in cover soon after seeding and then observe a gradual decline in cover until *E. glaucus* remains at 5-10% cover, on average, by year 5 to 10 after replanting. *Bromus carinatus*, another seeded nurse grass species, has also shown a decline in all plots, similar to other revegetation projects. It has totally disappeared from two plots; once in 2007 and once in 2009. In the other three plots, it has decreased to trace cover.

Sedges have consistent cover throughout the project, increasing in cover in several areas. Although no sedges occur in plot 1, all other plots have at least 1% cover of a sedge species. From 2007 to 2009, sedges have increased from 5% to 15% on plot 5, 0% to 7% on plot 3, and trace to 7% on plot 2. *Carex rossii* is the most common sedge species found, ranging from trace to 6% cover, although *Carex microptera* has the highest sedge cover at 12% in one plot. *Carex pachystachya* also contributed trace to 3% cover in two plots and *Carex geyeri* has 1% cover in one plot. A mix of unnamed sedge species was seeded in this project so it is unknown if these species originated from seed or are naturally regenerating. *Carex athrostachya*, the only seeded sedge species that was identified, has not been observed in the project, although there is 1% cover of unidentifiable sedge in plot 5.

Other seeded grass species have had mixed results. *Festuca idahoensis* has high cover on one plot at 9% but only has trace cover on two other plots and has disappeared from two additional plots that had trace cover in 2005. *Elymus trachycaulus* had been present in all plots, reaching 2% cover in one plot, but has slowly disappeared from all plots. Finally, *Festuca ovina* and *Pseudoroegneria spicata*, each present in only one plot, are maintaining their cover at trace to 1% in 2009.

Other native grass species present with greater than trace cover include *Danthonia intermedia* with 1% cover in one plot and *Poa palustris* with trace to 5% cover in three plots. The remaining native graminoids occurred by natural regeneration and were present in only trace amounts.

2c. Exotic Forbs

After a substantial decline in exotic forbs between 2005 and 2007, non-native forbs increased slightly in average cover in 2009 from 26% to 28%. This increase is due primarily to increases of *Melilotus officinalis*, *Veronica officinalis*, *Prunella vulgaris*, and *Hypericum perforatum*. Other dominant weeds include *Chrysanthemum leucanthemum* and *Veronica serpyllifolia* that have maintained 2% cover since 2007. It is important to note that weeds had been sprayed shortly prior to monitoring, so covers for some weed species may be even less than reported in results. Most *H. perforatum*, *Trifolium sp.* and some *C. leucanthemum* found in plots were killed from herbicide.

Trifolium species have steadily declined from 66% cover in 2005 to 18.5% cover in 2007 to 5.8% cover in 2009 (since the 2009 monitoring event was earlier in the season, many *Trifolium* species had not yet bloomed and were thus lumped into *Trifolium sp.* rather than identified to individual species). This decline of clover species has been observed on various other revegetation projects in the past. Clovers are good

colonizers and with little competition, clovers in the seed bank along the bike path likely took early advantage of the open space to establish. As other native species begin to grow, however, clover cover typically declines over time. It has also been observed that clover species are sensitive to precipitation levels, increasing under wetter years and decreasing in drier years. The last few years have been within a moderate drought supporting the decline of clovers in drier years. For all of these reasons, clovers can be ephemeral species and thus have not been considered long term threats to the success of native plant restoration projects. It should be noted, however, that in the first part of the bike path between the entrance road to the bone yard and the west entrance station, clover covers remain quite high. No plots were installed in this section but higher clover cover has been observed here. Similarly, *Melilotus officinalis* cover reached 25% in one plot this year. These areas should be closely monitored in the future to determine changes in clover cover.

Of greater concern is the continued increase of *Veronica officinalis*. This species is steadily increasing in all plots, ranging between 1% and 8% cover. While these covers do not compare with some of the peak covers of clover species, *V. officinalis* is an aggressive creeping species that is able to penetrate tree canopy and grow in the shade. *Prunella vulgaris* also appears to be increasing steadily. This species can produce a thick groundcover as well but may be less persistent.

2d. Exotic grasses

Exotic grass cover remained relatively stable since 2007, averaging 13% in 2009. Surprisingly, *Agrostis stolonifera*, a weedy grass species of high concern due to its aggressive, rhizomatous nature, actually decreased in several plots. Average cover is 7%, decreasing from 10.5% cover in 2007. *Pbleum pratense*, on the other hand, has increased in cover in several plots with an average cover of 5% in comparison to 2% in 2007. Only three other exotic grass species were found in monitoring plots. *Elymus repens* was found in two plots with approximately 1% cover. This is another aggressive rhizomatous species to watch. *Poa pratensis* and *Poa compressa* were each found in four plots with trace to 1% cover.

While exotic grasses appear to be stable and not increasing dramatically over time, this lifeform is traditionally the most problematic for revegetation projects and should be closely monitored.

2e. Shrubs

Shrub cover has increased since 2005 to 1.5% average cover. While most species are still only present with trace cover, a few shrubs have increased in cover. *Spiraea betulifolia*, a seeded species, was found with 1% cover in two plots, and *Symphoricarpos albus*, also seeded, had 2% cover in one plot. The only other shrub species with greater than 1% cover was *Rubus parviflorus* with 1% cover in one plot. Four other shrub species were found in the project with trace covers. Future monitoring will document if shrubs continue to increase, potentially adding to the vegetative structure along the bike path and outcompeting exotic species in this project.

2f. Trees

Tree cover has increased to over 1% average cover in the project, increasing from trace cover in 2005 and 2007. Most of this is due to regenerating *Populus balsamifera* seedlings which were found in all plots in 2009 with 1% cover in four of the five plots. While no other species had greater than trace cover in any plot, *Pinus contorta* seedlings have also recruited to three of the five plots this year. The establishment and potential increase of *P. contorta* is a positive step to blend with the adjacent forest and provide for structural change along the edges of the bike path. *Picea engelmannii* and *Populus tremuloides* also each maintained trace cover on one plot and were each found in one new plot this year. *Pseudotsuga menziesii* recruited to one new plot this year at the same time disappearing from three plots since 2005. New tree species recruiting to plots this year include *Betula sp.* and *Larix occidentalis*.

Table 11. Bike Path Revegetation Project: Ocular Canopy Cover of all Species by Plot, 2005-2009.

	Planted/ Seeded?	MD-05-01			MD-05-02***			MD-05-03			MD-05-04			MD-05-05		
		2005	2007	2009	2005	2007	2009	2005	2007	2009	2005	2007	2009	2005	2007	2009
GROUND COVER																
Bare soil		0	0	0	0	0	0	1	0	1	3	1	3	1	3	1
Gravel		1	1	0	0	0	0	45	45	0	T	T	1	0	0	0
Rock (>3cm)		1	0	0	T	0	0	4	4	0	0	0	1	0	0	0
Litter		96	96	93	97	97	94	33	32	66	88	94	68	64	62	88
Wood		0	1	1	0	0	0	5	5	8	2	1	2	3	2	2
Moss/lichen		0	T	1	1	T	3	10	10	20	5	1	20	30	30	5
Basal vegetation		2	3	5	2	3	3	2	3	5	2	3	5	2	3	4
Other		0	0	0	0		0	0	0	0	0	0	0	0	0	0
TREE		T	T	1	T	0	T	T	T+	1+	T	T	2	T	T+	1
<i>Betula sp.</i>													T			
<i>Larix occidentalis</i>													T			
<i>Picea engelmannii</i> seedlings			T	T									T			
<i>Pinus contorta</i> seedlings							T		T	T			T	T		
<i>Populus balsamifera</i>		T	T	1			T	T	T+	1	T		1		T+	1
<i>Populus tremuloides</i> seedlings									T	T			T			
<i>Pseudotsuga menziesii</i>					T					T	T	T		T		
SHRUB		0	1	1+	T	T+	2-	T	T+	T	1	1	3	0	1-	T
<i>Arctostaphylos uva-ursi</i>									T							
<i>Mahonia repens</i>										T						
<i>Rosa sp.</i>						T	T									
<i>Rosa woodsii</i>			T	T+												
<i>Rubus idaeus</i>						T	T	T	T				T			
<i>Rubus parviflorus</i>			T+	1	T	T	T									
<i>Salix bebbiana</i>			T+	T		T		T	T+		T	T	T		1-	T
<i>Salix sp.</i>																
<i>Spiraea betulifolia</i>	S				T	T	1				T	T	1			
<i>Symphoricarpos albus</i>	S						T				T	1	2			
NATIVE FORB		9	20	27	3	9	24	3	10	10	3	14	10	1	5	5-
<i>Achillea millefolium</i>	S	8	15	20	2	6	16**	2	3-	3	T	T	2	T	T	1
<i>Adenocaulon bicolor</i>												T				
<i>Anaphalis margaritacea</i>	S		1-	2	T	1	4	T	5	3+		3	3			
<i>Antennaria howellii</i>										T		T				
<i>Antennaria racemosa</i>													1			
<i>Antennaria sp.</i>									T							
<i>Apocynum androsaemifolium</i>			T+	1-	T	1	T*				2	5	1**			
<i>Campanula rotundifolia</i>								T	T+							
<i>Cerastium arvense</i>						T	T					5	1		4	
<i>Chamerion angustifolium</i>	S		T-			T		1	1-	T						T
<i>Collinsia parviflora</i>								T	T							
<i>Epilobium halleianum</i>								T						T	T	
<i>Equisetum arvense</i>													T	T		2
<i>Fragaria vesca</i>													T			
<i>Fragaria virginiana</i>											T		T		T	T
<i>Galium triflorum</i>		T	T		T	T+	2					T			T	T
<i>Hieracium albiflorum</i>								T	T							
<i>Hieracium sp.</i>							T				T	T	1**		T	T
<i>Hieracium umbellatum</i>								T	T							
<i>Microsteris gracilis</i>									T							
<i>Osmorhiza berteroi</i>			T	T		T			T	T		T	T		T	T
<i>Penstemon confertus</i>	S		T	T			T	T	1	3						
<i>Potentilla pensylvanica</i>								T								
<i>Pteridium aquilinum</i>			2	1												
<i>Ranunc.</i>												T				
<i>Ranunculus uncinatus</i>														T		
<i>Senecio pseudodureus</i>													T	T	T	1-
<i>Smilacina stellata</i>			T	T+	T	T	1-				T		T		T	1-
<i>Solidago canadensis</i>	S	T	T+	T+		T			T		T	T			T	T
<i>Symphotrichum laeve</i> var. <i>laeve</i>	S	T	T	2	T	T	1					T	T	T	T	
<i>Xerophyllum tenax</i>	S															

Table 11 con'd. Bike Path Revegetation Project: Ocular Canopy Cover of all Species by Plot, 2005-2009.

NATIVE GRAMINOIDS		3	30	21	4	25	20+	19	30	50	1	9	18	3	38	32
<i>Agrostis scabra</i>			T	1	T	T		T	T+	T+						
<i>Bromus carinatus</i>	S	T	3-	T	1	4		7	8	T	T	1	T	T		
<i>Carex athrostachya</i>	S															
<i>Carex concinnoides?</i>							T									
<i>Carex cranfordii</i>																
<i>Carex geyeri</i>										1						
<i>Carex microptera</i>						T	1+						1	T		12
<i>Carex pachystachya</i>										T					5	3
<i>Carex rossii</i>							3	T		6	T		T		T	T
<i>Carex sp.</i>	S		T		T	T			T+			T		T	T	1
<i>Danthonia intermedia</i>					T	T+	1	T								
<i>Elymus glaucus</i>	S	2	30	20	2	20	15	8	18	32	T	7	12	1	30	15
<i>Elymus trachycaulus v. trachycaulus</i>	S	T+			T+	T		T+	1		T			1	2	
<i>Festuca idahoensis</i>	S	T	T	T	T	T	T	2	2+	9	T			T		
<i>Festuca ovina</i>	S								T	T						
<i>Grass sp.</i>														T		
<i>Juncus ensifolius</i>															T	T
<i>Poa palustris</i>										T	T	1	5-	T	T	1
<i>Pseudoroegneria spicata</i>	S							T		1						
<i>Trisetum canescens</i>					T	T									T	
EXOTIC FORB		83	41	47	85	24	6	18	12	25	100	19	19	39	4	20
<i>Cerastium fontanum</i>											T			T		
<i>Chrysanthemum leucanthemum</i>		T	T	T					T	3	2	5	4**	1	3	1
<i>Cirsium arvense</i>				T							T	T	T			
<i>Cirsium vulgare</i>		T			T	T	T* (dead)							T		
<i>Filago arvensis</i>								T								
<i>Hypericum perforatum</i>								T	2-	4*						
<i>Medicago lupulina</i>		1			T	T		2	3		T			T	T+	
<i>Melilotus alba</i>		T	T													
<i>Melilotus officinalis</i>		T		25										T		
<i>Plantago lanceolata</i>			T	T		T				T				T		
<i>Plantago major</i>		T	T	T							T		2	2	1	T
<i>Prunella vulgaris</i>		T	T	1+				T	T	4	T	3	5	1	5	9
<i>Taraxacum officinale</i>			T	1							T	T	T	T		
<i>Trifolium agrarium</i>		80	40	12	80	20		7	2		70	3		2	16	
<i>Trifolium hybridum</i>		1	T	6	5	2		1	T		50	2		25	6	
<i>Trifolium pratense</i>				T							1			2	T	
<i>Trifolium repens</i>								4			T			2		
<i>Trifolium sp.</i>							4*			6*			T			
<i>Verbascum thapsus</i>					T	T		2	T							
<i>Veronica officinalis</i>			T	1+	T+	1+	2	T	5	8	T	5	5			5
<i>Veronica serpyllifolia ssp. serpyllifolia</i>					T			T			T	1	3	3	1	5
EXOTIC GRASS		1	2	2	1	19	10	T+	1+	3	9	25	29	45	19	22
<i>Agrostis stolonifera</i>		1	1	1	1	15	7	T+	1+	2	8	20	16	25	15	9
<i>Elymus repens</i>			1-	T+												1
<i>Lolium multiflorum</i>					T											
<i>Phleum pratense</i>		T			T	T+	1				1	5	12	20	4	12
<i>Poa compressa</i>			T	T			T	T		1						T
<i>Poa pratensis</i>			T	T	T	3	1						1			T
<i>unknown grass</i>							1									

*** 2009: Plot heavily sprayed recently

* sprayed: all or mostly dead

** sprayed: some dead

D. CONCLUSIONS AND RECOMMENDATIONS

Average overall lifeform composition has remained relatively stable in this project since 2007. Native grasses continue to dominate the project with 28% average cover, increasing slightly from 26% cover in 2007. *Elymus glaucus*, hydroseeded on this project, continues to be the dominant species with an average of 19% cover, a slight decrease from 21% cover in 2007. This species is often considered a nurse grass, growing quickly while other slower growing but more persistent native species establish. In this project, *E. glaucus*

appears to be fulfilling this role so far. It took advantage of open habitat with the dramatic decline of *Trifolium* species after 2005 and has been maintaining its cover since then. It will be interesting to document whether the slight decrease in cover of this species is the beginning of a trend of decline and whether native species can capitalize on any vegetation openings and outcompete exotic species. *Bromus carinatus*, also hydroseeded and another nurse grass, also declined slightly this year, although its cover was never very high. Its average cover was only 0.3% this year, after reaching 3% cover in 2007.

The challenge will be for native species, rather than weed species, to fill empty niches. Exotic forbs, although they are being very actively targeted by herbicide application, still outnumber native forbs 23% to 15%. Additionally, exotic grasses are averaging 13% cover. While this cover has been relatively stable over the last two years, this lifeform tends to be the most threatening to revegetation projects. Rhizomatous species such as *Agrostis stolonifera*, the exotic grass species with the highest cover in this project (7%), can especially take over. Additionally, many of the most successful native forb species that may take advantage of open niches, such as *Achillea millefolium* and *Anaphalis margaritacea*, are also being affected by herbicide. Other exotic forbs may also be troublesome. Most notable is *Veronica officinalis*, a creeping forb that is perhaps the only species in the park that is capable of expanding under the forest canopy (Lesica, 2002). This plant is a member of the *Scrophulariaceae* family which tend to be resistant to herbicides utilized. Assuming that nurse grasses decline, some of the native species that are best poised to fill these open niches are *Carex* species and forbs from non-aster families, such as *P. confertus*.

This project should be monitored again in 2014, ten years after revegetation. At this time, trends of nurse grasses, exotic grasses and herbicide resistant native forbs should become clearer.

IV. 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 automated 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 12 for seed prescription). Additionally, the disturbed road corridor south of the planting site was mechanically hydroseeded.

B. METHODS

Two salvage monitoring plots were installed on October 29, 2008 and two hydroseed monitoring plots were installed on September 21, 2009 (Figure 8). 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 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 to document progress of hydroseeding throughout the project (Table 13).

On September 15, 2009, the two salvage monitoring plots were read and on September 21, 2009, the two hydroseed plots were established and read. Ocular covers of all species in the plots were recorded (Table 14). In the salvage plots, special note was taken to determine if the material was salvaged or naturally occurring to assess the success of each. *Vaccinium myrtilloides* in the salvage plots were assessed for health and height and width were measured. Photomonitoring took place on September 15, 2009.

Table 12: West Entrance Station: Seed Prescription, Fall 2008. (Approx. 3 acre)

<u>Forbs/Shrubs:</u>	<u>Collection #:</u>	<u>Grams of seed:</u>	<u>Seeds/ft²:</u>
<i>Achillea millefolium</i>	03-110	11.2 g	
	02-135	10.6 g	3 seed/ ft²
<i>Aquilegia flavescens</i>	98-175	30.30 g	0.16 seed/ ft².
<i>Anaphalis margaritacea</i>	05-136	30.55 g	
	9087364	0.5 g	4 seed/ ft²
<i>Antennaria</i> sp.	9087370	14 g	1.5 seed/ ft²
<i>Arnica cordifolia</i>	05-022	4.9 g	
	07-003	40 g	0.16 seed/ ft²
<i>Aster laevis</i>	03-118	1 g	
	02-512	86.46 g	2.1 seed/ ft²
<i>Symphotrichum laeve</i>	9081447	70 g	1.63 seed/ ft²
<i>Aster</i> sp.	9087432	5 g	0.11 seed/ ft²
<i>Campanula rotundifolia</i>	04-189	0.35 g	0.06 seed/ ft²
<i>Eurybia conspicua</i>	9087433	300 g	6.9 seed/ ft²
<i>Geum macrophyllum</i>	9087654	600 g	7.7 seed/ ft²
<i>Heracleum maximum</i>	95-205	23.7 g	0.02 - old seed
<i>Illiamna rivularis</i>	06-089	600 g	1.3 seed/ ft²
<i>Penstemon confertus</i>	06-090	21.66 g	0.97 seed/ ft²
<i>Potentilla gracilis</i>	03-091	107 g	3 seed/ ft²
<i>Rubus parviflorus</i>	07-041	23.48 g	
	06-038	25 g	17 seed/ ft²
<i>Solidago canadensis</i>	04-192	14 g	
	03-090	88 g	10.5 seed/ ft²
<i>Spiraea betulifolia</i>	9082154	5 g	0.10 seed/ ft²
<i>Xerophyllum tenax</i>	03-029	269 g	0.98 seed/ ft²
<u>Graminoids:</u>			
<i>Bromus carinatus</i>	9087805	655 g	1.3 seed/ ft²
<i>Bromus marginatus</i>	9054510	49 g	0.10 seed/ ft²
<i>Bromus vulgaris</i>	07-017	314 g	0.58 seed/ ft²
<i>Calamagrostis rubescens</i>	00-022	400 g	
	00-021	550 g	42.4 seed/ ft²
<i>Carex athrostachya</i>	04-297	368 g	
	9081443	704 g	40.27 seed/ft²
<i>Carex deweyana</i>	05-074	17 g	
	02-513	44 g	0.10 seed/ ft²
<i>Carex douglasii/ deweyana</i>	9078646	122 g	
	01-523	33 g	0.30 seed/ ft²
<i>Carex pachystachya</i>	03-513	291 g	
	66-869 (2000)	200 g	
	9078645	1360 g	25.75 seed/ ft²
<i>Elymus glaucus</i>	06-053	156.41 g	0.35 seed/ ft²

Figure 8: West Entrance Station: Location of Revegetation Monitoring Plots.

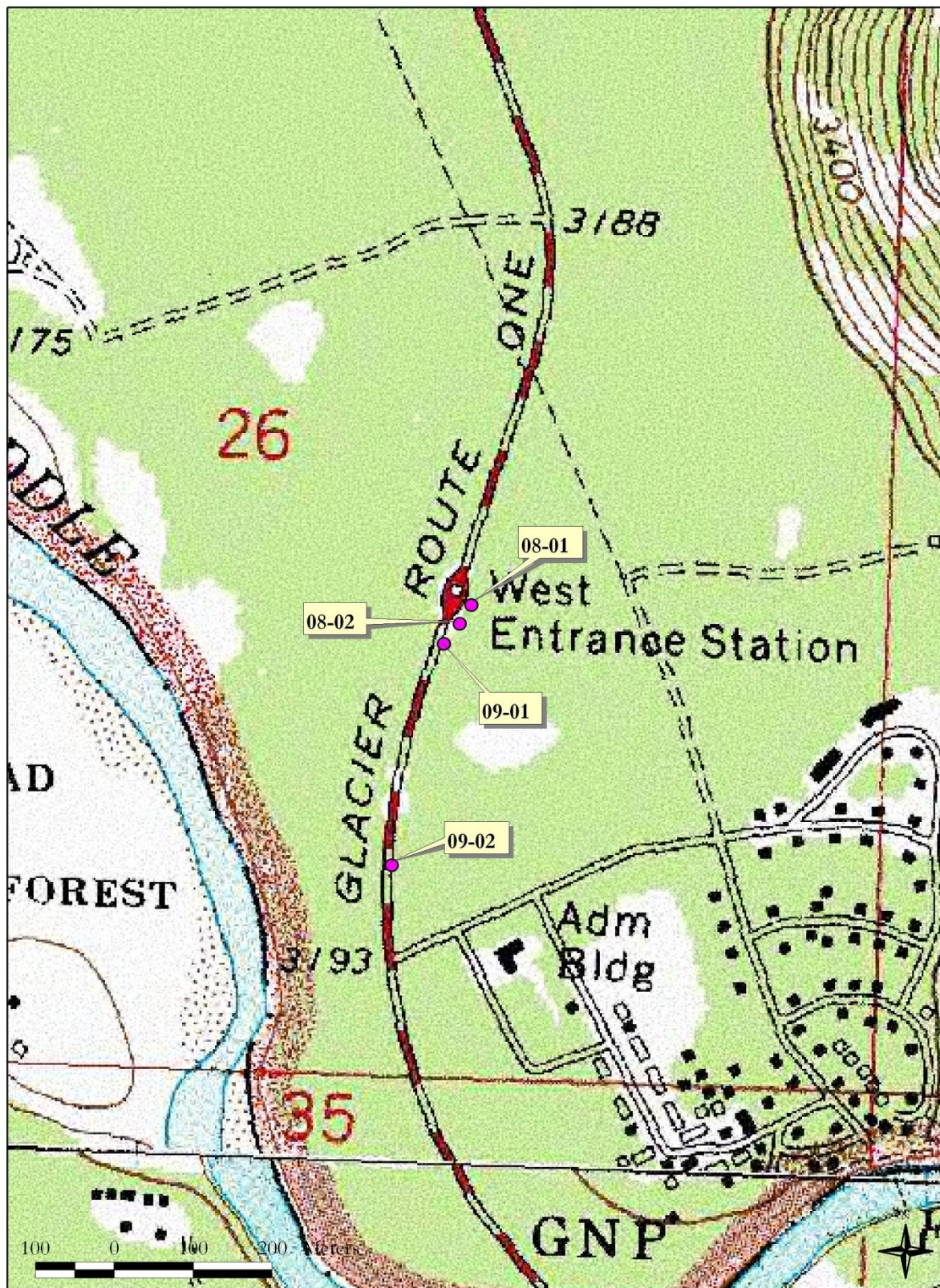


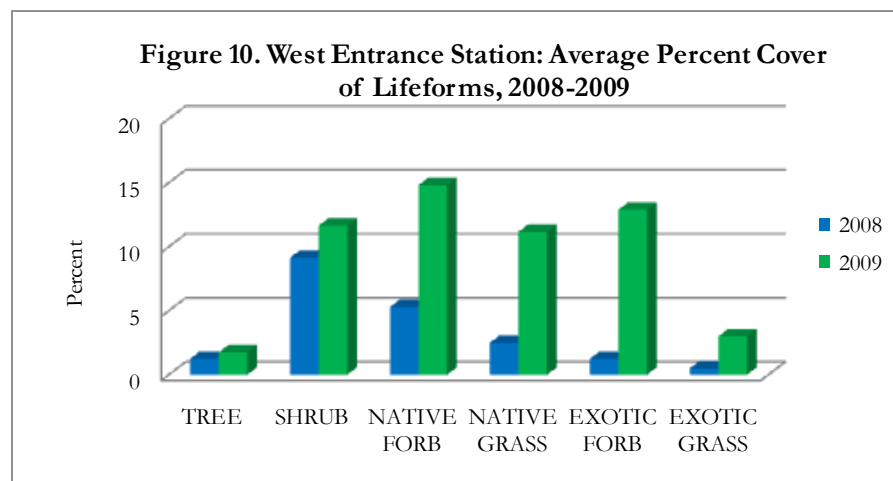
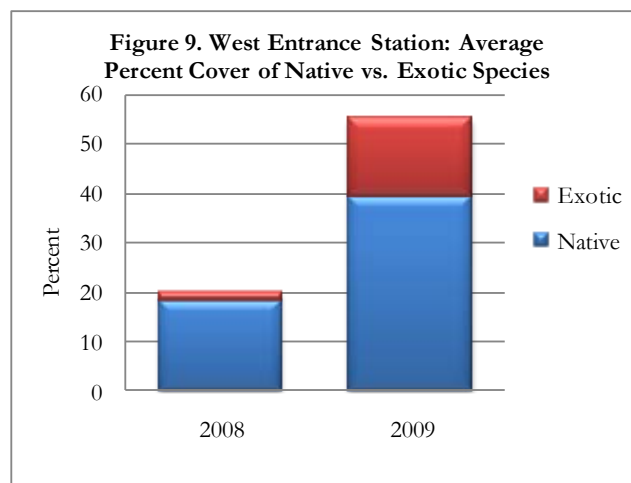
Table 13. West Entrance Station: Photomonitoring Sites.

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

C. RESULTS

1. Salvage Plots

Overall ground cover has more than doubled in salvage plots over the last year, increasing from 20% to 55%. Both native and exotic species have increased but there was a larger increase in native species, many of which were seeded in 2008 (Figure 9). Average cover of native species increased from 18% to 39%, while cover of exotic species rose from 2% to 16%. All lifeforms increased in cover since last year, but forbs and grasses contributed the most to the increase in native vegetation (Figure 10).



1a. Native Grasses

Native grasses increased dramatically (Figure 10 and Table 14). Of the seeded grasses, *Bromus carinatus* is showing the most success, providing 7% cover in plot 1 and just over 1% cover in plot 2. Sedges, both seeded and salvaged, also provided notable cover. Seeded *Carex* species added 3% cover in plot 1 and trace cover in plot 2. Seeded *Calamagrostis rubescens* is establishing as well with 1% cover in both plots. Given the fact that this grass species does not like competition and can have very low germination, 1% cover should be considered fairly successful establishment. *Elymus glaucus* is slowly establishing with trace cover in both plots, while salvaged *Festuca occidentalis* has over 1% cover in plot 1.

1b. Native Forbs

A few native forbs have contributed substantially to the overall increase in native cover (Figure 10 and Table 14), especially *Achillea millefolium*. Seeded *A. millefolium* reached over 4% cover in plot 1, while salvaged *A. millefolium* remained at trace cover in both plots. The other seeded native forb that fared well this year was *Solidago canadensis*, contributing 2% cover to plot 1. Regenerating *Fragaria virginiana*, which was not present in 2008, contributed over 2% cover in plot 1 in 2009. Salvaged *Linnaea borealis* increased from 2% to 3% in plot 1. *Xerophyllum tenax* has not thrived after being salvaged, decreasing slightly in both plots from 1% to trace cover. It was noted that due to the slope of the road shoulder near plot 2, much of the seeded material from this area has migrated to the ditch below the plot. Additionally, plot 2 appeared drier than plot 1 and more of the plant material was dried up, dead or dying in this plot.

1c. Shrubs and Trees

Shrubs have fared well in the last year (Figure 10 and Table 14), mostly due to the success of a few species. Salvaged *Spiraea betulifolia* has thrived, rising from trace cover in both plots to over 2% in plot 1 and nearly 4% in plot 2. *Symphoricarpos albus*, also salvaged, has increased from trace to 2% cover in plot 2. Unfortunately, *Vaccinium myrtilloides*, the Montana Species of Concern specifically targeted for salvage, declined slightly since last year in both plots. In both plots it decreased from 2% to 1% cover. Shrubs of this species were much healthier in plot 1, however, and none died in this plot (Table 15). In plot 2, four shrubs presumably died and one was missing. Tree cover in salvaged plots has not changed dramatically since last year (Figure 10).

1d. Exotic Species

Most of the increase in exotic cover is due to a few species (Figure 10 and Table 14). Many new exotic species established in plots since 2008, but so far have only have trace covers. Seventeen new exotic forb species established in plot 1 while 10 new exotic species were found in plot 2 since 2008. *Medicago lupulina*, not present in 2008, increased to 6% cover in plot 1 in 2009, the highest cover of any species in salvage plots. Similarly, *Trifolium* spp. increased from 0% to 5% cover this year. This species can dominate early revegetation projects, but usually does not persist with high covers. The only other exotic forb species found with over trace cover this year was *Plantago major* with just over 1% cover in plot 1. Only four species of exotic grasses were observed in salvage plots in 2009. All had trace cover with the exception of *Elymus repens*, which had just over 3% cover in plot 2 and just over 1% cover in plot 1. This rhizomatous grass can be aggressive and should be monitored closely in the future.

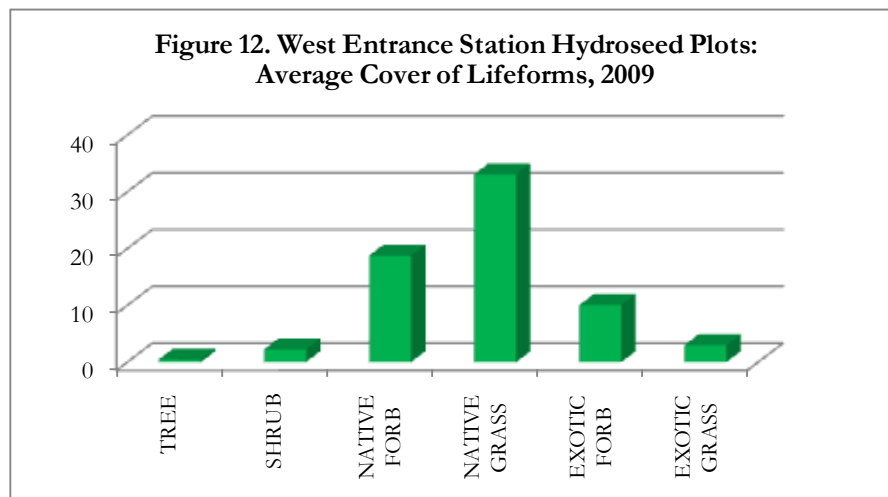
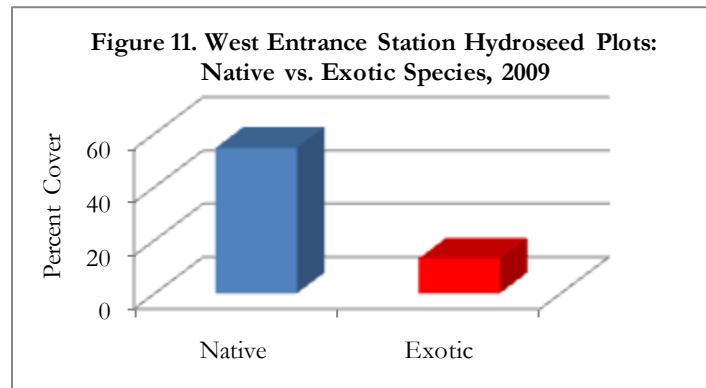
2. Hydroseeded Plots

Native vegetation cover was over four times higher than exotic species in hydroseeded plots by 2009, one year after seeding (55% vs. 13%, Figure 11). Native grasses and native forbs were the largest contributors to cover with 33% native grass cover and 19% native forb cover. In contrast, exotic forbs accounted for 10% cover and exotic grasses had 3% cover (Figure 12).

2a. Native Grasses

Native grass currently dominates the hydroseed plots with the highest cover of any lifeform (Figure 12). Several seeded native grass species are showing success in the hydroseeded plots (Table 16). *Bromus carinatus* had 14% cover in plot 1 and 7% cover in plot 2. Surprisingly, *Calamagrostis rubescens* also provided

good initial cover at 3% and 8% in plots 1 and 2. As stated above, this grass species has had very low germination in other revegetation projects. *Carex* species have established 6% cover in plot 1 while *Elymus glaucus* reached over 3% in plot 2. *Festuca idahoensis* established in plot 2 with 1% cover.



2b. Native Forbs

Native forbs had the second highest cover of any lifeform on the project (Figure 12). Of the sixteen native forb species that were hydroseeded in the project, eight were found in monitoring plots (Table 16). Of these, *Achillea millefolium* and *Geum macrophyllum* were the most successful. *A. millefolium* had 8% cover in plot 1, while it only had trace cover in plot 2. *G. macrophyllum* was found with 6% cover in both plots. Only three other species had reached more than trace cover in either plot; *Anaphalis margaritacea* and *Solidago canadensis*, both seeded species, and regenerating *Chamerion angustifolium* were all found with 1% cover in plot 1. Ten other species were regenerating in monitoring plots.

2c. Shrubs and Trees

Both seeded shrub species germinated within the project; *Spiraea betulifolia* had trace cover in both plots and *Rubus parviflorus* was only found in one plot with trace cover. Four other shrub species established in at least one plot; all with trace covers. Tree contribution was negligible at this time with only small, unidentifiable conifer seedlings found with trace cover in both plots.

2d. Exotic Species

Plot 2 had higher cover of exotic species than plot 1. *Medicago lupulina*, *Melilotus sp.*, *Verbascum thapsus* and *Phleum pratense* each had 3% cover in this plot. *Dactylis glomerata* also had 1% cover. In addition, ten other

non-native forbs and three exotic grasses recruited into plot 2 with trace cover. Species to watch include several noxious weeds, including *Hypericum perforatum* and *Chrysanthemum leucanthemum*, as well as *Veronica officinalis*, a non-noxious creeping weed that can be very aggressive. All currently only have trace cover. Weedy grasses also tend to be difficult to control. *Bromus inermis*, currently with only trace cover, could be the most potentially damaging.

In plot 1, *V. thapsus* had 3% cover, the only exotic species with more than 1% cover. Six exotic forbs and one exotic grass species recruited into this plot. No noxious weeds were found in this plot. The species of most concern in this plot is *Bromus tectorum*, which can be very aggressive in open habitats. It was pulled from this plot in 2009. It is uncertain why plot 1 has fewer weeds than plot 2.

D. CONCLUSIONS AND RECOMMENDATIONS

1. Salvage Plots

Pre-construction salvage of native plant material is continuing to be assessed by the Native Plant Restoration Program at Glacier National Park. Most projects where plant salvage has been utilized in the montane zone have only been monitored for a few years so far so long term success is yet to be determined. In plots at the West Entrance Station where this technique was employed, salvaged plant material seems to be relatively stable one year after transplanting, and in some cases, has increased in cover. Certain species are thriving after being relocated, particularly *Spiraea betulifolia*, *Symphoricarpos albus* and *Linnaea borealis*. Other species have not shown as much vigor. Salvaged *Vaccinium myrtilloides* and *Xerophyllum tenax* have decreased in cover in the last year in this project. However, many of the species salvaged are difficult or impossible to grow in a nursery setting and this method may be the only way to establish or maintain these species. Additionally, many plant species require mycorrhizal relationships with soil fungi, which can best be supplied by salvaging plant material with its associated soil. It remains to be seen how well certain species survive transplanting over time.

In general, salvage plots at the West Entrance Station are faring very well. In addition, supplemental seeding has helped establish vegetative ground cover, which has increased more than two times over last year. Seeded grasses have shown some of the best early germination in this project, especially *Bromus carinatus*, *Carex* species and *Calamagrostis rubescens*. It will be interesting to monitor the success of these species over time, but these grasses are providing good initial ground cover. Several other seeded species have germinated in the project, most with trace cover that will hopefully increase over time. *Achillea millefolium* and *Solidago canadensis* have shown the best early establishment. Exotic species have not invaded dramatically in this area. Some of the clover species, such as *Trifolium* sp. and *Medicago lupulina*, have established with relatively high covers. More concerning species are weedy grasses, especially *Elymus repens*, and creeping aggressive exotic forbs like *Veronica officinalis*. Only one noxious weed was found, *Leucanthemum vulgare*. Regular herbicide spraying should keep this species under control, but unfortunately it will likely be at the expense of some of the more successful seeded forbs such as *A. millefolium* and *S. canadensis*.

2. Hydroseeded Plots

Hydroseeded plots have more than 10% higher vegetative cover one year after seeding than salvage plots with supplemental hand seeding. Native grasses account for most of the success in hydroseeded plots. *Bromus carinatus* has the highest cover, but *C. rubescens*, *Elymus glaucus* and *Carex* species also exhibited good early establishment. In particular, *C. rubescens* is showing greater success from seed than on other revegetation projects and should be monitored to track its future success. Several seeded forbs are also showing good early establishment, including *A. millefolium*, *S. canadensis* and *Geum macrophyllum*. Weed coverage is relatively low one year after planting, currently four times less than native cover. *Trifolium* sp. and *M. lupulina* are again the largest contributors to weed cover. *Verbascum thapsus* also had relatively high cover, which may need to be hand pulled. Few weedy grass species have established after year one.

Monitoring plots should be read again in 2010, 2011, 2013, and 2018 for data at 2, 3, 5, and 10 years after replanting and hydroseeding.

Table 14. West Entrance Station Salvage Plots: Canopy Cover (%) of Species by Plot, 2008-2009.

GROUND COVER	Source	MD-08-01		MD-08-02	
		2008	2009	2008	2009
Basal vegetation		3	5	2	4
Litter/Duff (this included lots of pine/larch needles this event)		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
Species		2008	2009	2008	2009
TOTAL TREE			1-		T
<i>Abies lasiocarpa</i>	?	T	T		
<i>Betula papyrifera</i>	salvage (in mat)	T			
<i>Picea engelmannii</i>	salvage	1 (1 TREE)	T+		
<i>Pinus monticola</i>	salvage	T (1 TREE)	T-		
<i>Populus balsamifera</i>	natural	T	T	hanging over	
<i>Pseudotsuga menziesii</i>	natural	T (hanging over)		hanging over	T
unknown conifer seedlings			T		T
TOTAL SHRUB			12		
<i>Arctostaphylos uva-ursi</i>	salvage	2-	2-	T	T+
<i>Alnus viridis</i>	?		T+		
<i>Amelanchier alnifolia</i>	salvage	1-	T	T	T
<i>Mahonia repens</i>	salvage	T	T	T	T
<i>Paxistima myrsinites</i>	salvage	T	T	T	
<i>Rubus parviflorus</i>	seeded		T (1 plant)		T
<i>Rosa acicularis</i>	salvage	T			
<i>Rosa woodsii</i>	salvage	1-	1	T	2-
<i>Spiraea betulifolia</i>	salvage	1-	2+	T	4-
<i>Symphoricarpos albus</i>	salvage	1-	1+	T	2-
<i>Vaccinium caespitosum</i>	salvage	T+	T	T	T
<i>Vaccinium membranaceum</i>	salvage	1-	1-	T	T
<i>Vaccinium myrtilloides</i>	salvage	2	1+	2-	1+
<i>Vaccinium myrtilloides</i>	natural			T	
<i>Vaccinium scoparium</i>	natural	T+	T+	T	T
Unknown				T	
Vaccinium myrtilloides # of plants	salvage	10	10	24	20
TOTAL NATIVE FORB	Source				
<i>Achillea millefolium</i>	salvage	T	T	T	T+
<i>Achillea millefolium</i>	seeded		4+		T+
<i>Anaphalis margaritacea</i>	seeded		T		T
<i>Antennaria bonellii</i>	seeded		T		
<i>Arenaria serpyllifolia</i>	regen		T		T
<i>Chamerion angustifolium</i>	regen		T		
<i>Chimaphila umbellata</i>	salvage	T	T	T	dead
<i>Clintonia uniflora</i>	regen				T
<i>Epilobium brachycarpum</i>	regen		T		T
<i>Fragaria vesca</i>	salvage	1-	1+	T	1-
<i>Fragaria virginiana</i>	regen		2+		T
<i>Galium triflorum</i>	regen				T
<i>Geum macrophyllum</i>	seeded		1		T
GEUPAL	regen		T		
<i>Gnaphalium macounii</i>	salvage	T			
<i>Linnæa borealis</i>	salvage	2-	3-	1	1-
<i>Maianthemum stellatum</i>	regen		T		T
<i>Solidago canadensis</i>	seeded		2		
<i>Symphotrichum leave (Aster laevis)</i>	seeded		T		
<i>Vicia americana</i>	regen		T		T
<i>Viola orbiculata</i>	salvage			T	T-
<i>Xerophyllum tenax</i>	salvage	1	T+ (some dying)	1	T
<i>Xerophyllum tenax</i>	natural	1	1	T	T

* *Vaccinium myrtilloides* tags: # 1-10 were used in plot 1, #11-34 in plot 2

Table 14, con't. West Entrance Station Salvage Plots: Canopy Cover of Species (%) by Plot, 2008-2009.

		MD-08-01		MD-08-02	
Species		2008	2009	2008	2009
TOTAL NATIVE GRASS					
<i>Bromus carinatus</i>	seeded		7		1+
<i>Calamagrostis rubescens</i>	seeded	T	1	T	1
<i>Calamagrostis rubescens</i>	salvage		2-		
<i>Carex concinnoides</i>	salvage	T	1-	T	T
<i>Carex</i> sp.	seeded		3		T
<i>Danthonia intermedia</i>	regen		T		T
<i>Elymus glaucus</i>	seeded		T		T
<i>Festuca occidentalis</i>	salvage	T	1+	T	T
<i>Oryzopsis asperifolia</i>	salvage	T	T	T	T
Grass spp. (unknown)	?	T	T+	T	
TOTAL EXOTIC FORB					
<i>Amaranthus retroflexus</i>				T	T
<i>Cirsium vulgare</i>			T		T
<i>Filago arvensis</i>			T-		T
<i>Leucanthemum vulgare</i>			1-		T
<i>Lactuca serriola</i>			T		
<i>Madia glomerata</i>			T		
<i>Medicago lupulina</i>			6		T+
<i>Melilotus</i> sp.			T		
<i>Plantago major</i>			1+		T
<i>Potentilla argentea</i>			T	T	T
<i>Potentilla norvegica</i>		T			
<i>Prunella vulgaris</i>			T		
<i>Taraxacum officinale</i>			T		
<i>Trifolium pratense</i>			T		
<i>Trifolium</i> sp.					5
<i>Verbascum thapsus</i>					T
<i>Veronica officinalis</i>			T	T (pulled)	T
<i>Veronica peregrina</i>			T		T
Unknown Mustard		T (pulled)	T		T
Unknown			T		T
TOTAL EXOTIC GRASS					
<i>Dactylis glomerata</i>		T			T
<i>Elymus repens</i>		T	1+		3+
<i>Phleum pratense</i>			T+		
<i>Poa compressa</i>			T-		

* Due to the late start date for this project, plots were read in late October. Some shrubs have lost all leaves, so it is possible that some species were missed.

* In 2008, there was also a large amount of larch needles in the plots, accounting for much of the litter.

Table 15. West Entrance Station: Health, Heights and Widths of *Vaccinium myrtilloides* in Salvage Plots, 2009.

Plot# MD-08-01			
Tag #	Health	Height	Width
1	5	30	33
2	4	38	42
3	5	28	20
4	5	34	30
5	5	20	30
6	5	19	23
7	4	37	34
8	3	17	35
9	4	30	22
10	5	34	30

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

*Health: 1=dead, 2=missing, 3=almost dead, 4=fair, 5=good

*1=dead was assigned when plants appeared desiccated and no leaves were attached. It is possible that plants were still alive, but seasonally lost leaves

*3=almost dead was assigned when leaves were dried up but still attached to plant, which did not appear healthy. It is also possible that this is also a seasonal change.

Table 16. West Entrance Station Hydroseed Plots: Canopy Cover (%) of Species by Plot, 2009.

GROUND COVER	Source	MD-09-01		MD-09-02	
		Canopy cover	Estimated Density	Canopy cover	Estimated Density
Basal vegetation		5		6	
Litter/Duff (this included lots of pine/larch needles this event)		49		60	
Moss		0		1	
Bare Soil		20		10	
Gravel		25		20	
Rock		1		1	
Wood		0		2	
Other		0		0	
Species					
TREE					
<i>Unknown conifer seedlings</i>	regen	T		T	
SHRUB					
<i>Alnus viridis</i>	regen	T		T	
<i>Betula papyrifera</i>	regen			T	
<i>Rosa acicularis</i>	regen			T	
<i>Rubus parviflorus</i>	seeded	T	1		
<i>Spirea betulifolia</i>	seeded	T	1	T	1
<i>Symphoricarpos albus</i>	regen	T		T	
NATIVE FORB					
<i>Achillea millefolium</i>	seeded	8	3	1-	1
<i>Aquilegia flavescens</i>	seeded				
<i>Anaphalis margaritacea</i>	seeded	1	1	T	1
<i>Antennaria bonellii</i>	seeded	T	1	T	1
<i>Aralia nudicanlis</i>	regen			T	
<i>Arnica cordifolia</i>	seeded				
<i>Campanula rotundifolia</i>	seeded				
<i>Chamerion angustifolium</i>	regen	1+	2	T	
<i>Cerastium arvense</i>	regen			T	
<i>Eurybia conspicua (Aster conspicuus)</i>	seeded				
<i>Epilobium brachycarpum</i>	regen	T	1	T	
<i>Equisetum arvense</i>	regen			1	2
<i>Fragaria vesca</i>	regen	T	1		
<i>Fragaria virginiana</i>	regen	T	1	T	
<i>Geum macrophyllum</i>	seeded	6	3	6+	3
<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	1	T	1
<i>Potentilla gracilis</i>	seeded	T	1	T	1
<i>Rubus parviflorus</i>	seeded				
<i>Solidago canadensis</i>	seeded	1	1	T	1
<i>Symphotrichum leave (Aster laevis)</i>	seeded	T	1	1+	2
<i>Viola orbiculata</i>	regen	T	1	T	
<i>Xerophyllum tenax</i>	seeded				
<i>Xerophyllum tenax</i>	salvage				
<i>Xerophyllum tenax</i>	natural/regen	T	1	T	

Table 16, con't. West Entrance Station Hydroseed Plots: Canopy Cover of Species (%) by Plot, 2009.

		MD-09-01		MD-09-02	
NATIVE GRASS		Canopy cover	Estimated Density	Canopy cover	Estimated Density
<i>Agrostis scabra</i>	regen			T	1
<i>Bromus carinatus</i>	seeded	14	2	7	2
<i>Bromus marginatus</i>	seeded				
<i>Bromus vulgaris</i>	seeded				
<i>Calamagrostis rubescens</i>	seeded	3	3	8	3
<i>Carex athrostachya</i>	seeded				
<i>Carex deneyana/ douglassii</i>	seeded				
<i>Carex pachystachya</i>	seeded				
<i>Carex sp.</i>	seeded	6	2	1-	2
<i>Danthonia intermedia?</i>	regen			T	1
<i>Festuca idahoensis</i>	regen			1	1
<i>Elymus glaucus</i>	seeded	3+	2	1-	1
<i>Poa palustris</i>	regen	T+	1		
<i>Pseudoroegneria spicata</i>	regen			T	1
EXOTIC FORB					
<i>Artemisia absinthium</i>	regen	T			
<i>Capsella bursa-pastoris</i>	regen	T		T	
<i>Hypericum perforatum</i>	regen			T	
<i>Filago arvensis</i>	regen	T			
<i>Lactuca serriola</i>	regen	T			
<i>Leucanthemum vulgare</i>	regen			T	
<i>Medicago lupulina</i>	regen	T		3	
<i>Melilotus sp.</i>	regen			3	
<i>Plantago lanceolata</i>	regen			T	
<i>Plantago major</i>	regen			1-	
<i>Taraxacum officinale</i>	regen			T	
<i>Trifolium sp.</i>	regen	T		T	
<i>Verbascum thapsus</i>	regen	3-		3	
<i>Veronica officinalis</i>	regen			T	
<i>Veronica serpyllifolia</i>	regen			T	
unknown	regen			T	
EXOTIC GRASS					
<i>Bromus inermis?</i>	regen			T	
<i>Bromus tectorum</i>	regen	T (pulled)			
<i>Dactylis glomerata</i>	regen			1	
<i>Phleum pratense</i>	regen			3	
<i>Poa compressa</i>	regen			T	
unknown	?			T	

V. LAKE MCDONALD DORMS: SITE ANALYSIS

A. BACKGROUND AND PURPOSE

In the fall of 2008, construction started on a new Lake McDonald Lodge dorm called the Lewis Dorm that was built for GPI employees. The dorm is located south of the general store and east of the Lake McDonald post office and Jammer Joe's in what was once a forested area southwest of the northern-most entrance road to the Lodge (Figure 13). The dorm consists of one three story building with approximately five new parking spaces, including two handicap spaces. This fall, three other small buildings (Jammer Dorm, Boys 1 and Boys 2) will be re-located from the floodplain in the Snyder Creek area to an area south of the Lewis Dorm. Also, new construction will occur in 2010-2011 of another new dorm/employee dining area with the same design as the Lewis Dorm. The three re-located structures will serve as temporary housing until the new dorm is built, at which time they will be removed (Figure 13). In 2007, baseline data was collected for this site to develop recommendations for revegetation species and document the pre-disturbance condition.

Figure 13. Lake McDonald Dorm: Site Locations.



B. METHODS

Prior to construction on June 6th 2007, a site analysis was performed of the area. One non-permanent 400m² circular plot was placed in an area that was representative of the vegetation and best captured the one plant association in this location. Ocular percent cover of each species present in the plot was estimated and recorded. Additional physical data were also documented and photographs were taken of the plot and nearby areas. The proposed construction area was also walked and a species list was compiled. This species list was taken into consideration when the seed prescription was determined for this site. Weed and rare plant surveys were also completed for the area.

Approximately 500 plants were planted at the Lewis Dorm 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 17). Plants were only installed along the north and east sides of the dorm. 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 (Table 18).

Table 17. 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>Mahonia 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.

Table 18. Lake McDonald Dorm: Hydro-seed Prescription 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				
		<i>Solidago canadensis</i>	8g				
		<i>Tiarella trifoliata</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.

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 20). 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 19).

Table 19. 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> .

C. RESULTS

In 2007, the site analysis plot captured the most common species in this area. The plot was located in the center of the forested area where construction was proposed. It captured moderate forest canopy cover with a mix of overstory trees and mostly native, low-growing understory species. The forest type found was a mixed tree forest that is within a *Tsuga heterophylla*/*Clintonia uniflora*/*Xerophyllum tenax* Plant Association (Nature Serve, 2005). Coniferous trees are the dominant lifeform in the plot with approximately 50% cover. The majority of trees are pole-sized to mature and in some areas there was a defined subcanopy. Overall, cover of non-native plants was relatively low in the area of the plot, but cover became higher at the perimeter of the forest. No rare plant species were discovered during this site assessment. Table 20 lists the species found during this initial site assessment.

Most of the vegetation present in 2007 was removed around the construction site. The tree and shrub cover is greatly reduced and will most likely remain with low woody cover in the area surrounding the dorm.

Since the initial site assessment in 2007, a total of 26 new non-native forb species and seven new non-native grass species have established within the three monitoring plots (Table 20). Plot MD09-03 was the most exposed of all the sites and seemed to have incurred the most disturbance. It had 26 non-native grass and forb species present, 16 of which are new to this area and comprise over 50% of the total vegetation cover in this plot. Most of this cover is due to high cover of *Capsella bursa-pastoris* and *Thlaspi arvense*, two colonizing mustard species that tend to establish quickly after disturbance but disappear two to three years after replanting. Tree, shrub and native forb cover were all low with 0.2%, 0.4% and 3.1% covers, respectively. Native grass was higher with 14.4% cover. Plot MD09-04 had approximately 12% cover of non-native forbs and grasses with 10 new non-native grass and forb species. Tree, shrub and forb cover were similar to the previous plot with 0.2%, 0.4% and 2% cover, respectively. Native grass was the highest of all the plots at 17.7% cover. Finally, plot MD09-05 had much lower non-native cover at approximately 6%, which included 12 non-native grass and forb species that were not present in 2007. Tree, shrub and forb cover were all higher with 0.9%, 3.7% and 4.7% cover, respectively. Native grasses were lower with 2.6% cover.

Table 20. Lake McDonald Dorm: Ocular Canopy Cover by Species for Each Plot at Lewis Dorm, 2009, Compared to Species Present in 2007, Pre-Disturbance.

Ground Cover	source	2007	MD-09-03	MD-09-04	MD-09-05
Basal Veg			4	3	2
Bare Ground			60	20	5
Gravel			2	56	20
Litter			34	20	66
Moss			0	0	1 (under tree)
Rock			0	1	5
Wood			0	0	1
Other			0	0	0
Species	source	2007	MD09-03	MD09-04	MD09-05
Trees		69.2	0.2	0.2	0.9
<i>Betula papyrifera</i>	planted	3			0.5
<i>Larix occidentalis</i>	Pre-disturbance	30			
<i>Picea engelmannii</i>	Pre-disturbance	1			
<i>Pinus monticola</i>	planted	0.2			0.2
<i>Populus balsamifera</i>	regen		0.2	0.2	0.2
<i>Prunus virginiana</i>	Pre-disturbance	in area			
<i>Pseudotsuga menziesii</i> (plot 5 ignore)	overstory	5			
<i>Thuja plicata</i>	Pre-disturbance	10			
<i>Tsuga heterophylla</i>	Pre-disturbance	20			
Shrubs		34.8	0.4	0.4	3.7
<i>Acer glabrum</i>	planted	5			0.2
<i>Amelanchier alnifolia</i>	planted	1			0.2
<i>Arctostaphylos uva-ursi</i>	planted	in area			0.5
<i>Cornus sericea</i>	planted				
<i>Holodiscus discolor</i>	regen			0.2	
<i>Juniperus communis</i>	Pre-disturbance	in area			
<i>Linnaea borealis</i>	planted	10			0.2
<i>Mahonia repens</i>	planted	in area			0.5
<i>Paxistima myrsinites</i>	Pre-disturbance	in area			
<i>Rosa acicularis</i>	Pre-disturbance	0.2			
<i>Rosa sp.</i>	seeded				
<i>Rubus idaeus</i>	planted	0.2	0.2		0.5
<i>Rubus idaeus</i>	seeded			0.2	0.2
<i>Rubus parviflorus</i>	Pre-disturbance	0.2			
<i>Salix bebbiana</i>	planted				0.2
<i>Sorbus sitchensis</i>	Pre-disturbance	0.2			
<i>Spiraea betulifolia</i>	seeded	1			
<i>Symphoricarpos albus</i>	planted	15			1
<i>Symphoricarpos albus</i>	seeded		0.2		0.2
<i>Vaccinium membranaceum</i>	Pre-disturbance	2			

Species present in 2007 were in the area as the proposed dorm site, not necessarily in the exact same spot as the new plots.

Table 20 con't. Lake McDonald Dorm: Ocular Canopy Cover by Species for Each Plot at Lewis Dorm, 2009, Compared to Species Present in 2007, Pre-Disturbance.

Species	source	2007	MD-09-03	MD-09-04	MD-09-05
Native Forbs		45	3.1	2	4.7
<i>Achillea millefolium</i>	regen	0.2	0.1		
<i>Adenocaulon bicolor</i>	Pre-disturbance	1			
<i>Anaphalis margaritacea</i>	seeded		0.2	0.2	0.2
<i>Antennaria howellii</i>	seeded	in area		0.2	0.2
<i>Antennaria rosea</i>	Pre-disturbance	in area			
<i>Apocynum androsaemifolium</i>	Pre-disturbance	in area			
<i>Aquilegia flavescens</i>	regen				0.2
<i>Aralia nudicaulis</i>	Pre-disturbance	in area			
<i>Aster laevis</i>	seeded		0.2	0.2	
<i>Chamerion angustifolium</i>	seeded			0.2	
<i>Chimaphila umbellata</i>	regen				0.2
<i>Clintonia uniflora</i>	Pre-disturbance	1			
<i>Conyza canadensis</i>	regen		0.2		
<i>Corydalis sempervirens</i>	regen		0.2	0.2	1
<i>Cypripedium montanum</i>	Pre-disturbance	in area			
<i>Dryopteris felix-mas (6 plants)</i>	planted				1
<i>Fragaria vesca</i>	regen	5	0.1	0.2	0.2
<i>Fragaria virginiana</i>	Pre-disturbance	in area			
<i>Galium triflorum</i>	regen	0.2		0.2	
<i>Geum macrophyllum</i>	seeded		0.1	0.2	
<i>Geum macrophyllum</i>	planted	in area			0.1
<i>Goodyera oblongifolia</i>	Pre-disturbance	0.2			
<i>Hieracium albiflorum</i>	Pre-disturbance	0.2			
<i>Hieracium scouleri?</i>	regen				0.2
<i>Maianthemum stellatum</i>	regen	15			0.2
<i>Melampyrum lineare</i>	Pre-disturbance	in area			
<i>Osmorhiza berteroi</i>	Pre-disturbance	0.2			
<i>Penstemon albertinus</i>	seeded				
<i>Penstemon confertus</i>	seeded				
<i>Plantanthera orbiculata</i>	Pre-disturbance	1			
<i>Pteridium aquilinum</i>	Pre-disturbance	in area			
<i>Solidago canadensis</i>	seeded	in area	2	0.2	0.2
<i>Tiarella trifoliata</i>	seeded				
<i>Viola orbiculata</i>	regen	1		0.2	
<i>Xerophyllum tenax</i>	salvage				0.5
<i>Xerophyllum tenax</i>	regen/undisturbed	20			0.5

Species present in 2007 were in the area as the proposed dorm site, not necessarily in the exact same spot as the new plots.

Table 20 con't. Lake McDonald Dorm: Ocular Canopy Cover by Species for Each Plot at Lewis Dorm, 2009, Compared to Species Present in 2007, Pre-Disturbance.

Species	source	2007	MD-09-03	MD-09-04	MD-09-05
Native Grasses		8.4	14.4	17.7	2.6
<i>Agrostis scabra</i>	regen		0.2	0.2	
<i>Carex athrostachya</i>	seeded				
<i>Carex concinnoides</i>	salvage?	3			0.2
<i>Carex pachystachya</i>	seeded				
<i>Carex rossii</i>	Pre-disturbance	0.2			
<i>Carex</i> spp.	seeded		0.2	0.5	0.2
<i>Deschampsia caespitosa</i>	seeded				
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>	seeded		3	2	1
<i>Elymus glaucus</i>	planted	1			0.2
<i>Festuca occidentalis</i>	seeded	4	11	15	1
<i>Oryzopsis asperifolia</i>	Pre-disturbance	0.2			
Exotic Forbs		1.8	50.4	11.5	7.9
<i>Amaranthis</i> (flowers in axils)	regen		0.2		
<i>Arenaria serpyllifolia</i>	regen		0.5		0.2
<i>Capsella bursa-pastoris</i>	regen		25	0.2	0.5
<i>Centaurea biebersteinii</i>	regen	in area			0.2
<i>Cirsium vulgare</i>	regen				0.2
<i>Cynoglossum officinale</i>	Pre-disturbance	0.2			
<i>Digitallis?</i>	regen			0.2	
<i>Descurainia sophia</i>	regen		0.2		
<i>Erodium cicutarium</i>	regen		0.2		
<i>Filago arvensis</i> / <i>Gnaphalium palustre</i>	regen		0.2	0.2	0.2
<i>Hypericum perforatum</i>	Pre-disturbance	in area			
<i>Lactuca serriola</i>	regen		0.2		
<i>Leucanthemum vulgare</i>	regen	0.2	1	0.2	1
<i>Medicago lupulina</i>	regen	in area	1	0.2	0.2
<i>Melilotus</i> spp.	regen			2	
<i>Plantago lanceolata</i>	Pre-disturbance	in area			
<i>Plantago major</i>	regen	in area	0.2		0.2
<i>Polygonum aviculare</i>	regen		0.2		0.2
<i>Polygonum convolvulus</i>	regen		3	0.1	0.2
<i>Potentilla argentea</i>	regen				0.2
<i>Potentilla norvegica</i>	regen			0.1	0.2
<i>Potentilla recta</i>	Pre-disturbance	in area			
<i>Prunella vulgaris</i>	regen	0.2		0.1	
<i>Rumex acetocella</i>	regen	in area		0.5	1
<i>Silene latifolia</i>	regen		0.2		0.2
<i>Sisymbrium altissimum</i>	regen		1		

Species present in 2007 were in the area as the proposed dorm site, not necessarily in the exact same spot as the new plots.

Table 20 con't. Lake McDonald Dorm: Ocular Canopy Cover by Species for Each Plot at Lewis Dorm, 2009, Compared to Species Present in 2007, Pre-Disturbance.

Species	source	2007	MD-09-03	MD-09-04	MD-09-05
Exotic Forbs Con't		1.8	50.4	11.5	7.9
<i>Taraxacum officinale</i>	regen	0.2	0.2		
<i>Thlaspi arvense</i>	regen		16		0.2
<i>Trifolium agrium</i>	regen	in area			0.5
<i>Trifolium hybridum</i>	regen			0.5	0.5
<i>Trifolium pratense</i>	regen		0.2		
<i>Trifolium spp.</i>	regen		0.2		
<i>Verbascum thapsus</i>	regen	in area	0.5	1	1
<i>Veronica officinalis</i>	regen	1	0.2	6	1
<i>Veronica serpyllifolia</i>	regen			0.2	
Exotic Grasses		0.5	1.2	1.8	1.2
<i>Achnatherum hymenoides</i>	seeded		0.2	1	0.2
<i>Avena sativa</i>	regen		0.2	0.2	
<i>Bromus inermis</i>	salvage	in area			0.5
<i>Dactylis glomerata</i>	regen	in area	0.2		
<i>Elymus repens?</i>	salvage	in area			0.2
<i>Lolium multiflorum</i>	regen			0.2	
<i>Phleum pratense</i>	regen	in area	0.2	0.2	0.1
<i>Poa compressa</i>	Pre-disturbance	in area			
<i>Poa pratensis</i>	regen	0.5	0.2	0.2	0.2
<i>Setaria glauca?</i>	regen		0.2		

Species present in 2007 were in the area as the proposed dorm site, not necessarily in the exact same spot as the new plots.

D. CONCLUSIONS AND RECOMMENDATIONS

Tree and shrub cover decreased dramatically from our initial site assessment in 2007, a result that should be expected since the area was cleared of woody material to build the dorm. Some weed encroachment was also to be expected, given the removal of the overstory and the proximity of nearby weed populations. The majority of the non-native species that occurred after construction are within the area with imported soil, including plot MD09-03. Despite vigorous efforts to prevent weeds from coming in with the soil, it is virtually impossible to guarantee the soil will be weed free. This site was also in the most exposed and heavily disturbed area, making it more susceptible to weed encroachment. The good news is the majority of the species in this area, such as *Capsella bursa-pastoris* and *Thlaspi arvense*, are annuals that appear in high concentrations initially and then decrease as the native vegetation begins to establish. Tree and shrub cover are low in this site and will most likely remain so due to its exposure. Forb cover currently remains relatively low at 3.1% but will hopefully increase next year as more plants germinate and grow in size. Native grass, at 14.4% cover, should also increase next year.

Plot MD09-04 is on the south side of the dorm at the forest edge. It has higher canopy cover and seems to have experienced less disturbance than the first plot, both perhaps contributing to less weed encroachment in this plot. This plot also has native soil of the area that may have resulted in fewer new colonizing weeds at this site. At the same time, the native soil did retain *Veronica officinalis* with this plot having the highest cover of *V. officinalis* at 6%. *Veronica officinalis* was present in the initial 2007 assessment and is a very difficult weed to control due to its ability to root at the nodes and grow under a forest canopy.

Finally, plot MD09-05 that was both seeded and planted was also the least disturbed. This site still has a good amount of canopy cover from the edge of the construction zone and also had the highest cover of native trees, shrubs and forbs due to the nursery and salvage plantings. Due to the higher cover of native species and the low cover of exotic forbs and grasses here, this site will most likely be the fastest to establish with native vegetation. Future monitoring should track the effectiveness of hydro-seeding, as it sometimes takes multiple years for seeds to germinate and the plants to fully establish. It also takes time for the salvage and nursery plants to recover and begin to thrive after planting.

During our initial assessment a rare plant survey was conducted and no rare plants were found. This year, *Corydalis sempervirens*, a species of concern, was found in all three plots and in most of the disturbed areas around the dorm. Globally, *Corydalis sempervirens* has a status of G4, meaning it is “uncommon but not rare (although it may be rare in parts of its range), and usually widespread. In the state of Montana, *Corydalis sempervirens* has a rating of S2, meaning it is at “at risk because of very limited and/or declining numbers, range, and/or habitat, making it vulnerable to global extinction or extirpation in the state.” (Montana Field Guide, 2009). 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 will be monitored every year to track this population. The level II plots and photomonitoring areas should also be revisited according to our monitoring plan in 2010, 2011, and 2013 for their year two, three and five year monitoring events.

VI. 303-F: UPPER MCDONALD CREEK SECTION OF GTSR

A. BACKGROUND AND PURPOSE

The Upper McDonald Creek section of the Going-To-The-Sun Road (GTSR), from the head of Lake McDonald to just north of Avalanche Campground, was reconstructed during 1998. A total of 4.3 miles of road surface was repaved and numerous turnouts were modified, resulting in 4.9 acres (212,160 ft²) of disturbed road shoulders and turnouts.

Prior to restoration efforts, four site analyses were conducted at four locations along the GTSR in 1995 (Asebrook *et al* 1995). These plots documented the pre-disturbance condition of the roadside and existing turnouts prior to construction and provided baseline data to guide the selection of plant material for revegetation. Areas that were sampled included an open roadside community south of Avalanche Campground, a sunny roadside community north of the Mt. Brown turnout, a shrubby, shady roadside community near McDonald Falls, and a moist roadside community at Moose Country.

Restoration of these areas was conducted in the fall of 1999 and the summer of 2000. Revegetation included a seed treatment of grasses and forbs and a planting treatment of trees, shrubs, forbs, and grasses. In total, 4,106 plants were installed and 60 kg of native seed was sown. Turnouts were seeded with grasses, sedges, and forbs at a rate of 168 seeds/ft², while road shoulders were seeded with a grass mix at 125 seeds/ft² and a forb mix of 65 seeds/ft² (Tables 21 and 22). All planted material was treated with a 13:13:13 (N:P:K) slow-release fertilizer, peat moss, and a Vitamin B1 anti-shock transplant solution.

Table 21. 303-F: Seeding Rates (seeds/ft²) for the McDonald Creek section of GTSR

	road shoulder	modified turnouts
GRASSES		
<i>Bromus carinatus</i>	15	
<i>Calamagrostis rubescens</i>	50	30
<i>Carex athrostachya</i>		20
<i>Carex douglasii</i>		2
<i>Carex hoodii</i>		9
<i>Carex spp.</i>		17
<i>Deschampsia cespitosa</i>	15	20
<i>Elymus glaucus</i>	20	
<i>Elymus trachycaulus</i>	15	
<i>Stipa occidentalis</i>	7	
<i>Stipa richardsonii</i>	3	
<i>Trisetum spicatum</i>		1
FORBS		
<i>Achillea millefolium</i>	15	5
<i>Anaphalis margaritacea</i>	6	5
<i>Anemone multifida</i>		10
<i>Antennaria bonellii</i>		10
<i>Antennaria rosea</i>	5	
<i>Aster laevis</i>	5	10
<i>Gaillardia aristata</i>	2	
<i>Geum macrophyllum</i>	5	5
<i>Penstemon albertinus</i>	3	10
<i>Penstemon confertus</i>	7	10
<i>Penstemon lyallii</i>		5
<i>Phacelia hastata</i>		tr
<i>Prenanthes sagittata</i>		tr
<i>Ranunculus uncinatus</i>		tr
<i>Senecio triangularis</i>		5
<i>Solidago canadensis</i>	12	tr
<i>Spiraea betulifolia</i>	5	5

Table 22. 303-F: Planted species by turnout

	Turnout #1	Turnout #2	Moose Country turnout
FORBS/GRASSES			
<i>Antennaria bonellii</i>	x	x	
<i>Aster laevis</i>	x	x	
<i>Castilleja rhexifolia</i>	x	x	
<i>Carex deneyana</i>	x	x	
<i>Carex hoodii</i>	x	x	
<i>Carex spp.</i>	x	x	
<i>Fragaria vesca</i>	x		
<i>Fragaria spp.</i>		x	
<i>Geum macrophyllum</i>	x	x	
<i>Geum triflorum</i>	x	x	
<i>Heracleum sphondylium</i>			x
<i>Penstemon confertus</i>	x	x	
LOW SHRUBS			
<i>Arctostaphylos uva-ursi</i>	x	x	
<i>Linnaea borealis</i>	x	x	
MEDIUM SHRUBS			
<i>Paxistima myrsinites</i>	x	x	
<i>Rosa woodsii</i>	x	x	x
<i>Rubus parviflorus</i>	x	x	x
<i>Spiraea betulifolia</i>	x	x	
<i>Symphoricarpos albus</i>	x	x	x
<i>Vaccinium membranaceum</i>		x	
TALL SHRUBS			
<i>Acer glabrum</i>	x	x	x
<i>Amelanchier alnifolia</i>	x		
<i>Cornus sericeus</i>			x
<i>Prunus virginiana</i>	x		x
<i>Salix scouleriana</i>		x	
TREES			
<i>Abies bifolia</i>	x		
<i>Betula papyrifera</i>	x	x	x
<i>Juniperus communis</i>	x		
<i>Larix occidentalis</i>	x		
<i>Picea engelmannii</i>	x	x	
<i>Pinus contorta</i>	x		
<i>Pinus monticola</i>	x		
<i>Populus balsamifera</i>	x	x	x
<i>Pseudotsuga menziesii</i>	x		
<i>Thuja plicata</i>	x	x	
<i>Tsuga heterophylla</i>	x	x	

The purpose of monitoring these restoration efforts is to document the success of seeded and planted material throughout the project. Monitoring aims to:

- (1) Determine the canopy cover of all native and exotic species in each monitoring plot;
- (2) Track the success of seeded and planted material through estimates of canopy cover and density;
- (3) Document the instances of soil erosion; and
- (4) Determine if specific revegetation goals and objectives (Table 23.) are being met.

Table 23. 303F: Goals and Objectives

Goals and Objectives	Year 1	Year 2	Year 5	Year 10	Year 20
Surface soil stability	X				
Native species cover					
20%	X				
30%		X			
40%			X	X	X
Noxious weed cover (under herbicide use plan)					
< 10%	X	X	X		
< 5%				X	X
Other exotic species cover (under herbicide use plan)					
< 30%	X	X			
< 20%			X	X	X
Species composition and diversity					
Restore 75% of target restoration native community					X
Significant growth ($p > 0.05$) of nursery stock			X	X	X

B. METHODS

In June of 2000, five monitoring plots of various sizes were established, depending on the size of the area that was revegetated. Three plots were placed in modified turnout areas and two plots were placed along road shoulders (Figure 14). Plots begin at the first turnout (#1) north of the intersection of the Sun Road and the road to the Ranger Station at the head of Lake McDonald. They are located in the following places and have these dimensions: (MD00-04) 25m x 4m plot at the parking island in turnout #1; (MD00-05) 20m x 5m plot north of modified turnout #2; (MD00-06) 20m x 2m plot along the Moose Country turnout; (MD00-07) 20m x 5m plot along the road shoulder across from the Moose Country turnout; and (MD00-08) 20m x 1m plot on the road shoulder just south of turnout #5. Level II monitoring was conducted on all plots in 2000, 2001, 2002, 2004 and 2009, including information on soil erosion and ocular estimates of canopy cover for native and exotic species. Estimated density for seeded species from each plot was estimated during the first years of the project to determine germination success.

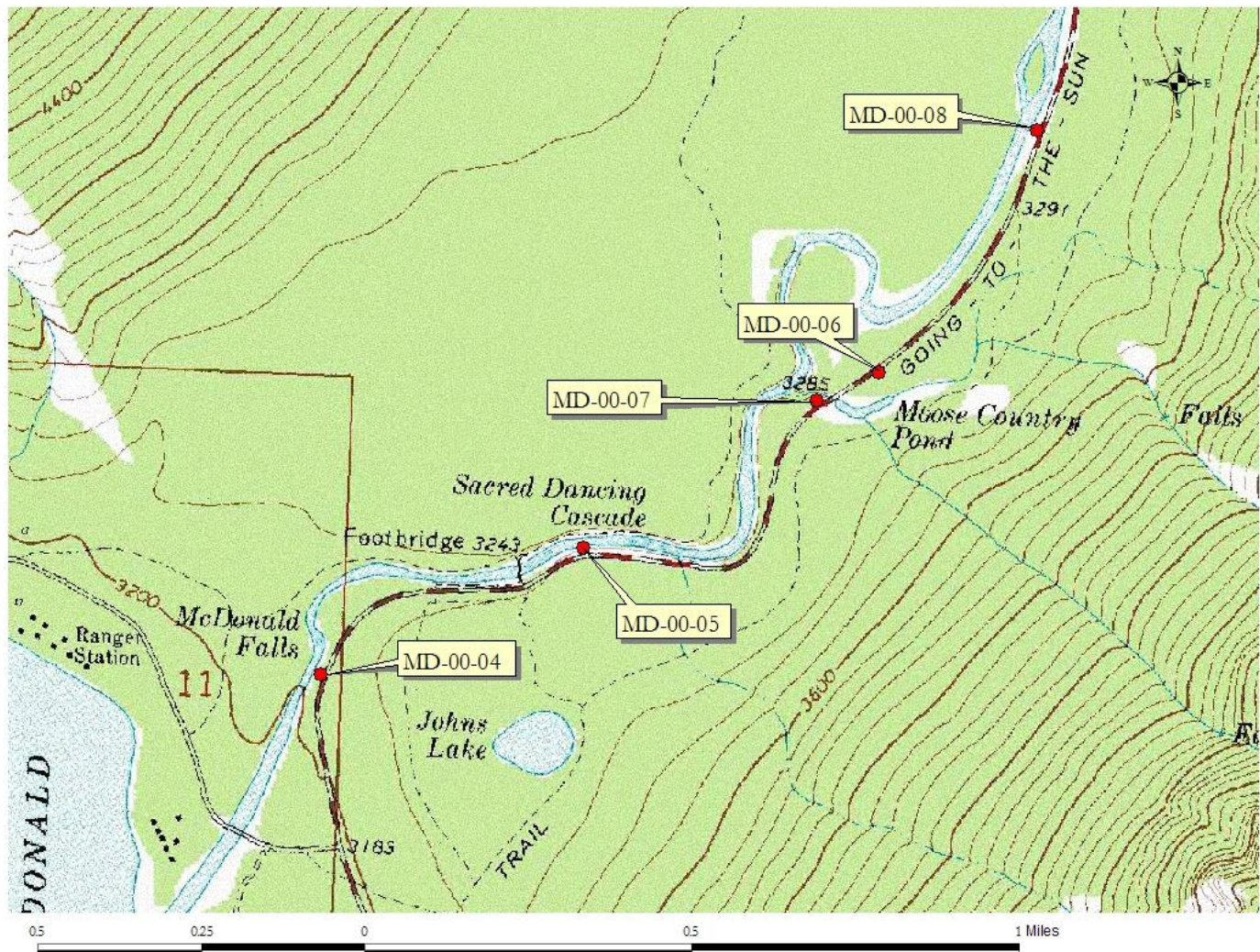
Pre-disturbance photographs were taken in 1998. Photomonitoring at established photopoints was continued in 2000, 2001, 2002 and 2004, and should be carried out in future years. Due to time constraints we were not able to get to the photomonitoring plots this year.

D. RESULTS AND DISCUSSION

1. Meeting Revegetation Goals

Pre-disturbance site analysis data documented a fair diversity of native species along this road corridor with certain areas dominated by shrubs and forbs. Exotic species, however, were common in most

Figure 14. 303F: Location of Upper McDonald Creek Section of GTSR Revegetation Monitoring Plots



areas prior to restoration efforts, particularly exotic grasses. The historic presence of these weeds will continue to affect the overall success of revegetation on 303-F.

Year ten goals for Project 303-F include the following: $\geq 40\%$ native cover, $\leq 20\%$ exotic cover, and $\leq 5\%$ noxious weed cover (Table 23). While most of the plots met at least one of the ten year revegetation goals, none of the plots met all of the goals (Table 24). Plot MD-00-06, a turnout plot, was the only plot to reach the native cover goal with 41% native cover. Despite its high native cover, it also had 68% exotic cover. Obviously there was some overlap in covers. Plots MD-00-05 and MD00-04, also turnout plots, were the only plots to meet the low exotic cover goal with 19% and 8% cover respectively but did not quite meet the native cover goal. Finally, plots MD00-07 and MD00-08 did not meet any of the ten year vegetation goals with the exception of soil stability as a first year goal. All the plots except MD00-07 met the noxious weed goal with less than 4% cover.

Unfortunately, native cover has decreased in every plot except MD00-04 since 2002 from 4% to 17%. At the same time, exotic cover increased in all plots from 5% to 36% with the exception of MD00-04 where it decreased by 14%. *Hieracium aurantiacum* was seen for the first time in 2004 and found in one additional plot this year. *Hypericum perforatum* was also found for the first time in 2009 at one site. *Euphorbia esula* was removed from the species list as it was found to be misidentified with *Linaria vulgaris* in plot MD00-07. All of the noxious weed species should be carefully monitored and managed.

Table 24. 303F: Overall Native and Exotic cover (%) by Plot, 2000-2009

	MD-00-04					MD-00-05					MD-00-06				
	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009
Native Cover	18%	30%	31%	28%	33%	16%	44%	41%	32%	22%	21%	35%	45%	42%	41%
Exotic Cover	9%	13%	5%	22%	8%	5%	9%	4%	11%	19%	26%	62%	56%	61%	68%
	MD-00-07					MD-00-08									
	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009					
Native Cover	7%	27%	31%	15%	4%	5%	37%	31%	12%	10%					
Exotic Cover	9%	18%	17%	29%	34%	5%	9%	11%	26%	62%					

2. Lifeform Results

In plots MD00-05 through MD00-08, overall native species cover decreased, while overall exotic species cover increased since 2002. This is due to a consistent decrease in native grass cover and a consistent increase in exotic grass cover. The only exception is plot MD00-04 where overall native cover has remained the same and overall exotic cover decreased by 14% since 2009. This was due primarily to a 10% increase of native grass cover and a decrease of exotic forb cover.

Overall, current native cover ranges from 4% to 41%, while exotic cover ranges from 8% to 68%. Refer to Table 25 at the end of this section for species information discussed in the following pages.

2a. Trees

Since trees were not planted along road shoulders, only the three turnout plots had tree cover. Tree cover increased slightly in plot MD00-05 from 0.4% to 0.7% due to growth of *Populus balsamifera*. Tree cover decreased on plot MD00-04 from 4.2% to 0.4% due to the loss of *Picea engelmannii* and *Pseudotsuga menziesii* and a decrease in cover of *Pinus monticola* and *Pinus contorta*. Plot MD00-06 has generally maintained 1% tree cover from a *Betula papyrifera* tree.

Seeding treatments around woody material were modified on this project in response to a hypothesis that herbaceous material, particularly grass, was outcompeting planted trees and shrubs for moisture, nutrients, and sunlight. A 'well' around each woody plant was not seeded in an effort to reduce competition and shading. At this time, success of this methodology remains undetermined, since tree cover remained low on all plots. Future monitoring should track the success of this modified seeding/planting method.

2b. Shrubs

There were no consistent changes in shrub cover from 2004 to 2009. As expected, shrub cover in road shoulder plots remained very low or absent, since no shrub species were planted in road shoulder areas. Shrub cover has remained essentially the same since 2004 in turnout plots. This trend is an improvement, since cover had declined in several plots over the first few years of the project. In 2002, shrub cover

Figure 15. 303F: Percent Canopy Cover by Lifeform for Plot MD00-04 (Turnout).

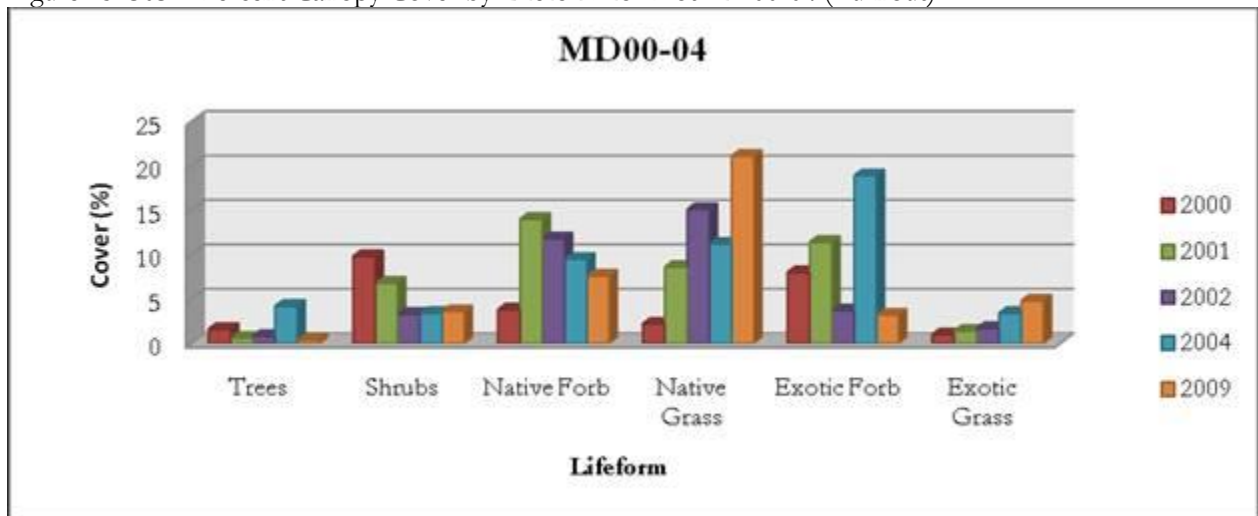


Figure 16. 303F: Percent Canopy Cover by Lifeform for Plot MD00-05 (Turnout).

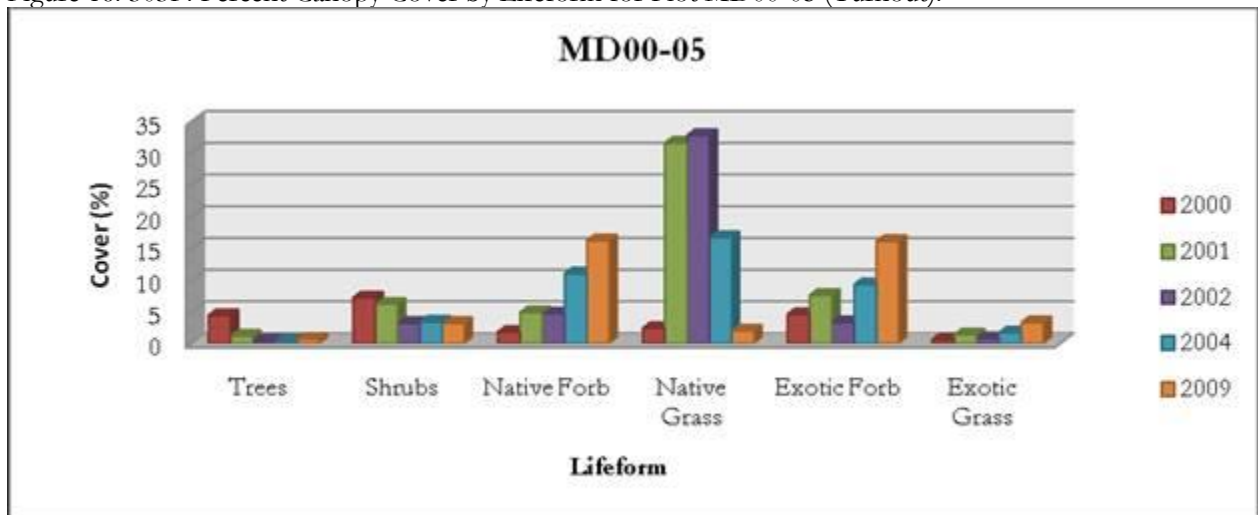


Figure 17. 303F: Percent Canopy Cover by Lifeform for Plot MD00-06 (Turnout).

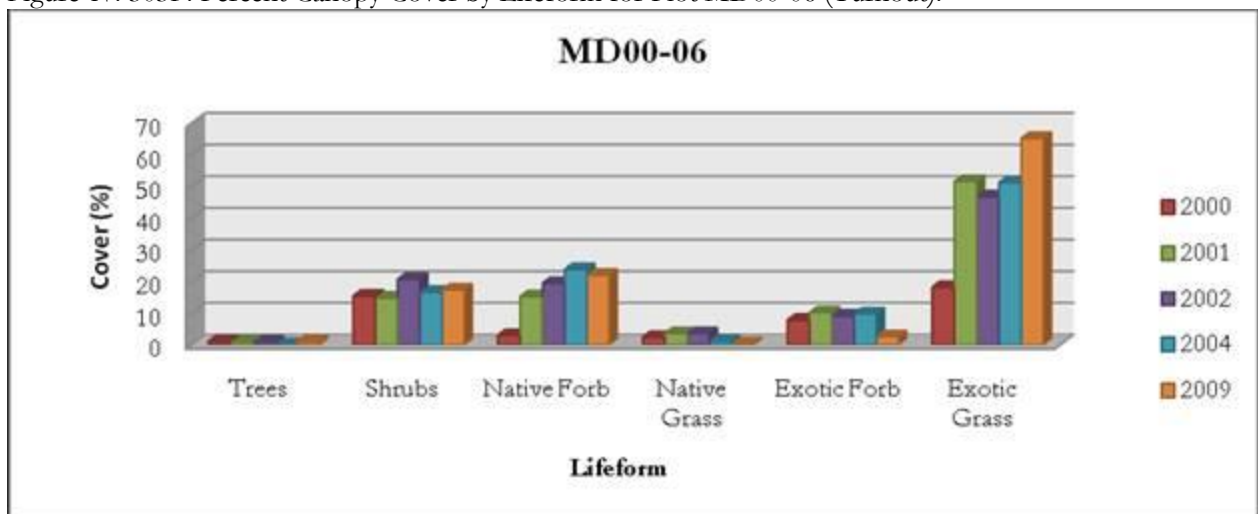


Figure 18. 303F: Percent Canopy Cover by Lifeform for Plot MD00-07 (Road Shoulder).

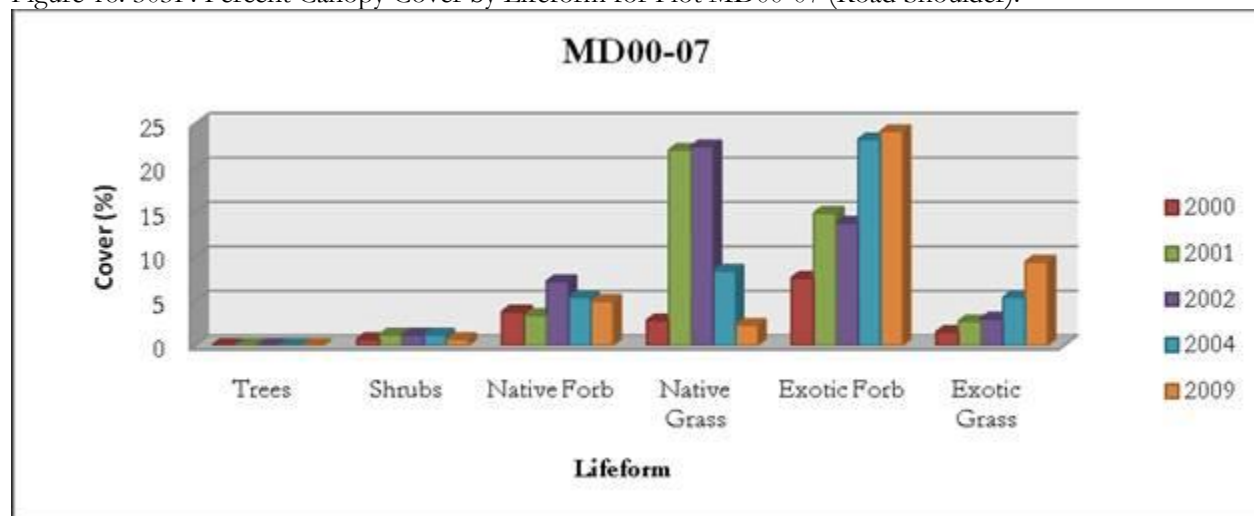
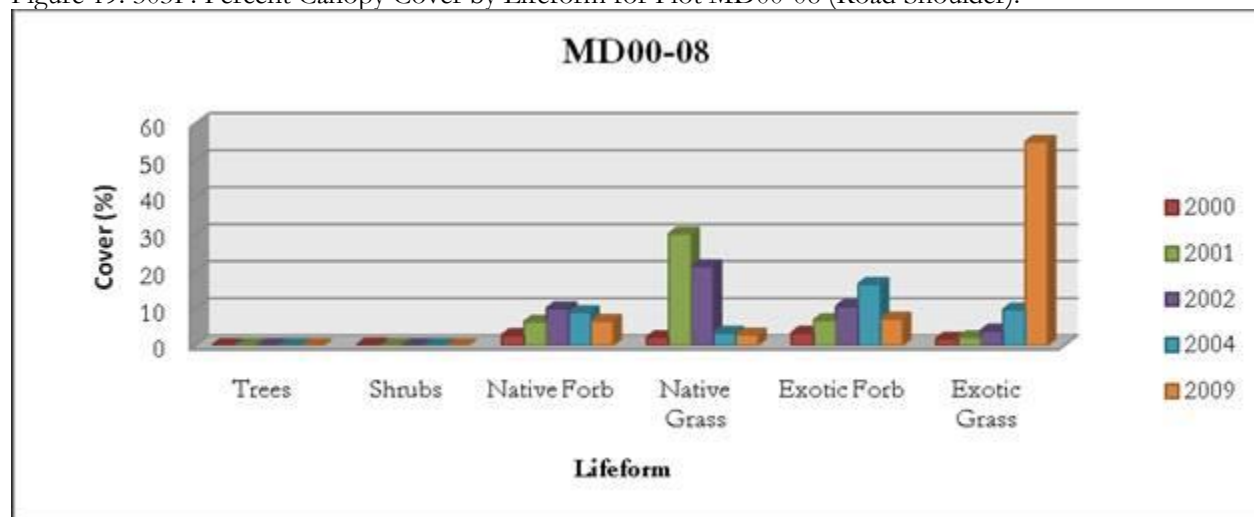


Figure 19. 303F: Percent Canopy Cover by Lifeform for Plot MD00-08 (Road Shoulder).



in two turnout plots had declined to approximately half of what it was when it was first planted.

Juniperus communis and *Symphoricarpos albus* were present in MD00-04 in 2004, but could not be relocated this year. *Prunus spp.*, a suspected ornamental that may have occurred in the area prior to planting, had a 5% cover in MD00-06 in 2002 and 2004 but was also not located this year. Despite the loss of these species, growth of other shrub species in both of these plots was high enough that overall cover still increased.

Several other planted species slightly increased or maintained cover in the project. *Arctostaphylos uva-ursi* increased from 1% cover to 3% cover in the only plot in which it was present at the beginning of monitoring. *Symphoricarpos albus* increased from 5% cover to 8% cover in plot MD00-06. *Cornus sericea* also increased by 1% in the only plot in which it was planted. *Rubus parviflorus* increased from 3% cover to 4% cover in one plot, but decreased from 1% to a trace in another plot.

It was noted in 2002 that while some shrubs have died, some shrubs have merely died back and are now resprouting from the roots. For a time, cover estimates were lower but these shrubs are beginning to recover. It is also possible that some shrubs have died due to drought the year after planting. Similar to trees, seeding was not done around the base of each shrub to prevent competition with herbaceous material, particularly grass, for moisture, nutrients, and sunlight. It is still not obvious whether seeded material is impacting the survival of planted shrubs.

2c. Native Forbs

Generally, native forbs decreased slightly in all plots except in plot MD00-05 where it increased by 5%. This increase was due to an increase in cover of *Antennaria howellii*, *Aster laevis*, *Penstemon confertus* and *Solidago canadensis*. Regardless of decreases in cover in some plots, however, native forb cover remained higher than initial monitoring levels in all plots. Also, despite some decreases, native forb cover was higher than exotic forb cover in all three turnout plots by a trace to 19% at year ten after replanting. Overall native forb cover in the three turnout plots ranged from 7% to 22%.

As with other road revegetation projects, the road shoulder areas are not faring as well. Cover in the two road shoulder plots was lower than all of the turnout plots at 7% and 8%. Both road shoulder plots saw a slight decrease of native forb cover from 2004 to 2009 due primarily to the loss of *Anemone multifida*, *Antennaria howellii*, *Fragaria vesca*, and *Gaillardia aristata*. Overall, there has been less than a 4% change in native forb cover on road shoulder plots since planting in 2000 and native cover is lower than exotic forb cover in both plots.

As in previous years, dominant native forbs continue to be *Achillea millefolium*, *Aster laevis*, *Aster foliaceus*, *Geum macrophyllum*, *Solidago canadensis*, and *Penstemon confertus*. Notable increases in cover of some of these species were found in several plots from 2004 to 2009, while slight decreases were found in others. In 2002, it was predicted that the above seeded species would likely provide the most consistent cover over subsequent years, since many of these plants have proven to be persistent when re-introduced to a roadside community. While *Achillea millefolium* was the dominant native forb in all plots in 2002, it decreased by 3-6% in four of the five plots since 2002. The decline in *Achillea millefolium* cover is typical, since this species tends to diminish over time. The most noteworthy native forb increases were from *Penstemon confertus* on plots MD-00-06, MD00-05, and MD00-08. Observations should continue to track the success of these species.

Three of the seventeen seeded forb species (Table 21) have still not been observed ten years after replanting. These include *Antennaria rosea*, *Penstemon hyalii*, and *Senecio triangularis*. *Prenanthes sagittata* was observed with trace cover in 2004, but not seen in 2009. Also, *Phacelia hastata* was found on one plot in year one but has not been observed since. Many of these species had very low seed rates and were not seeded throughout the entire project.

2d. Native Grasses

The most consistent changes across all plots occurred with native grass cover. After a pattern of increasing for the first three years, native grass cover decreased in all plots by year five. By year ten, this trend continued with a steady decline in grass cover between 0.5% and 15% in all but one plot. Cover of native grasses ranged from a trace to 22%, while it ranged 1% to 16% at year five and from 4% to 32% at year three.

MD00-04 was the only plot to see an increase in native grass cover from 11% to 21%. This entire increase is due to a 20% increase in cover of *Festuca saximontana*. *Festuca saximontana* was not planted here and only had 1% cover in 2004. It remains uncertain about the identity of this grass and where its seed source came from, as neither *Festuca saximontana* nor any other *Festuca* species were seeded on this project. Most notable decreases were seen in *Elymus trachycaulus ssp. trachycaulus*, *Elymus glaucus* and *Deschampsia cespitosa*. The largest decreases were seen in *Elymus trachycaulus ssp. trachycaulus*, which declined in cover in three plots by 0.5% to 7% and disappeared from one plot. *Elymus glaucus* also decreased by 10% in one plot and disappeared from another plot. *Deschampsia cespitosa* disappeared in two plots this year and declined by 2% in the other. Finally, *Carex microptera* was found only in one plot with 5% cover in 2004. This year it was gone from this plot but appeared as a trace in another plot.

Reduction in cover of *Elymus glaucus* is expected at year ten, since it is often planted as a nurse grass to establish quickly and compete with invasive exotic species. Similarly, *Deschampsia cespitosa* has declined on nearby 303-B, requiring moister environments. The decline of *Elymus trachycaulus ssp. trachycaulus* is less expected, however, as this grass has been successful in other projects. Typically, this grass requires mineral soil and low competition to germinate (Steele, 1995; Hassell, 1983) so it is possible that competition from rhizomatous grasses, such as *Bromus inermis* and *Poa pratensis*, is preventing the establishment of this grass.

Similar to other west-side roadside projects, *Calamagrostis rubescens*, the seeded grass species with the highest seed rate, was not present in any areas at year ten. Like *E. trachycaulus*, *C. rubescens* also requires mineral soil and low competition to germinate. It has been observed that when *C. rubescens* is seeded in a seed mix with larger grasses and a number of forbs, its germinate rate is very low if it germinates at all. Finally, it is uncertain why planted or seeded *Carex* species did not establish well in this project, as *Carex* species have established well in other revegetation projects.

Several seeded grass species still have not been observed within the monitoring plots since they were revegetated. These include *Carex douglasii*, *Stipa richardsonii*, and *Trisetum spicatum*. *Carex hoodii* was observed on one plot in 2000 but has not been observed since. *Carex douglasii*, *Trisetum spicatum*, and *Stipa richardsonii* had very low seed rates (≤ 3 seeds/ft²), likely resulting in the lack of observations. These grass species may have germinated elsewhere on the project, however. It is speculated that *Festuca idahoensis* was seeded on the modified turnout plots even though it is not listed as a seeded species. This grass would not naturally occur in habitat types along McDonald Creek; however it was present on two turnout plots.

2e. Exotic Forbs

No apparent trend was found across plots for changes in exotic forb cover by year ten. Exotic forb cover decreased in three plots at year ten, while it increased in two plots. On the turnout plots, exotic forb cover ranged from 2.6% to 16%. Exotic forb increased by 7% on one of turnout plots and decreased by 7% and 16% on the other two. One of the road shoulder plots saw a 1% increase while the other saw a 9% decrease.

Decreases in cover were due to large decreases of *Melilotus officinalis*, *Medicago lupulina*, (except for one plot) *Lactuca serriola*, and *Trifolium hybridum* from five to ten years. Noxious weed species were absent in one plot, decreased in two plots and increased in two plots from year five to ten. *Chrysanthemum leucanthemum* and *Centaurea maculosa* remain consistently present, while *Hieracium aurantiacum* and *Hieracium caespitosum* appear to be increasing throughout the project. *Euphorbia esula* was misidentified and discovered to be *Linaria vulgaris*, which remains on one plot with low cover. *Cirsium arvense* is also present on one plot with low cover. Exotic forb cover should continue to be monitored to assess its long-term change and impact on the success of the restoration along this stretch of the GTSR.

2f. Exotic Grasses

With exotic grass cover under 10% on three of the five plots, exotic grasses have remained relatively low on this project as a whole. Two turnout plots and one road shoulder plot had 4.8%, 3.3%, and 9.4% exotic grass cover, respectively. Despite the relatively low cover in these three areas, exotic grass cover increased on all five plots since 2004. Plot MD-00-08, a road shoulder plot, saw the largest increase in exotic grass cover from 9.7% to 55%, due primarily to large increases in *Agrostis stolonifera*, *Dactylis glomerata*, and *Phleum pratense*. Exotic grass cover also remained very high on plot MD 00-06 where it increased from 51% to 65%, due mostly to a 10% increase in *Bromus inermis*. This plot has had high exotic grass cover since the beginning of the project. Overall, exotic grass cover was higher than native grass cover on four plots this year, compared to only two plots in 2004. *Bromus inermis*, *Dactylis glomerata*, *Phleum pratense*, and *Poa pratensis* were the dominant exotic grasses present on all of the plots.

The remaining exotic grass species each had very low covers ranging from a trace to 2%. While most of these are very difficult to control, it may be beneficial to try to control *Bromus tectorum* in the few areas where it is present along this stretch of GTSR. *B. tectorum* has shown the ability to overtake large swaths of roadside habitat in other areas in the west, and recently in Glacier National Park, in the last few years. This species is present in only trace amounts in this project and may be fairly easily eliminated at this point.

D. CONCLUSIONS AND RECOMMENDATIONS

As with many roadside revegetation projects, non-native plants that were in the seed bank at the start of the project are hard to overcome. From year five to year ten, native cover decreased on four out of five plots by 2% to 12%. At the same time, exotic cover increased in four out of five plots by 5% to 36%. Native cover ranged from 4% to 41%, while exotic cover ranged from 8% to 68%. Currently, exotic cover dominates on three out of the five plots, particularly on the road shoulder plots where exotic cover is four to six times as high as native cover. Two of the turnout plots, however, have higher native cover than exotic cover. These turnout areas are larger and tend to be easier to revegetate than road shoulders due to less disturbance. These are the areas to look for restoration successes including increasing shrub cover, high native forb cover, higher native grass cover, and generally lower exotic cover, particularly of exotic forbs. Revegetation species that are doing well within this project include native forbs *Achillea millefolium*, *Aster laevis*, *Aster foliaceus*, *Geum macrophyllum*, *Solidago canadensis*, and *Penstemon confertus* and native grasses *Bromus carinatus*, *Elymus glaucus*, *Carex* spp., and *Elymus trachycaulus*. *Festuca occidentalis* should be considered as a revegetation species in future west side road projects and consideration should be given to seeding *Calamagrostis rubescens* alone or with a few forbs in certain areas to encourage its establishment. *Symphoricarpos albus*, *Rosa woodsii*, *Rubus parviflorus*, and *Arctostaphylos uva-ursi* are consistent shrubs within revegetation areas.

Road shoulder areas continue to be a problem to restore with native vegetation. Continual disturbance to these areas is preventing native species from getting established and perpetuating weed species. Perhaps study trials should be conducted along road shoulders to determine what seed mix works for these areas.

These plots should be monitored again in 2014 at the fifteen-year mark. Future monitoring should track which native species are persisting, document any change in woody material cover, particularly in light of planting strategies that have left a “well” around planted shrubs and trees, and assess the long-term potential of native lifeforms. Increases or decreases of persistent weed cover, particularly noxious weeds, should be documented.

Table 25. 303-F: Canopy Cover (%) by Plot, 2000-2009.

	MD-00-04 Turnout #1					MD-00-05 Turnout #2					MD-00-06 Moose Entry turnout					MD-00-07 Moose Country shoulder					MD-00-08 Turnout #5 shoulder				
	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009
<i>Basal Veg</i>					6					3					8					3					6
<i>Rock</i>					1					4					1					30					0
<i>Gravel</i>					5					4					1					10					2
<i>Bare soil</i>					1					2					3					1					10
<i>Moss</i>					5					15					3					35					6
<i>Litter</i>					82					72					84					21					76
<i>Wood</i>					0					0					0					T					T
<i>Other</i>					0					0					0					0					0
Species:	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009
TREE	1.6	0.6	0.8	4.2	0.4	4.4	1.2	0.4	0.4	0.7	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0
<i>Betula papyrifera</i>	1			2		1					1	1	1		1										
<i>Larix occidentalis</i>																									
<i>Picea engelmannii</i>	0.2	0.2	0.2	1		0.2	0.2	0.2	0.2	0.2															
<i>Pinus contorta</i>			0.2		0.2 (dying)																				
<i>Pinus monticola</i>	0.2	0.2	0.2	1	0.2																				
<i>Populus balsamifera</i>						2	1-	0.2	0.2	0.5															
<i>Pseudotsuga menziesii</i>		0.2	0.2	0.2																					
<i>Thuja plicata</i>						0.2																			
<i>Tsuga heterophylla</i>	0.2					1																			
SHRUB	9.8	6.8	3.3	3.4	3.6	7.2	6.2	3.2	3.4	3.2	15.4	14.8	20.7	16.6	17.4	0.7	1.2	1.2	1.2	0.7	0.2	0	0	0	0
<i>Acer glabrum</i>						4	3	1+	2	1	2	0.2	1	0.2	0.2										
<i>Amelanchier alnifolia</i>												0.2	1	0.2	0.2										
<i>Arctostaphylos uva-ursi</i>	1	1	1	1+	3																				
<i>Cornus sericea</i>											2	0.2	0.5	1	2										
<i>Juniperus communis</i>	0.2	0.2	0.2	0.2																					
<i>Paxistima myrsinites</i>	0.2	0.2	0.2	0.2	0.2																				
<i>Prunus spp.</i>											1	1	5	5											
<i>Prunus virginiana</i>											0.2														
<i>Ribes inermis</i>																					0.2				
<i>Rosa acicularis</i>						0.2	0.2	0.2	0.2		0.2	0.2	0.2			0.5	1	1	1						
<i>Rosa woodsii</i>	0.2	0.2	0.2							1-				0.2	2					0.5					
<i>Rubus idaeus</i>											1+	3	3	2	1										
<i>Rubus parviflorus</i>	5	3	0.5	1	0.2	1	1	1	0.2	0.2	3	3	3	3	4										
<i>Spiraea betulifolia</i>	0.2	0.2	0.2		0.2																				
<i>Symphoricarpos albus</i>	3	2	1+	1		2	2	1	1+	1	6	7	7	5	8	0.2	0.2	0.2	0.2	0.2					
NATIVE FORB	2004	2015	2014	2014	2017	2002	2006	2007	2015	2025	2003	2016	2021	2028	2031	2004	2004	2009	2009	2014	2003	2007	2012	2013	2016
<i>Achillea millefolium</i>	0.5	8	7	2	0.2	0.2	3	3	5	3	0.5	10	9	8	5	0.2	1	4	2	1	1+	4	4	1	0.2
<i>Anaphalis margaritacea</i>		0.2	0.2	0.2	0.2												0.2	0.2	0.2	0.2					
<i>Anemone multifida</i>		0.2	0.2	0.2	0.2					0.2									0.2	0.2				0.2	
<i>Antennaria howellii</i>		0.2	0.2				0.2	0.2	1	2								0.2	0.2			0.2	0.2	0.2	
<i>Arabis drummondii</i>												0.2	0.2									0.2	0.2	0.2	
<i>Aster laevis</i>	0.2	2	2	1	3	0.2	0.5	0.5	4	6	0.2	0.2	2	3	outside	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2	1-	
<i>Aster spp.</i>																			0.2						
<i>Campanula rotundifolia</i>	0.2	0.2		0.2	0.2				0.2							0.2			0.5	0.5					
<i>Castilleja miniata</i>		0.2	0.2	0.2	0.2																				
<i>Chamerion angustifolium</i>													0.2					0.2		0.2					
<i>Circaea alpina</i>																0.2									
<i>Collinsia parviflora</i>				2+																					
<i>Collomia linearis</i>																					0.2				
<i>Epilobium halleanum</i>						0.2	0.2			0.2	0.2	0.2	0.2	0.2		0.2		0.2							
<i>Equisetum arvense</i>											0.2					0.2									
<i>Fragaria vesca</i>									0.2				0.2	0.2	0.2		0.2	0.2	0.2	0.2		0.2	0.2	2	
<i>Fragaria virginiana</i>	0.2	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2			0.2	1-							0.2				
<i>Galium triflorum</i>																0.2									
<i>Gaillardia aristata</i>										0.2									0.2				0.2	0.2	

	MD-00-04 Turnout #1					MD-00-05 Turnout #2					MD-00-06 Moose Cntry turnout					MD-00-07 Moose Country shoulder					MD-00-08 Turnout #5 shoulder				
	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009
<i>Geum aleppicum</i>											0.2	1	1	1	0.2				0.2						0.2
<i>Geum macrophyllum</i>	1	0.5	0.2			0.2	0.2	0.2			0.2	1	2	1	0.2	0.2	0.2	0.2	0.2		0.2	1	1	3	0.2
<i>Geum triflorum</i>	0.2	0.2	0.2	0.5	0.2																				
<i>Heracleum sphondylium</i>											0.5	1	1	1	0.2	0.2	0.2	0.2	0.2						
<i>Hieracium albiflorum</i>																		0.2							
<i>Maianthemum stellatum</i>																		0.2							
<i>Microsteris gracilis</i>	0.2	0.2			0.2					0.2														0.2	
<i>Myosotis</i> spp.						0.2																			
<i>Osmorhiza chilensis</i>			0.2								0.2		0.2			0.2	0.2								
<i>Penstemon albertinus</i>							0.2	0.2		0.2									0.2						
<i>Penstemon confertus</i>	0.5	0.5	1	3	3	0.2	0.2	0.2	0.2	3	0.2	0.2	1	2-	7+			0.2	0.2	0.2	0.2	0.2	0.2	1	4
<i>Phacelia hastata</i>	0.2																								
<i>Polygonum douglasii</i>	0.2					0.2					0.2					0.2					0.2				
<i>Prenanthes sagittata</i>																			0.2						
<i>Ranunculus uncinatus</i>	0.2	0.2				0.2										1-	0.2	0.2		0.2					
<i>Rhisanthus crista-galli</i>																					0.2				
<i>Senecio pauperculus</i>																	0.2		0.5	0.2		0.2			
<i>Senecio psendaureus</i>											0.2		0.2	0.2	0.2	0.2		0.2		0.2	0.2				
<i>Solidago canadensis</i>		0.2	0.2				0.2	0.2	0.2	1	0.2	2	2	6	4	0.2	0.2	0.2	0.2	0.5	0.2	0.2	0.2	0.2	1+
<i>unknown mint</i>	0.2																								
<i>Veronica serpyllifolia</i>		0.2									0.2	0.2	0.2				0.2	0.2				0.2	2		
<i>Viola adunca</i>																		0.2							
<i>Viola</i> spp.																0.2	0.2								
<i>Aster foliaceus</i>															5					1-					1
NATIVE GRASS	2.2	8.6	15.1	11.2	21.1	2.4	31.6	32.8	16.7	2	2.4	3.6	3.6	1.2	0.2	2.8	22	22.4	8.4	2.3	2.2	30.2	21.4	3.4	2.9
<i>Agrostis scabra</i>				0.5													0.2								
<i>Bromus carinatus</i>						1	1	0.2		0.2	2-	1	1	0.2	0.2	0.2	1	2	0.2	1	1	3	2		
<i>Calamagrostis rubescens</i>				0.2																					
<i>Carex athrostachya</i>					0.2			0.2		0.2															
<i>Carex hoodii</i>																0.2									
<i>Carex microptera</i>	1+	3	4	5																0.2					
<i>Carex pachystachya</i>					0.5																				
<i>Carex</i> spp.					0.2		0.2																		
<i>Danthonia intermedia</i>		0.2								0.2							0.2	0.2							0.2
<i>Deschampsia caespitosa</i>	1	5	10	2		0.2	2	2	0.5		0.2	0.2	0.2				0.2				0.2	2	4	3	1
<i>Elymus glaucus</i>			0.2				3	5	5	0.2	0.2	0.2	1	1-		2	15	15	5	0.2	1	0.2	0.2	0.2	
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>				0.5		1	25	25	7	0.2		2	1			0.2	5	5	3	0.5		25	15	0.2	
<i>Festuca idahoensis</i>		0.2	0.2	2			0.2	0.2	3	0.2															
<i>Festuca saximontana</i>		0.2	0.5	1	20				1	1+						0.2	0.2	0.2	0.2	0.2					0.5
<i>Poa palustris</i>	0.2		0.2				0.2	0.2				0.2	0.2				0.2					0.2			
<i>Stipa nelsonii</i>													0.2							0.2					1-
<i>unknown grass (long awns)</i>						0.2																			
<i>Festuca campestris</i>					0.2																				
<i>Lolium multiflorum</i>																									0.2
EXOTIC FORB	2008	2012	2006	2023	2012	2005	2009	2005	2013	2025	2008	2011	2011	2014	2012	2008	2016	2016	2027	2033	2003	2008	2013	2021	2016
<i>Achillea nobilis</i>		0.2		0.5	0.2				0.2	0.2									0.5	0.5					
<i>Arenaria serpyllifolia</i>	0.2	0.2	0.2			0.2	0.2			0.2							0.2	0.2							0.2
<i>Artemisia absinthium</i>		0.2	0.2	0.2			0.2	0.2									0.2	0.2	1	1+		0.2	0.2	0.2	
<i>Camelina microcarpa (Conyza?)</i>	0.2	0.2	0.2			0.2	0.2		0.2	0.2						0.2	0.2				0.2	0.2			
<i>Capsella bursa-pastoris</i>	0.2	0.2				0.2	0.2	0.2	0.2	0.2											0.2				
<i>Centaurea maculosa</i>			0.2		0.2		0.2			0.5						0.2	0.2	0.2	0.2	2				0.2	
<i>Cerastium fontanum</i>																0.2	0.2	0.2				0.2		0.2	0.2
<i>Chenopodium album</i>	0.2																								
<i>Chorispora tenella</i>	0.2																								
<i>Chrysanthemum leucanthemum</i>		0.2	0.2		0.2						1	7	6	4	1	0.2	5	5	3	5	0.2	0.2	1	3-	0.2
<i>Cirsium arvense</i>		0.2	0.2								0.2		0.2				0.2	0.2		0.2					
<i>Cirsium vulgare</i>												0.2					0.2	0.2					0.2		

	MD-00-04 Turnout #1					MD-00-05 Turnout #2					MD-00-06 Moose Cntry turnout					MD-00-07 Moose Country shoulder					MD-00-08 Turnout #5 shoulder				
	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009	2000	2001	2002	2004	2009
<i>Descurainia sophia</i>	0.2					1					0.2	0.2				0.2	0.2				0.2				
<i>Gnaphalium palustre</i>									0.2	0.2															
<i>Euphorbia esula</i> *													1+	mis-ID*											
<i>Hieracium aurantiacum</i>									0.2										0.2	4	0.2				
<i>Hieracium caespitosum</i>																			5				0.2		
<i>Hieracium?</i>													0.2	0.2								0.2			
<i>Hypericum perforatum</i>											0.2	0.5	0.2	1	2-					0.2				0.2	
<i>Lactuca biennis</i>									0.5							0.2	0.5								
<i>Lactuca serriola</i>	0.2	0.2				0.2	0.5	0.2			0.2		0.2	0.2		0.2	0.2	0.2	8	0.2					
<i>Linaria vulgaris</i>											0.2	0.2	0.2		0.2		0.2	0.2	0.2						
<i>Marrubium vulgare</i>	0.2					0.2																			
<i>Matricaria matricarioides</i>	0.2																								
<i>Medicago lupulina</i>	1-	5	0.5	1+	2	0.2	3	1	1-	10	0.2	0.2	0.2	0.2	0.2	1	1	0.2	0.2	5	1	2	3	1-	2
<i>Medicago sativa</i>							0.2	0.2	1	2															
<i>Melilotus albus</i>							0.5		0.2										0.5						
<i>Melilotus officinalis</i>	0.2	3	0.2	15		0.2	1		5	0.2	0.2					0.2	2	1	5	0.2		0.2	0.2	2-	
<i>Plagiobothrys scouleri</i>	3					0.2			0.2		3-										0.2				
<i>Plantago major</i>		0.2	0.2				0.2	0.2				0.5	0.2	1	0.2	0.2	1	1	0.2	0.2		3	4	4	2
<i>Polygonum achoreum</i>							0.2					0.2													
<i>Polygonum convolvulus</i>	0.2					0.2					0.2					0.2					0.2				
<i>Potentilla argentea</i>									0.2			0.2	0.2											0.2	
<i>Potentilla norvegica</i>																						0.2	0.2		
<i>Prunella vulgaris</i>																0.2	0.2	0.2		0.2			0.2	0.2	1-
<i>Satureja vulgare</i>																	0.2								
<i>Silene conoidea</i>	0.2					0.2															0.2				
<i>Silene latifolia</i>													0.2	1	0.2			0.2							
<i>Sisymbrium altissimum</i>	1					1					1	0.2	0.2			0.2	0.2				0.2				
<i>Sonchus asper</i>																			0.2						
<i>Taraxacum officinale</i>	0.2	0.2	0.2				0.2	0.2	0.2	0.2	1	0.2		0.2	0.2	0.2	1	1	2	1-				0.2	
<i>Thlaspi arvense</i>	0.2					0.2					0.2					0.2					0.2				
<i>Tragopogon dubius</i>		0.2							0.2										0.2	0.2					
<i>Trifolium agrarium</i>					0.2								0.2			0.2	0.2	0.2	0.2			0.2			
<i>Trifolium hybridum</i>		1	1	2	0.2		0.2	0.2				0.2	0.2			3	0.2						1		
<i>Trifolium pratense</i>							0.2	0.2	0.2	1						0.2	0.2	0.2	0.2		0.2	0.2	0.2	0.2	
<i>unknown mustard</i>	0.2					0.2										0.2			0.2						
<i>Verbascum thapsus</i>		0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.2	0.2		0.2	0.5	0.2			0.2	0.2	0.2	0.2					
<i>Veronica officinalis</i>			0.2				0.2	0.2				0.2	0.2	1	mis-ID*	0.2	1	3	1+	0.2	0.2	0.2	0.2	5	0.2
<i>Veronica serpyllifolia</i>															0.2										1
<i>Tanacetum vulgare</i>									0.2																
<i>Myosotis micrantha</i>									0.2																0.2
EXOTIC GRASS	1	1.4	1.7	3.4	4.8	0.6	1.4	0.8	1.7	3.3	18.2	51.6	46.8	51.2	65.2	1.5	2.7	3	5.4	9.4	1.8	2.2	4	9.7	55
<i>Agrostis stolonifera</i>			0.2		0.2		0.2					0.2	0.2	0.2		0.2	0.5	1	1	1	0.2	0.2	0.2	1-	10
<i>Avena sativa</i>	0.2			0.2		0.2	0.2						0.2			0.2									
<i>Bromus inermis</i>		0.2			0.2						15	50	45	40	50					0.2	0.2	0.2	1	5	6
<i>Bromus tectorum</i>	0.2	0.2	0.2	0.2		0.2	0.2	0.2	0.2	0.2						0.2				0.2					
<i>Dactylis glomerata</i>		0.2	0.2	0.5	0.2		0.2									0.2	0.2	0.2	0.2	1	0.2		1	1	15
<i>Elymus repens</i>	0.2	0.2	0.5	0.5	1-				1		0.2			1	10		0.2	0.2	1	2-		0.2	0.2	0.2	2-
<i>Lolium multiflorum</i>	0.2																0.2						0.2		
<i>Phleum pratense</i>		0.2	0.2	1-	1-		0.2	0.2	1	0.2	2	1	1	10	2	0.5	0.2	0.2	1	1	1	1	1+	16	
<i>Poa annua</i>												0.2					0.2	0.2				0.2			
<i>Poa compressa</i>		0.2	0.2	1+	2+		0.2	0.2	0.5	1			0.2		0.2		0.2	0.2	0.2	1		0.2	0.2	0.5	1
<i>Poa pratensis</i>		0.2	0.2		0.2		0.2	0.2		0.5	1	0.2	0.2		3	0.2	1	1	2	3	0.2	0.2	0.2	1	5
<i>unknown grass (like regreen?)</i>	0.2					0.2																			
<i>Bromus (tall)</i>									0.2																
<i>Bromus (short)</i>									0.2																

*mis-ID: most likely LINVUL

VII. CAMAS HYDROMULCH

A. BACKGROUND AND PURPOSE

The Camas Creek Road hydro-mulch project was created as a post-fire restoration effort. After the Robert Fire swept through portions of the North Fork subdistrict of Glacier National Park in July 2003, weeds invaded many roadside areas. Fire suppression activities, coupled with normal road use, caused additional disturbance and helped to further weed propagation along the Camas Creek Road corridor. Rehabilitation of these sites was sought to restore roadsides to more native conditions and to reduce potential weed spread into the recently burned areas.

An interagency Burned Area Emergency Rehabilitation (BAER) team produced a report documenting the fire and fire suppression effects on the road corridor, and made recommendations for mitigation and management (USDA Forest Service and USDI National Park Service, 2003). Based on the conclusions of that report, funding was provided by the BAER program to perform rehabilitation along the Camas Creek Road corridor.

Efforts to rehabilitate a disturbed area can sometimes have inadvertent adverse effects. Following a disturbance such as fire, revegetation efforts can detrimentally impact soils by reducing existing vegetative cover, reworking existing soil, and introducing new soil. Additionally, imported soil can be contaminated with weed seeds even when care is taken to obtain sterile soil. In an effort to avoid this type of added disturbance, an alternative method for rehabilitating this recently burned roadside was sought.

The methodology tested in this project sought to minimize soil disturbance while reducing weeds and increasing native plant cover. The course of action chosen was to spray the area with an herbicide prior to planting to reduce broadleaf noxious weeds, followed by a “two-pass” hydro-seed / hydro-mulch application of native seed. Hydro-seeding is a process that mixes, distributes and plants seed in a spray of water. Hydro-mulching is often used as a method to mix seeds with water and mulch for improved germination. Hydro-mulching stabilizes soil, holds seeds in place for germination, and provides protection from desiccation. However, seeding with hydro-mulch also poses problems. Seedlings sometimes germinate within the mulch, rather than within the soil, and fail to properly establish (Lapp 2004.). Therefore a combination of the two methods was used in this project. By hydro-seeding first, followed by a second “pass” with hydro-mulch alone (no seed), the benefits of mulch are gained with less detrimental effect to survival of germinants. This project was performed on a small scale, since hydro-seeding and hydro-mulching are expensive, and results compared with traditional revegetation methods are unknown.

B. METHODS

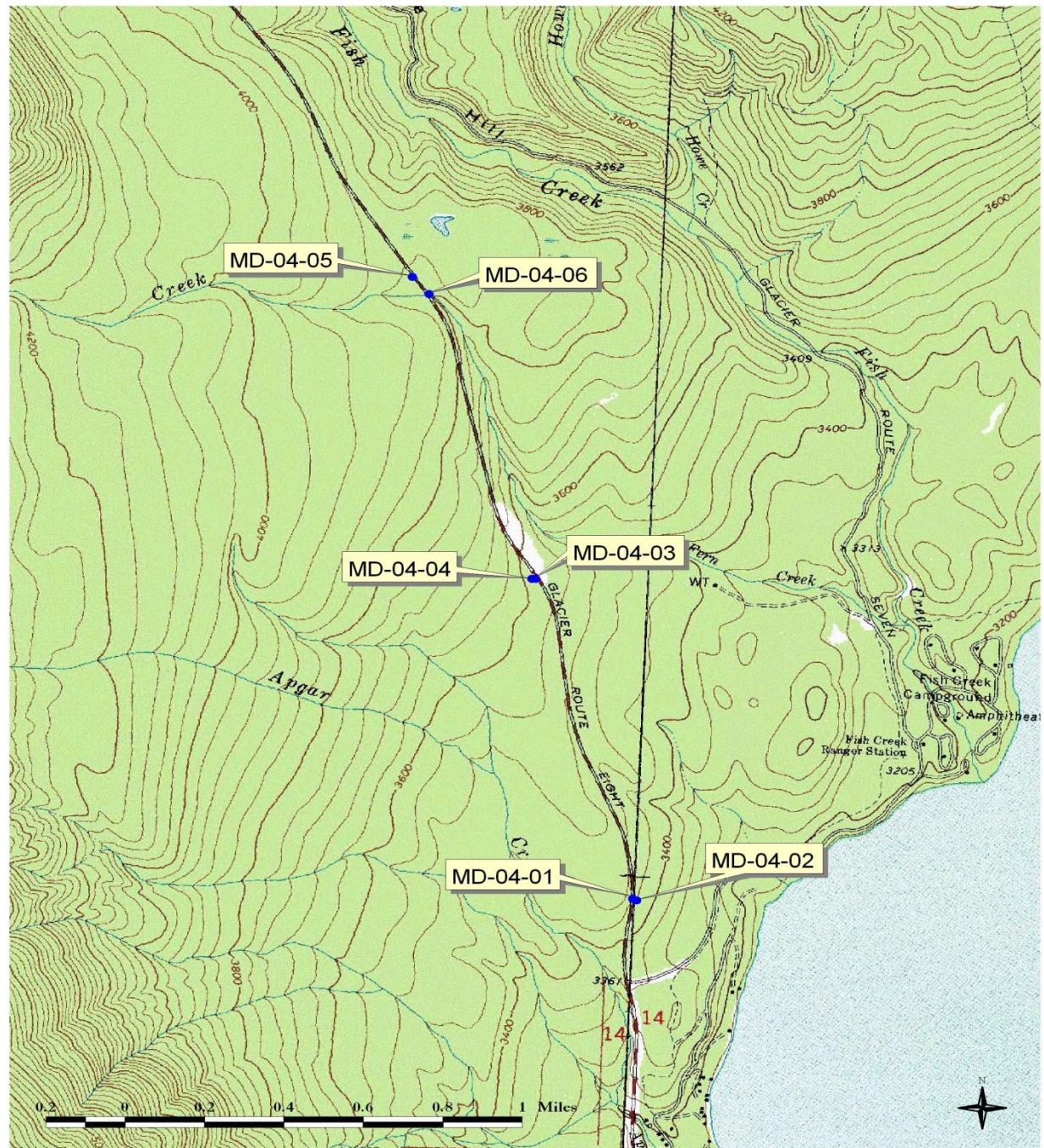
A small portion of the Camas Creek Road corridor was selected for this experimental project. Application of the hydro-seed/mulch began shortly after the turnoff for Fish Creek Campground and extended approximately three miles northwest along the Camas Creek Road. To reduce existing weeds and prepare the site for seeding, the area was sprayed with a series of broad leaf herbicides between June 15 and August 5, 2004. A “two-pass” hydro-seed / hydro-mulch mixture was subsequently applied on September 30, 2004. Native grasses were chosen for this project since the germination rate for this lifeform on similar projects has been generally more successful than native forb establishment. Four native grass species were seeded in different proportion at a rate of 30 pounds per acre (Table 26).

Table 26. Camas Creek Road Hydro-mulch Project: Grasses Seeded, 2004.

Species:	Percent of mix:
<i>Bromus carinatus</i>	36%
<i>Elymus glaucus</i>	33%
<i>Festuca idahoensis</i>	10%
<i>Pseudoroegneria spicata</i>	21%

Six permanently marked monitoring plots were established along the roadside between October 3rd and 6th, 2004 (Figure 20). Plots measured 10m long by 1m wide to accommodate the linear nature of the treated area. Plots were marked with a nail in the upper right corner (when facing the plot from the road). Plots differed slightly in physical aspects such as burn severity, slope, adjacent habitat, ground cover, gravel content, soil moisture content, presence of ditches, and shade. Level II Site Analyses were conducted in 2004, and Level II Monitoring was performed in 2005, 2007 and 2009 (Table 27). Photographs were taken during all monitoring events. An ocular estimate of canopy cover for all species, as well as ground cover, was collected for each plot.

Figure 20. Camas Creek Road Hydro-mulch project: Location of Monitoring Plots



C. RESULTS

1. Effects of Hydro-seeded Species

Table 27 summarizes all of the data between 2004 and 2009 for all plots within the Camas Creek Road Hydro-mulch project. Only two of the four species of hydro-seeded native grasses were present in the plots in 2009, compared with three in 2007 and two species in 2005. *Bromus carinatus* continued to be unobserved throughout the project. *Elymus glaucus* had previously been found in one plot in 2005 with trace cover, and in two new plots with trace cover in 2007. This species was not found at all in 2009. *Pseudoroegneria spicata* was found in the project for the first time in 2007, germinating in five plots with trace cover. This species remained stable in three plots and increased slightly in cover in two plots, to 1% in 2009. It also germinated in the last plot, so that now this species is present in all plots. *Festuca idahoensis* continued to be the most successful hydro-seeded species in the project and the only hydro-seeded species that has had more than 1% cover throughout monitoring of the project. It was found in every plot in 2007 and in 2009. Cover continued to be variable. In the two plots where cover of *F. idahoensis* was highest, it was present before germination of hydro-seed. In both of these plots, cover decreased to nearly half of its 2005 cover, decreasing from 25% to 15% in plot 3 and from 25% to 12% in plot 4. The plots with *F. idahoensis* presence only after hydroseed germination all increased in cover from 2007 to 2009, however. This species may be more indicative of natural regeneration than germination with 7%, 2% and 1% cover in these plots.

Hydro-seeded grasses have taken several years to establish in this project. There was one new germination event of hydro-seeded grasses in 2009, five years after planting, compared with eleven new germination events in 2007. There was only one instance of germination in 2005. It is unlikely that *B. carinatus* will germinate within the project at this point, especially with the dominance of aggressive exotic grasses. However, this species, along with *E. glaucus*, tends to be a short-lived revegetation species that is often planted to establish early cover and subsequently declines or disappears. More promising long term covers come from *P. spicata* and *F. idahoensis*.

2. Lifeform Results

For the first time during the course of monitoring this project, overall covers of lifeforms has decreased. All categories of lifeforms have decreased since 2007, but most decreases are not large enough to be considered pertinent and may be within the realm of observer differences. However, an overall 6.4% decrease in native forb cover may represent an actual decrease in this lifeform. While regular treatment with herbicide is a necessary management tactic for roadsides to curb exotic forb invasion, herbicide has been repeatedly shown to have negative impacts on native species as well, particularly native forbs. Many native forb species disappeared from monitoring plots entirely in 2009, most likely as non-targeted casualties of herbicide use. Some of these species were also annuals whose populations naturally fluctuate.

Exotic species continue to dominate the area with 47% average exotic cover in comparison to 13% average native cover across plots (Figure 21). Although average exotic species cover has decreased since 2007, native cover has also decreased. The decrease in native cover, however, was almost double that of the decrease in exotic cover with a decline of 9.3% (from 22.3% in 2007 to 13% in 2009). Exotic species cover decreased 4.8% overall (from 51.5% in 2007 to 46.7% in 2009).

Exotic grasses continue to be the dominant lifeform in all plots with 42% average cover (Figure 22). This is slightly lower than in 2007 when exotic grass cover was 46.3%. *Bromus inermis* is the dominant species in most plots, ranging from 8% to 30% cover. In most cases, it is increasing in cover. Interestingly, a number of exotic grasses have decreased in cover since 2007, most notably *Agrostis stolonifera* which decreased in all plots. It is possible that the early reading of these plots caused identification of this species to be difficult, but it is also possible that *A. stolonifera* is being outcompeted by *B. inermis*.

Exotic forb cover decreased slightly, although the difference is likely within the realm of observer differences. Average exotic forb cover dropped from 5.2% in 2007 to 4.7% in 2009. This is a substantial decrease from 2005, however, when exotic forb cover was 19.7%. Herbicide regimes are clearly working to keep non-native forbs in check.

**Figure 21. Camas Creek Rd. Hydro-mulch project:
Native and Exotic Covers Across Plots, 2004 - 2009**

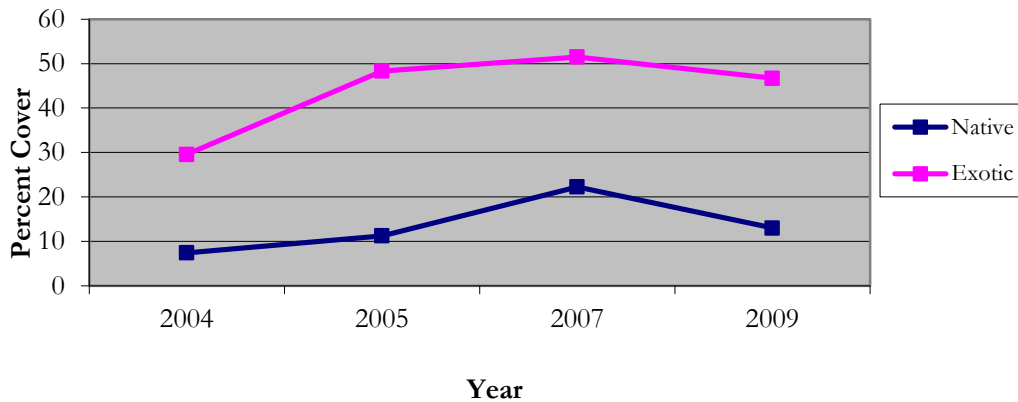
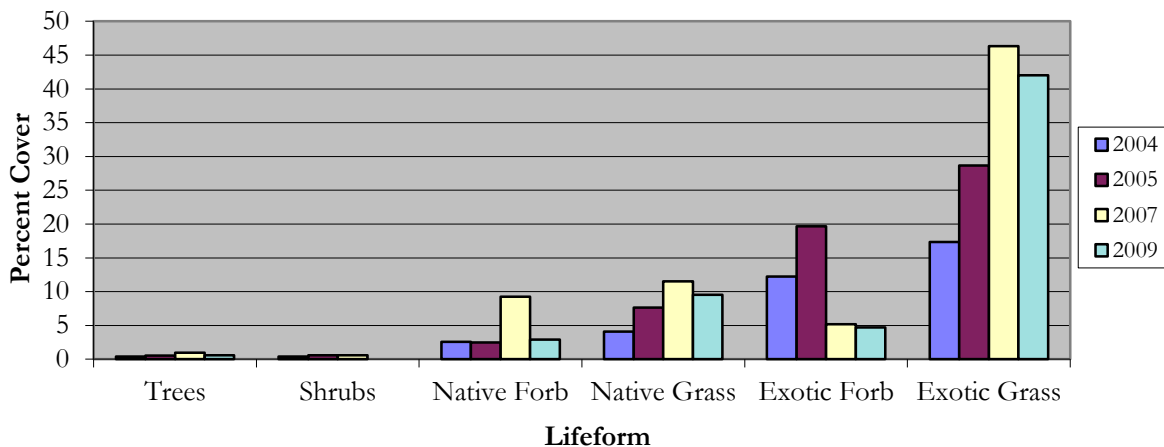


**Figure 22. Camas Creek Rd. Hydro-mulch project: Average
% Cover Across Plots for Lifeforms, 2004 - 2009**



Native grasses provide the second highest cover of lifeforms on average with 9.5% cover. This lifeform decreased slightly from 12% in 2007 to 10% in 2009, mostly due to a decrease in cover of *F. idahoensis* in two plots. Most other native grass species increased in cover.

Shrubs have disappeared from all plots by 2009, although there has never been more than 2% cover of shrubs in any plot. Tree cover continued to be negligible with less than 2% average cover in each plot. Covers for all species and lifeforms are reported in Table 21.

2a. Trees and Shrubs

As stated above, shrubs were eliminated in all plots by 2009, although shrubs never exhibited more than 2% cover during the course of the project. While mowing of road corridors may keep covers of woody material at bay, much of the previous shrub component was made up of *Arctostaphylos uva-ursi*, a very low-

growing sub-shrub that would not be affected by mowing. Herbicide is probably responsible for at least some of the decline of shrubs in the project. *A. uva-ursi* was the only shrub to ever have more than trace cover across the project.

Tree cover remained low on all plots in 2009 with no species having more than 2% cover in any plot. In 2007, *Pinus contorta* cover approached 2% in two plots, even though it had just recruited to plots in 2005. By 2009, *P. contorta* had reduced to trace cover in one of these plots and was shriveled from herbicide in another plot where it struggled to retain its 2% cover. This supports the hypothesis that herbicide application is affecting woody material in these roadside plots. Several tree species have disappeared from plots in the past few years. It is likely that cover from woody species will continue to be negligible due to mowing and herbicide application with the possible exception of low growing shrubs such as *A. uva-ursi*.

2b. Native Forbs

Native forb cover decreased from 9.3% to 2.9% from 2007 to 2009, basically reversing the trend from 2005 to 2007 where cover increased from 2.5% to 9.3%. Much of this change in cover is due to fluctuation in annual forbs and erratic species. For instance, *Collinsia parviflora*, a diminutive annual, increased substantially in 2007 from trace to 20% in one plot, only to fall back again to 8% by 2009. *Rhinanthus crista-galli*, an erratic species that may be common one year and rare the next (Lesica, 2002), provided 5% cover in one plot in 2007 and then disappeared in that plot by 2009. Other species were likely knocked back by herbicide treatment. *Anaphalis margaritacea*, *Solidago canadensis* and *Senecio pseud aureus* had begun to establish substantial cover in a few plots by 2007 but were reduced dramatically by 2009. These species are in the aster family which are typically some of the hardest hit by herbicide. Another aster, *Microsteris gracilis*, had been present in all plots in 2007, but by 2009 has disappeared from all plots. *Cerastium arvense*, a species that held promise for persistent ground cover, also disappeared from all four plots from which it was present in 2007. A few other species diminished in cover or disappeared since 2007 including *Anemone multifida*, *Antennaria howellii*, *Chamerion angustifolium*, *Collomia linearis*, *Fragaria virginiana* and *Gentianella amarella*. The forb species that shows the most potential for lasting cover under an herbicide regime is *Penstemon confertus*. Members of the figwort family seem to withstand spraying better than most other families. This species increased to 3% cover in one plot where it had not been seen since 2005.

Native forb cover decreased in every plot from 2007 to 2009. Cover ranged from trace to 8% with an average of 2.9%.

2c. Native Grasses

There was no clear overall trend in the performance of native grasses across the project. Cover of native grasses increased in two plots, decreased in two plots and stayed the same in two plots. Average cover of native grasses for the project decreased 2% since 2007 from 11.5% to 9.5%. Most of the changes occurred in cover of *Festuca idahoensis*. Interestingly, in the plots where this species was present prior to hydroseeding, the cover diminished substantially since 2007, decreasing from 25% to 15% in one plot and from 25% to 12% in another. In the four plots where hydroseeding introduced this species for the first time, cover increased (from 2% to 7% in one plot, from trace to 3% in one plot, from trace to 2% in one plot and from trace to 1% in one plot).

The hydroseed mix utilized was composed of solely native grass species which showed varied results. *F. idahoensis* was the most successful of the four hydro-seeded species with results discussed above. *Pseudoroegneria spicata* is slowly establishing in all plots but with low covers. It had established in five of the six plots in 2007 with trace cover, but has increased to 1% cover in two plots and remained at trace cover in two plots. It also recruited into the last plot in 2009 with trace cover. Neither *Elymus glaucus* nor *Bromus carinatus* were present in 2009. *E. glaucus* germinated in one plot in 2005 and in two plots in 2007, all of which disappeared by the subsequent monitoring event. *B. carinatus* has never germinated in the project.

One of the more promising naturally regenerating native grass species is *Carex rossii* with 1% or 2% cover in three plots and trace cover in one plot. *Carex petasata* increased its cover from trace to 2% in one plot, further suggesting that *Carex* species may be good candidates for seeding in revegetation projects.

However, *Carex pachystachya* did not fare as well and disappeared from four plots since 2007, two of which previously had 2% to 4% cover.

While native grasses appear to have the most potential for long term success in this project, their survival is threatened by exotic graminoids.

2d. Exotic forbs

Overall cover of exotic forbs across plots has remained relatively stable since the last monitoring event in 2007, due to a diligent herbicide application regime. Only one plot harbored a noxious weed species. *Hypericum perforatum* was found with trace cover in one plot. Five other noxious weed species that have been found over the years on the project are no longer present. The only species found with more than trace cover in 2009 were *Silene cucubalis* with 5% cover in one plot and *Veronica officinalis* which had 5% cover in one plot and 3% cover in another plot. Both of these species can be quite aggressive and should be targeted by herbicides in the future. *V. officinalis* is especially worth watching as it can spread rapidly and is capable of surviving under the shady forest canopy.

At times, species of clovers can dominate early revegetation projects. Earlier in the project, *Trifolium agrarium* had up to 20% cover in some areas. All clover species have been gone from all monitoring plots since 2005. This could either be due to the cyclical nature of these species or, more likely, their vulnerability to herbicide.

2e. Exotic Grasses

The overall success of this project is clearly threatened by the invasion of exotic grasses. While overall cover of exotic grasses has actually decreased in 2009, it continues to be the overwhelmingly dominant lifeform with 42% average cover. *Bromus inermis*, a quickly spreading rhizomatous grass, is the most aggressive species. Covers of *B. inermis* increased in four of the six plots, now estimated at 25-30%. It has remained stable in one plot at 8% and has decreased by 5% in another plot where it is now 30%. Overall vegetative cover has decreased in this plot, possibly replaced by moss which has increased from 23% to 45% since 2007. *B. inermis* has the highest percent cover of all species in five of the six plots. In the plot where it was not the most abundant, *Phleum pratense* had the highest cover at 30%, while *B. inermis* had 25% cover. In all other plots, cover of *P. pratense* has actually decreased, presumably being outcompeted by *B. inermis*.

Oddly, *Agrostis stolonifera*, another aggressive rhizomatous grass, has decreased substantially in all plots. It could be that it, too, is being outcompeted by *B. inermis*. However, due to the early date of reading these plots this year, identification of early emergent *A. stolonifera* could have been mistaken. A number of other exotic grasses have decreased in cover since 2007 including *Poa compressa* in one plot, *Dactylis glomerata* in two plots and *Festuca arundinacea* in one plot.

Unfortunately, once exotic grasses become established, they tend to quickly dominate areas. Short of using Round-Up to kill all vegetation prior to revegetation, there is little that can be done to avert exotic grasses once established. These grasses were present before germination of hydro-seeded native grasses took place, making it difficult for natives to compete.

D. CONCLUSIONS AND RECOMMENDATIONS

In 2009, the Camas Creek Hydroseeding project was monitored five years after revegetation. Major trends include:

- Exotic grasses are dominating all plots. On average, exotic grasses have approximately four times more cover than the next most abundant lifeform in the project.
- Success of the project is severely threatened by rhizomatous weedy grasses, especially *Bromus inermis*.

- Two of the four hydro-seeded species are not present in the project by year five. *Bromus carinatus* has never been found within monitoring plots. *Elymus glaucus* had germinated in three plots in previous years but was lost by 2009.
- *Pseudoroegneria spicata* was found in the project for the first time in 2007 and is now present in all plots; its cover remains, however, 1% or less.
- *Festuca idahoensis* continued to be the most successful hydro-seeded species in the project and the only hydro-seeded species that has had more than 1% cover throughout monitoring of the project. It was found in every plot in 2007 and in 2009 with an average of 7% cover. This species was present in some plots before hydroseeding, however.
- Exotic forb covers have been kept low over the course of the project by diligent herbicide use. Only one noxious weed species was found in 2009: *Hypericum perforatum* with trace cover. There have been five other noxious weed species present in plots in the past.
- Clover species, particularly *Trifolium agrarium*, which have had high covers in this project in the past, are now absent from monitoring plots. This lends more evidence to the ebb and flow of clover species, which can appear worrisome at the beginning of revegetation projects. It is likely that these species succumbed to herbicide as well.
- Native forbs have also been affected by herbicide. *Penstemon confertus*, *Senecio pseudolaureus* and *Solidago canadensis* appear to be surviving fairly well in selected areas. *Antennaria howellii* may produce good ground cover over time if it is not hit by herbicide or outcompeted.
- All shrubs in monitoring plots had disappeared by 2009, presumably affected by herbicide.
- Tree cover continues to be low, at less than 2% in all plots. Trees have been affected by herbicide as well as mowing. A new policy whereby a 15 foot swath is to be regularly mowed and cleared of brush makes future survival of trees and shrubs on the camas road nearly impossible.

Future monitoring of the Camas Creek Road Hydro-mulch Project should track longer-term success of hydro-seeded material. Additional monitoring will also determine how well native species can compete with rhizomatous weedy grasses over time under rigorous annual herbicide application. It is difficult to combat exotic grasses under any conditions but especially when they are present at the beginning of a revegetation project. Success of hydro-seeded species in this project should not necessarily be extrapolated to all future scenarios.

This project should be monitored in 2019, ten years after revegetation.

Table 27. Camas Creek Road Hydro-mulch Project: Canopy Cover of Species (%) by Plot, 2004-2009.

	MD-04-01				MD-04-02				MD-04-03				MD-04-04				MD-04-05				MD-04-06			
	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009
Bare ground			T	T			0	T			0	T			0	1			2	T			0	2
Basal Vegetation			3	5			2	3			2	4			3	5			3	4			2	3
Moss			10	24			23	45			35	50			40	50			1	6			35	44
Gravel			5	1			15	7			20	4			12	3			25	12			15	6
Litter			82	70			60	45			43	42			45	41			69	78			48	45
Wood																T				T				
SPECIES	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009
TREE	T	T	2-	2-	T	T+	2	T	0	T	1	T	T	T	T+	T	T	T	0	0	T	T	0	0
conifer seedlings	T	T	T		T					T			T				T							
<i>Abies lasiocarpa</i>											1	T									T	T		
<i>Pinus contorta</i>		T	2-	2*		T+	2	T		T				T	T									
<i>Pseudotsuga menziesii</i>														T^				T			T	T		
<i>Larix occidentalis</i>				T*											T+	T								
SHRUB	T	T	T	0	0	0	2	0	T+	2	0	0	0	0	T	0	T	T	0	0	T	T	T	0?
<i>Arctostaphylos uva-ursi</i>		T					2 (dying)		T+	2														
<i>Salix bebbiana</i>																					T	T		
<i>Salix boothii</i>	T	T	T																					
<i>Spiraea betulifolia</i>																	T	T						
<i>Paxistima pyrsinites</i>															T								T	
NATIVE FORB	T	2	7	2	0	1	21	8	1	2	1+	T	1	1	T	T	11	8	25	7	2	1	T	0?
<i>Achillea millefolium</i>																	T	T						
<i>Anaphalis margaritacea</i>														T^			2	2	13	T		T		
<i>Anemone multifida</i>	T	T	1																					
<i>Antennaria bonellii</i>			T	T						T				T			2	3	3	1				
<i>Arabis drummondii</i>																						T		
<i>Arabis sp.</i>		T									T	out of plot												
<i>Arnica sp.</i>																	T							
<i>Aster laevis</i>																		T		T				
<i>Botrychium multifidum</i>		T	T	T									T	T										
<i>Castilleja miniata</i>																								
<i>Chamerion angustifolium</i>	T										T								1-					
<i>Cerastium arvense</i>	T		T								T								2				T	
<i>Collomia linearis</i>			T				T	T		T									T			T	T	
<i>Collinsia parviflora</i>		1	2			T+	20	8	T	T	1	T			T	T	4-				1-		T	
<i>Equisetum arvense</i>																						T^		
<i>Fragaria virginiana</i>									1-	T+	T			T			T	T			T+	T		
<i>Galium boreale</i>									T	T														
<i>Gentianella amarella</i>		T	T							T														
<i>Microsteris gracilis</i>		T	1			T	T+			T	T		T	T	T		1	T			1	T		
<i>Penstemon confertus</i>										1							T+	1		3				
<i>Rhinanthus crista-galli</i>										T				T				T	5					
<i>Senecio pseudolaurens</i>	T	T+	2	2				T					T+	T^										
<i>Solidago canadensis</i>																	1	1^	3	2+				
<i>Spiranthes romanoffiana</i>																		T						
<i>Viola spp.</i>																	T							
NATIVE GRASSES	2	1	9	17	T	T+	2	5+	12	31	25	16	8	7	27	13	1	2	4	4	1	4	2	2
<i>Agrostis scabra</i>		T																1						
<i>Carex microptera</i>		T+								T+												T		
<i>Carex rossii</i>				2										T+		1		1		1				T
<i>Carex spp.*</i>	T+		T+					T																

	MD-04-01				MD-04-02				MD-04-03				MD-04-04				MD-04-05				MD-04-06			
	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009	2004	2005	2007	2009
<i>Danthonia intermedia</i>	T+	T	4	4	T	T+	1+	1+				T			T	T		T			T+	2+	2	1
<i>Deschampsia caespitosa</i> ?	T																							
<i>Elymus glaucus</i>															T				T			T		
<i>Elymus trachycaulus</i> v. <i>trachycaulus</i>									T	T							1		T		T+	1		
<i>Festuca idahoensis</i>			2	7			T+	3	12	30	25	15	8	6	25	12	T		T	2+			T	1
<i>Koeleria macrantha</i>		T	T+							T									T	T				
<i>Poa palustris</i>	T																							
<i>Stipa nelsonii</i>																		T		T				
Grass spp. (unknown)*									T								T							
<i>Carex petasata</i>			T	2																				
<i>Pseudoroegneria spicata</i>			T	T			T	1			T	1			T	T			T	T				T
<i>Trisetum spicatum</i>																							T	T
<i>Carex pachystachya</i>			2	2			T				T				2				4				T	
<i>Carex concinnoides</i> ?				T												T								
EXOTIC FORB	29	16	6	6	7+	15	T	T	2	5	T	1-	3	10	2	1-	21	43	18	10	11	29	4	3
<i>Arenaria serpyllifolia</i>		T		1	5+			T				T				T								
<i>Centaurea maculosa</i>	T				T																			
<i>Cerastium fontanum</i>	T													T				1+	3	T		T		
<i>Chrysanthemum leucanthemum</i>		T			T	T			T	T							T	T^			T	1^		
<i>Cirsium arvense</i>					T																			
<i>Hieracium aurantiacum</i>																	T+	T+						
<i>Hypericum perforatum</i>	7	1	T		T	T	T		T	1			T	4^				T^	T	T	1	2^		
<i>Medicago lupulina</i>					1+				T+															
<i>Melilotus officinalis</i>		T																						
<i>Myosotis micrantha</i> ?					T	T			T															
<i>Potentilla argentea</i>										T														
<i>Potentilla recta</i>					T				T									T						
<i>Prunella vulgaris</i>			2						1+	3	T	T	3	6	2	T	T	T	T	T		T		
<i>Silene cucubalis</i>	2	9	4	5	T+	T		T						T	T	T	4	14	8	4	T	T		
<i>Taraxacum officinale</i>																	T							
<i>Trifolium agrarium</i>						14				T							15	20^				T		
<i>Trifolium hybridum</i>																	1	2				T		
<i>Trifolium spp.</i>																	T							
<i>Verbascum thapsis</i>	20	5	T		T	T								T										
<i>Veronica officinalis</i>		T		T						T	T	T				T	T	5	7	5	10	25	5	3
<i>Veronica serpyllifolia</i>		1	T	T				T				T		T				T		T		T		
EXOTIC GRASS	13	63	39	46	33	35	37	30	12	12	51	43	16	20	53	42	12	22	38	50	18	20	60	41
<i>Agrostis stolonifera</i>	T	T	5	T			1		3	2	8	2	T+	2+	9		4	4	15		1+	T	10	2
<i>Bromus inermis</i>		2	8	8	3	35	35	30	3+	2	20	30	3	2	18	20	3	6	8	25	10	15	26	28
<i>Dactylis glomerata</i>		T	1	10									2+	2	9	7	2	1	1+	5		T	T	T
<i>Festuca arundinacea</i>	10	60	7	15									2	2	4	2	T	T			T	1	1	1
<i>Phalaris arundinacea</i>																	1	2	4					
<i>Phleum pratense</i>	3	1	8	3	30	T	1	T	4-	5	15	8	8	11	16	10	2	8	9	30	4	3	14	8
<i>Poa compressa</i>	T	T	8	8		T	T		2	T	5	3			T	1					2	T	9	3
<i>Poa pratensis</i>	T		2	2						3	3	T	T					T			T	T	T	T
<i>Elymus repens</i>															1	2			T				T	T

*= shriveled; sprayed

! Due to the late start date for this project, plots were read in early October when plant ID was difficult; FESSUB in 2004 was actually FESARU, Grass with bent awn was DANINT

^ appeared to be affected by herbicide treatments

VIII. 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.

- To reduce noxious weed species using a combination of herbicide and revegetation.
- To restore native vegetation to areas opened up by the removal of non-native species, thus preventing other exotic plant invasion.
- 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 and 2009, 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. These sites are proposed to be spot sprayed in the spring of 2010 and then will be seeded in the fall with a proposed seed mix.

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 and 2009, 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 should be spot sprayed in the spring of 2010 and then seeded in the fall with a proposed seed mix.

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 28. St. Mary Weed Revegetation Project: Canopy Cover (%) by Species for all plots, 2008-2009.

(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

Species	WEED REVEG 08-01				WEED REVEG 08-02				WEED REVEG 09-01	
	2008		2009		2008		2009		2009	
	Ocular Cover (1)	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
<i>Populus tremuloides</i>	T									
TOTAL NATIVE SHRUB		4.3 (2)		0.56		3.80		1.80		3.91
<i>Amelanchier alnifolia</i>	T					1.95		1.60		0.85
<i>Arctostaphylos uva-ursi</i>		0.55		0.35						0.80
<i>Dasiphora floribunda</i>		0.90	1.5	0.06	T					1.75
<i>Rosa acicularis</i>		1.65								
<i>Rosa woodsii</i>		1.20		0.16		1.85		0.20		0.51
<i>Prunus virginiana</i>	T				T					
TOTAL NATIVE GRASS		3.24		10.12		7.40		21.74		9.01
<i>Carex sp. (at least 3, inc rossii)</i>		1.48		4.51		2.81		5.85		4.10
<i>Danthonia intermedia</i>		0.01		0.01		0.07		0.41		
<i>Pseudoroegneria spicata</i>		0.05				0.39		2.61		
<i>Elymus trachycaulus ssp. trach.</i>				0.76		0.06		0.40		0.10
<i>Festuca campestris</i>		0.67		2.31		0.51		1.36		0.90
<i>Festuca idahoensis</i>		0.81		1.11		0.77		2.46		1.95
<i>Helictotrichon hookeri</i>						0.15				
<i>Koeleria macrantha</i>		0.13		0.95		1.41		3.01		1.41
<i>Poa secunda ssp. juncifolia</i>						0.20				
<i>Stipa nelsonii</i>		0.01		0.11		0.33		0.56		0.05
<i>Stipa richardsonii</i>		0.10		0.38		0.73		5.11		0.50
TOTAL NATIVE FORB		23.76		13.57		19.45		13.59		14.94
<i>Achillea millefolium</i>		0.48	T			0.57		0.06		
<i>Allium cernuum</i>						0.11		0.11		
<i>Androsace septentrionalis</i>						0.86				
<i>Anemone multifida</i>		0.36	T					0.40	T	0.05
<i>Antennaria anaphaloides</i>		0.05		0.25						0.15
<i>Antennaria rosea</i>		0.15		0.05	T					
<i>Arabis nuttallii</i>	T	0.00		0.01				0.05		0.01
<i>Arenaria capillaris</i>						0.71		0.70		
<i>Arnica sororia</i>						0.46				
<i>Aster campestris</i>								1.05		
<i>Aster laevis</i>		0.56		0.10						0.05
<i>Agoseris glauca</i>				0.11						0.21
<i>Campanula rotundifolia</i>		1.01		0.05		0.46		0.01		0.01
<i>Cerastium arvense</i>		4.66		2.91		2.55		1.26		8.31
<i>Comandra umbellata</i>			T			0.06		0.25		

Table 28 (cont.). St Mary Weed Revegetation Project: Canopy Cover (%) by Species for all plots, 2008-2009

	WEED REVEG 08-01				WEED REVEG 08-02				WEED REVEG 09-01	
	2008		2009		2008		2009		2009	
Species	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>Erigeron speciosus</i>		2.62		0.20		0.05			T	
<i>Erigeron caespitosus</i>						3.06		1.50		
<i>Fragaria virginiana</i>		3.70		2.65						1.70
<i>Gaillardia aristata</i>		0.26				0.30		0.01		
<i>Galium boreale</i>		0.71		0.05		1.21		0.20	T	
<i>Galium triflorum</i>						0.35				
<i>Geranium viscosissimum</i>	T		T							0.20
<i>Geum triflorum</i>						0.45		0.50		
<i>Hedysarum sulphurescens</i>		0.10				4.30		0.50		
<i>Heterotheca villosa</i>					T		T			
<i>Lithospermum ruderae</i>		0.65		0.80		1.45		0.86		0.05
<i>Lupinus sericeus</i>		3.86		1.90		0.95		0.45		0.15
<i>Lomatium triternatum</i>		2.21		3.30			T			3.25
<i>Monarda fistulosa</i>					T					
<i>Penstemon confertus</i>		1.35		0.35		0.11		0.15		0.10
<i>Polemonium pulcherrimum</i>							T			
<i>Potentilla gracilis</i>		0.86		0.31			T			0.41
<i>Potentilla hippiana</i>			T						T	
<i>Potentilla pensylvanica</i>						0.06				
<i>Selaginella densa</i>								3.60		
<i>Senecio canus</i>		0.20				0.20	T			
<i>Sisyrinchium montanum</i>		0.06				0.06	T			
<i>Solidago multiradiata</i>		0.15		0.55		1.05		1.80		0.31
<i>Viola adunca</i>						0.11				
<i>Zigadenus venenosus</i>					T			0.15		
TOTAL EXOTIC GRASS		0.53		1.11		2.57		6.76		2.32
<i>Agrostis stolonifera</i>		0.12								
<i>Phleum pratense</i>		0.22		0.36		1.37		5.21		0.17
<i>Poa compressa</i>		0.01								
<i>Poa pratensis</i>		0.19		0.75		1.20		1.55		2.16
TOTAL EXOTIC FORB		44.68		0.10		37.37		0.05		0.36
<i>Centaurea maculosa</i>		44.25				37.15	T			0.01
<i>Taraxacum officinale</i>		0.06		0.10		0.06				0.35
<i>Tragopogon dubius</i>		0.38				0.16		0.05	T	
# of CENMAC plants		118.65		0		97.05		0		0.10

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 sulphureum* 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% *Phleum pratense* 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 early July 2009, after most of the area had been sprayed three times. Similar trends from plots 08-01 and 08-02 include significant increases in total native grass cover and significant declines in exotic forb cover. Overall native forb cover and overall shrub cover each significantly decreased on plot 08-01, while decreasing only slightly on plot 08-02. Conversely, exotic grass cover significantly increased on plot 08-02 while only increasing somewhat on plot 08-01. There was no tree cover detected in either plot in any year.

The significant decline of exotic forbs was the most dramatic, decreasing from 44.7% to 0.1% cover on plot 08-01 and from 37.4% to 0.05% cover on plot 08-02. This was due almost exclusively to the significant decrease of *Centaurea maculosa* which completely or almost disappeared from both plots after spraying (Table 28). *Tragopogon dubius* significantly decreased on plot 08-01, disappearing from the plot in 2009, while decreasing somewhat on plot 08-02. *Taraxacum officinale*, the only other non-native forb documented at this site, disappeared from plot 08-02 while remaining about the same cover on plot 08-01.

Total native grass exhibited the next most dramatic change, significantly increasing from 3.2% to 10.1% cover on plot 08-01 and from 7.4% to 21.7% cover on plot 08-02. *Carex* spp., *Festuca campestris*, and *Koeleria macrantha* significantly increased on both plots, becoming three of the most dominant native grasses of the site (Table 28). *Stipa richardsonii* significantly increased on plot 08-02 while increasing only somewhat on plot 08-01. *Elymus trachycaulus* ssp. *trachycaulus*, *Festuca idahoensis*, and *Stipa nelsonii* each had small increases on both plots, although results were not statistically significant. *Festuca idahoensis* and *Stipa richardsonii* are also dominant grasses at this site. Interestingly, cover of both *Danthonia intermedia* and *Pseudoroegneria spicata* significantly increased on plot 08-02, while at the same time decreasing or remaining neutral on plot 08-01. Cover of both of these species was extremely low on plot 08-01 prior to spraying, much lower than on plot 08-02, which may explain their inability to recover after herbicide. Finally, herbicide may have negatively impacted *Helictotrichon bookeri* and *Poa secunda* ssp. *juncifolia* which disappeared from plot 08-02 where they were documented last year.

Like other studies have shown, herbicide application clearly has negative impacts on certain native forbs. The overall native forb decline was due mostly to significant or general decreases in cover of *Achillea millefolium*, *Antennaria rosea*, *Campanula rotundifolia*, *Cerastium arvense*, *Erigeron speciosus*, *Gaillardia aristata*, *Galium boreale*, *Hedysarum sulphureum*, and *Lupinus sericeus* on both plots. In addition, *Androsace septentrionalis*, *Arnica sororia*, and *Erigeron caespitosus*, and *Galium triflorum* significantly decreased on plot 08-02, while general decreases were observed with *Fragaria virginiana* and *Symphyotrichum laeve* on plot 08-01 and *Monarda fistulosa*, *Potentilla pensylvanica*, and *Viola adunca* on plot 08-02. Conversely, a few native forbs appear to benefit from the open space that herbicide application creates. Native forbs that showed some increase in cover include *Comandra umbellata*, *Lomatium triternatum*, and *Solidago multiradiata* on both plots, as well as *Antennaria anaphaloides* on plot 08-01. Several new native forb species were also documented after the repeated herbicide treatments including *Agoseris glauca*, *Aster campestris*, and *Potentilla hippiana* on plot 08-01 and *Polemonium pulcherrimum* on plot 08-02. *Allium cernuum*, *Anemone multifida*, *Arabis nuttallii*, *Arenaria capillaris*, *Geranium*

viscosissimum, *Geum triflorum*, *Heterotheca villosa*, *Senecio canus*, and *Zigadenus venenosus* appear to maintain but not increase their cover with continued herbicide application. Finally, a few species had mixed results, increasing on one plot while decreasing on the other plot. These include *Penstemon confertus*, *Potentilla gracilis*, and *Sisyrinchium montanum* that decreased on plot 08-01 while increasing on plot 08-02, as well as *Lithospermum ruderale* that increased on plot 08-01 while decreasing on plot 08-02. Future data may sort out the trends of these species.

Total exotic grass exhibited increases in cover but in general, they were smaller than anticipated. *Poa pratensis* significantly increased on plot 08-01, although not enough to cause overall exotic grass to significantly increase. On the other hand, *Phleum pratense* significantly increased on plot 08-02, enough to result in a significant increase in overall exotic grass on this plot. These species are the dominant non-native grasses that need to be kept from increasing in the future. Interestingly, *Agrostis stolonifera* and *Poa compressa* disappeared from plot 08-01 where they were documented in 2008. This is unusual as both of these exotic grasses tend to increase with disturbance. Cover of both species last year, however, was very low.

Finally, shrub cover was also negatively impacted by herbicide application, particularly on plot 08-01 where shrubs significantly declined. Both plots decreased in cover, due mostly to significant decreases of *Rosa woodsii* on both plots. *Dasiphora floribunda* and *Rosa acicularis* also both significantly decreased on plot 08-01 with *R. acicularis* disappearing altogether. Trace cover of *D. floribunda* also disappeared from plot 08-02. Lastly, trace cover of *Prunus virginiana* disappeared from both plots. Both *Amelanchier alnifolia* and *Arctostaphylos uva-ursi* maintained their cover since last year.

Since pre-herbicide data is not available for plot 09-01, no comparisons can be made for this plot since spraying. Plot 09-01 is generally similar to plant composition of plot 08-01 that is nearby on the flat part of the meadow except for shrub cover. In comparison, shrub cover is much higher on plot 09-01 than on plot 08-01. *Dasiphora floribunda* dominates the shrubs with 1.8% cover and *Amelanchier alnifolia*, *Arctostaphylos uva-ursi*, and *Rosa woodsii* each provide an additional 0.5 to 0.9% cover. Like plot 08-01, however, plot 09-01 is currently dominated by native forbs with 14.9% cover. *Cerastium arvense* has the highest cover of any species on this plot at 8.3%, much higher cover than on the other two plots where this species has moderate cover. Other dominant forbs are similar to plots 08-01 and 08-02 and include *Fragaria virginiana* and *Lomatium triternatum*, with notable cover from *Potentilla gracilis*, *Solidago multiradiata*, and *Agoseris glauca*. Overall native grass cover is the lowest of the three plots at 9.01%, although dominant grasses remain similar and include *Carex spp.*, *Festuca idahoensis*, *Koeleria macrantha*, and *Festuca campestris*. Finally, similar to the other plots, exotic cover remains low. Overall exotic forb cover is 0.36%, dominated almost exclusively by *Centaurea maculosa* at 0.35%. Overall exotic grass cover is 2.3%, dominated by *Poa pratensis*.

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.

Table 29. Camas Creek Overlook Weed Revegetation Project: Canopy Cover (%) by species, 2008-2009
(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

Species	WEED REVEG 08-03			
	2008		2009	
	Ocular Cover (1)	Average Cover	Ocular Cover	Average Cover
TOTAL NATIVE TREE *		4.55		1.75
<i>Larix occidentalis</i>	1	0.05		0.50
<i>Picea engelmannii</i>		4.50		1.25
<i>Populus balsamifera</i>			<i>T</i>	
<i>Pseudotsuga menziesii</i>	<i>T</i>		<i>T</i>	
TOTAL NATIVE SHRUB **		1.85		2.66
<i>Rosa woodsii</i>		1.10		2.66
<i>Salix drummondiana</i>		0.75	<i>1</i>	
<i>Spiraea betulifolia</i>	<i>T</i>			
TOTAL NATIVE GRASS		9.82		12.96
<i>Bromus carinatus</i>				0.01
<i>Danthonia intermedia</i>		0.01		
<i>Elymus glaucus</i>		0.32		
<i>Elymus trachycaulus?</i>				0.56
<i>Festuca idahoensis</i>		5.30		6.30
<i>Koeleria macrantha</i>		3.95		6.11
<i>Festuca occidentalis</i>		0.05		
<i>Poa interior</i>		0.20		
TOTAL NATIVE FORB		15.94 (2)		7.29
<i>Achillea millefolium</i>		4.26		1.87
<i>Antennaria rosea</i>	<i>T</i>		<i>T</i>	
<i>Antennaria howellii</i>			<i>T</i>	
<i>Aster sp.</i>	<i>T</i>		<i>T</i>	
<i>Collinsia parviflora</i>				0.11
<i>Collomia linearis</i>				0.06
<i>Epilobium brachycarpum</i>		0.52		0.01
<i>Fragaria virginiana</i>		1.90		0.15
<i>Gnaphalium palustre</i>		0.33		0.13
<i>Lupinus sericeus</i>	<i>T</i>		<i>T</i>	
<i>Microsteris gracilis</i>		1.62		0.12
<i>Penstemon confertus</i>		6.00	3	3.86
<i>Potentilla gracilis</i>		0.10	<i>T</i>	
<i>Solidago canadensis</i>		0.15	<i>1</i>	0.15
<i>Senecio sp.</i>	<i>in area</i>			
<i>Symphyotrichum laeve</i>		0.95		0.85
<i>Unknown 1 Hairy alternate lvs (solidago like)</i>		0.11		
<i>Viola sp.</i>		0.01		
TOTAL EXOTIC GRASS		4.83		5.37
<i>Agrostis stolonifera</i>		2.50		0.71
<i>Bromus inermis</i>		0.01		0.30
<i>Elymus repens</i>		0.61		
<i>Phleum pratense</i>		1.51		3.27
<i>Poa compressa</i>				0.30
<i>Poa pratensis</i>		0.21		0.80
TOTAL EXOTIC FORB		14.54		7.36
<i>Arenaria serpyllifolia</i>		0.61		0.46
<i>Centaurea maculosa</i>	<i>in area</i>			
<i>Cirsium arvense</i>	<i>T</i>			
<i>Hieracium piloselloides</i>		6.40		0.02
<i>Hypericum perforatum</i>	<i>in area</i>			
<i>Leucanthemum vulgare</i>	<i>T+</i>			0.01
<i>Myosotis micrantha</i>		0.61		0.33
<i>Medicago lupulina</i>		5.61		4.53
<i>Melilotus sp.</i>			<i>T</i>	
<i>Rumex acetosella</i>		0.40		0.26
<i>Taraxacum officinale</i>		0.81		1.36
<i>Thlaspi arvense</i>		0.01		
<i>Tragopogon dubius</i>		0.11		0.41
<i>Trifolium pratense</i>	<i>T</i>			
<i>Veronica peregrina</i>				0.01
<i>Verbascum thapsus</i>	<i>T</i>			
<i>Vicia villosa</i>	<i>T</i>			
# of HIEPIL rosettes		9.10		0.20

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: Similar to results at St. Mary Campground, spraying of herbicide at the Camas Overlook site caused both exotic and native forbs to significantly decrease and caused grass to generally increase. Unlike the St. Mary area where shrubs declined, shrub cover at the Camas Overlook site generally increased.

Despite being statistically significant, the decrease in overall exotic forb cover was not as dramatic as at the St. Mary site. Exotic forbs at the Camas Overlook site decreased from 14.5% to 7.4% this year, due mostly to the significant decline of the targeted *Hieracium piloselloides* that decreased from 6.4% to 0.02%. Density of this species declined as well, decreasing from 9.2 rosettes/0.25 m² to 0.2 rosettes/0.25m². All other weed species basically maintained their cover despite herbicide treatment. Some species, particularly *Taraxacum officinale* and *Tragopogon dubius*, increased slightly in cover. Herbicide application at this site is clearly controlling the target weed species but not impacting other weed species, particularly weedy legumes, as effectively as it has in other areas.

Native forbs significantly decreased from 15.9% to 7.3% cover at the Camas Overlook site. This decrease is over a 50% decline, a slightly higher percentage than at the St. Mary site. Declines were due mostly to significant decreases of *Achillea millefolium*, *Epilobium brachycarpum*, *Fragaria virginiana*, and *Microsteris gracilis* and a notable decrease of *Penstemon confertus*. *A. millefolium*, *F. virginiana*, and some *P. confertus* showed similar declines at the St. Mary site. At the same time, several species maintained their cover and three new species were detected at the site. Species that maintained their cover include *Gnaphalium palustre*, *Lupinus sericeus*, *Potentilla gracilis*, *Solidago canadensis*, and *Symphotrichum laeve*. New species included *Antennaria howellii*, *Collinsia parviflora*, and *Collomia linearis*. By comparison, *L. sericeus* and some *P. gracilis* decreased at the St. Mary site.

Native grass increased at the Camas Overlook site but results were not as dramatic as they were at the St. Mary site nor were the results statistically significant. Overall native grass increased from 9.8% to 12.9% cover becoming the lifeform with the highest cover. The increase was due to small increases of *Festuca idahoensis*, *Koeleria macrantha*, and *Elymus trachycaulus*, a grass new to the site. These same grasses showed similar increases at the St. Mary site. Several native grass species, however, disappeared altogether since last year, including *Danthonia intermedia*, *Elymus glaucus*, *Festuca occidentalis*, and *Poa interior*. Covers of these grasses were relatively low last year but their disappearance is odd given their persistence in other areas that are treated with herbicide. *Bromus carinatus* was newly observed at this site with trace cover.

Exotic grass cover at Camas Overlook followed similar trends to exotic grass cover at the St. Mary site, both increasing but not as dramatically as seen in other projects. Overall exotic grass cover increased from 4.8% to 5.4% cover, due mostly to a significant increase of *Pheum pratense* and a general increase of *Poa pratensis*. *Bromus inermis* also had a small increase in cover and *Poa compressa* was observed for the first time at this site. Countering these increases was a significant decrease of *Agrostis stolonifera*, similar to the St. Mary site, and the disappearance of *Elymus repens*. Again, this is an unusual result as both of these exotic grasses tend to increase with disturbance.

Finally, trees and shrubs had opposing results. Total tree cover decreased from 4.6% to 1.8% cover since last year, due primarily to a large decrease in cover of the one *Picea engelmannii* sapling that is within the plot. It may be that herbicide application is negatively affecting this individual tree. Notes were also made that *Larix occidentalis* in the plot appeared to be negatively impacted by herbicide. Total native shrub cover, conversely, increased slightly in cover from 1.9% to 2.7% cover. This was due to a small increase in cover of *Rosa woodsii*. 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 have each been reduced to trace cover after two to three herbicide applications. At the same time, herbicide application has also reduced other non-target exotic forb species, providing additional benefit. Although there are negative impacts of herbicide application, including the loss of certain native forb species, decrease in native forb cover, and the ‘release’ of certain exotic grasses that often opportunistically increase with additional space, these impacts were typically less than observed on other projects. Decrease of native forb cover was less than has occurred on other projects and overall very few native forb species disappeared altogether. Similarly, increases of exotic grass cover were less than observed on other projects with increases only amounting to 1-4%. In addition, native grasses were also ‘released’ with the removal of weed species, increasing dramatically at both project sites.

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 so low.
- (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 2010 and if possible, spot sprayed in the fall of 2010 prior to seeding in the fall. A total of five herbicide applications over a period of 26 months 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 30). Please note in the “mixed impact” column that results were almost always mixed due to the use of two different herbicides (Stinger vs. Milestone) on the three projects.

Table 30. 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>Symphoricarpos albus</i>
<i>Dasiphora floribunda</i>			
<i>Prunus virginiana</i>			
<i>Rosa acicularis/woodsii</i>			
<i>Spiraea betulifolia</i>			
Native forbs			
<i>Achillea millefolium</i>	<i>Antennaria anaphaloides</i>	<i>Allium cernuum</i>	<i>Agoseris glauca</i> (↑ Milestone, ↓ Stinger)
<i>Anemone multifida</i>	<i>Aster campestris</i>	<i>Arabis nuttallii</i>	<i>Androsace septentrionalis</i> (↓ Milestone, ↔ Stinger)
<i>Antennaria rosea</i>	<i>Collinsia parviflora</i>	<i>Arenaria capillaris</i>	<i>Fragaria virginiana</i> (↓ Milestone, ↑ Stinger)
<i>Arnica sororia</i>	<i>Collomia linearis</i>	<i>Arenaria rubella</i>	<i>Galium boreale</i> (↓ Milestone, ↔ Stinger)
<i>Astragalus spp.</i>	<i>Comandra umbellata</i>	<i>Geranium viscosissimum</i>	<i>Microsteris gracilis</i> (↓ Milestone, ↔ Stinger)
<i>Campanula rotundifolia</i>	<i>Lomatium triternatum</i>	<i>Geum triflorum</i>	<i>Penstemon confertus</i> (↓ Milestone, ↑ Stinger)

<i>Cerastium arvense</i>	<i>Polemonium pulcherrimum</i>	<i>Heuchera cylindrica</i>	<i>Potentilla gracilis</i> (↓ Milestone, ↑ Stinger)
<i>Epilobium brachycarpum</i>	<i>Potentilla glandulosa</i>	<i>Heterotheca villosa</i>	<i>Potentilla pensylvanica</i> (not enough info)
<i>Erigeron caespitosus</i>	<i>Potentilla hippiana</i>	<i>Lithospermum ruderale</i>	
<i>Erigeron speciosus</i>	<i>Solidago multiradiata</i>	<i>Polygonum douglasii</i>	
<i>Gaillardia aristata</i>		<i>Senecio canus</i>	
<i>Galium triflorum</i>		<i>Sisyrinchium montanum</i>	
<i>Hedysarum sulphurescens</i>		<i>Solidago canadensis</i>	
<i>Lupinus sericeus</i>		<i>Zigadenus venenosus</i>	
<i>Monarda fistulosa</i>			
<i>Oxytropis</i> spp.			
<i>Rhinanthus crista-galli</i>			
<i>Symphytotrichum laeve</i>			
<i>Vicia americana</i>			
<i>Viola adunca</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</i> spp.		<i>Poa secunda</i>
<i>Poa interior</i>	<i>Elymus trachycaulus</i> spp. <i>trachycaulus</i>		
	<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 31). 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 31 were similar but not always the same species.

Table 31. 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	Positive Impact - tolerant
<i>Gaillardia aristata</i>	Moderately tolerant	Negative Impact - susceptible
<i>Solidago canadensis</i>	Moderately susceptible	Neutral impact - tolerant
<i>Heterotheca villosa</i>	Moderately tolerant	Neutral impact - tolerant
<i>Solidago missouriensis</i> vs. <i>Solidago multiradiata</i>	Moderately tolerant	Positive 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	Negative Impact - susceptible
<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 rudemale</i>	Moderately tolerant	Neutral impact - tolerant
<i>Arabis nuttallii</i>	Tolerant	Neutral impact - tolerant
<i>Cerastium arvense</i>	Moderately susceptible	Negative Impact - susceptible
<i>Arenaria capillaris</i>	Susceptible	Neutral impact - tolerant
<i>Lupinus sericeus</i>	Tolerant	Negative Impact - susceptible
<i>Astragalus miser</i> vs. <i>Astragalus</i> spp	Susceptible	Negative Impact - susceptible
<i>Monarda fistulosa</i>	Tolerant	Negative Impact - susceptible
<i>Zigadenus venenosus</i>	Tolerant	Neutral impact - tolerant
<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	Positive Impact - tolerant
<i>Microsteris gracilis</i>	Tolerant	Negative Impact - susceptible
<i>Androsace occidentalis</i> vs. <i>Androsace septentrionalis</i>	Moderately susceptible	Negative Impact - susceptible
<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	Negative Impact - susceptible
<i>Fragaria virginiana</i>	Tolerant	Negative Impact - susceptible
<i>Collinsia parviflora</i>	Tolerant	Positive 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	Negative Impact - susceptible

Using this 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 2010 and one for one to three years after initial seeding when the area only requires minimal herbicide application (Table 32). Only one seeding prescription is recommended for the Camas Overlook site (Table 33). 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 32. 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 2010

<u>Dominant Grasses</u>	<u>Common Grasses (lower seed rate)</u>	<u>Dominant Forbs</u>	<u>Common Forbs (lower seed rate)</u>
<i>Carex rossii</i>	<i>Elymus trachycaulus</i> <i>ssp. trachycaulus</i>	<i>Antennaria anaphaloides</i>	<i>Geranium viscosissimum</i>
<i>Carex obtusata</i>	<i>Pseudoroegneria spicata</i>	<i>Penstemon confertus</i>	<i>Geum triflorum</i>
<i>Carex petasata</i>	<i>Stipa nelsonii</i>	<i>Solidago multiradiata</i>	<i>Heterotheca villosa</i>
<i>Festuca campestris</i>	<i>Stipa richardsonii</i>		<i>Polemonium pulcherrimum</i>
<i>Festuca idahoensis</i>			
<i>Koeleria macrantha</i>			

Potential forbs, grasses, and shrubs to seed/ plant at later date (1 to 3 years from 2010):

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

Table 33. Recommended Revegetation Species for Camas Creek Overlook Weed Revegetation Site

<u>Shrubs to Plant</u>	<u>Forbs</u>	<u>Grasses</u>
<i>Rosa woodsii</i> *	<i>Antennaria rosea</i>	<i>Elymus trachycaulus</i> <i>ssp. trachycaulus</i>
<i>Shepherdia canadensis</i> *	<i>Fragaria virginiana</i> (plant)	<i>Festuca idahoensis</i>
<i>Spiraea betulifolia</i> *	<i>Lupinus sericeus</i>	<i>Koeleria macrantha</i>
	<i>Penstemon confertus</i>	
	<i>Solidago canadensis</i>	
	<i>Symphyotrichum laeve</i>	

IX. SHUTTLE STOP PHOTOMONITORING

A. BACKGROUND AND PURPOSE

In July of 2007, a shuttle transit system was implemented to reduce traffic on the Going to the Sun Road (GTSR) during road construction. This shuttle system provides free transportation from Apgar to St. Mary for park visitors. Sixteen stops are provided along the GTSR; seven on the west side, including the Apgar Transit Center, eight on the east side, and one at Logan Pass (Figure 25).

The addition of shuttle stops along the road is expected to increase foot traffic at these stops while people wait for shuttles. Additionally, increased traffic in these areas from both humans and vehicles may introduce new weed species or spread existing populations. Photomonitoring of most of these sites was implemented in the spring of 2007 in order to document pre-disturbance vegetation condition and potential subsequent trampling. Subsequent photomonitoring occurred in the fall of 2007, 2008, and 2009.

B. METHODS

Photomonitoring of transit stops began in the spring of 2007, prior to the start of shuttle service, to provide baseline data. On July 3rd, 2007, all sites that were surrounded by vegetation were photographed. General percent cover for vegetation was recorded, along with a vegetation description, weed species present with relative cover for each species (low, medium or high) and any existing disturbance observed. Transit stops were photomonitoring again on September 6th, 2007, September 9th, 2008, and September 14th 2009 (2009 photos in Appendix C).

Fourteen transit stops were monitored. Two sites, Sunrift Gorge and Siyeh Bend, contain both an east-bound stop and a west-bound stop, which were both monitored at each site. The Fish Creek site is no longer a shuttle stop, but was monitored in 2009 anyway since we did not realize it had been removed. We will no longer monitor this site after this year. The Apgar Transit Center, Apgar Village, and Rising Sun Boat Dock were not monitored for this project as these shuttle stops are completely surrounded by concrete and contain no vegetation.

Photomonitoring points were chosen based on existing disturbance that had potential of increasing, areas that appeared to have potential for disturbance, and/or a general overview of the site. Several new photomonitoring points were established in the fall of 2008 and one new photopoint was established in 2009 to capture changes in the stops, such as structural modifications, unpredicted trampling or social trails, and the spread of weeds. Others were removed or modified in 2008 due to major structural changes in the stop locations.

C. RESULTS

Overall vegetative cover ranged from 20% to 95% across sites. Vegetation data for all monitored transit stops is in Table 34. Habitats ranged from forested areas to shrublands to a grass and forb community. Several sites were previously disturbed due to high foot traffic and/or construction. In 2008, five new photopoints were initiated and in 2009 one more was added in response to unpredicted disturbance. For all three years, highly forested sites consistently fared better in terms of trampling than sites with low profile vegetation. Weeds were present in all of the sites for the last two years, compared to ten of the fourteen sites in 2007. The number and cover of weed species has been consistently increasing over the last two years, although there were fewer new weed species found at the stops this year. This is most likely to the dramatic increase in species from 2007 to 2008, so most of the common weed species were already present by 2009. There were nine species of exotic grasses and eighteen species of exotic forbs in fall 2008 in comparison to seven species of exotic grasses and eight species of exotic forbs in spring 2007. No new weed species were added to our total list for all of the transit stops, but there were a total of 14 stops that saw the new establishment of weedy forbs or grasses this year.

1. Fish Creek

The Fish Creek Campground transit stop did not have weeds in 2007. In 2008 and 2009, however, a low cover of *Bromus inermis* was found in front of the ranger station. The island of vegetation across the road from the transit stop sign looks as if it has seen high activity and weed invasion. Another photo monitoring site was added here in 2008. In 2008, the island contained twelve different non-native species. In 2009, cover of *Elymus repens*, *Veronica officinalis*, and *Agrostis stolonifera* decreased, while cover of *Medicago lupulina* increased. One new species, *Taraxacum officinale*, was also found with a low cover. This site has been removed as a shuttle stop and will no longer be monitored.

2. Apgar Campground

In spring 2007, the Apgar Campground shuttle stop did not have any non-native species. In 2008, it had six non-native species present. This year we saw the addition of *Poa pratensis* with a low cover and an increase in cover for both *Trifolium sp.* and *Elymus repens*. All non-native species at this location occur on the social trails from campsites to the transit stop. Social trails seem to be expanding and increasing in numbers (PP26A, PP26B) (Appendix C).

3. Sprague Creek

The Sprague Creek campground has the most non-native species present of all the shuttle stops. In 2007, there were six non-native species with the addition of nine more species in 2008 and the introduction of *Elymus repens* and *Cirsium arvense* in 2009, totaling seventeen non-native species. Cover of *Hypericum perforatum*, *Taraxacum officinale*, *Poa compressa*, and *Linaria vulgaris* all increased this year. This shuttle stop sees the most visitor caused disturbance which is probably the leading cause behind its high weed cover. Disturbance is also still occurring from a signed recommendation to explore a nearby tree. Small social trails are increasing all around the shuttle stop area into the surrounding woods and there has been significant vegetation trampling (PP2, PP2A) (Appendix C). An increase in weed species and cover is also occurring across the road at the entrance to the campground.

4. Lake McDonald Lodge

At Lake McDonald Lodge, the area behind the shuttle stop has been torn up and revegetated due to the construction of the new dorms in the spring of 2009 (PP3A) (Appendix C). Despite this added disturbance, covers remained unchanged from 2008 to 2009 with the exception of *Centaurea maculosa* which went from trace cover in 2008 to 0% cover in 2009.

5. Avalanche

Some of the initial photopoints from 2007 were removed and some additional ones added in 2008 to accurately depict the sites that are being affected by shuttle stop visitors at Avalanche (PP5C, PP5D) (Appendix C). In 2007, there were no non-native species. *Cynoglossum officinale* was observed in 2008 but could not be relocated in 2009. Five other species were discovered this year including *Plantago major*, *Poa pratensis*, *Verbascum thapsus*, *Veronica officinalis*, and *Dactylis glomerata*, each with low to medium/low cover. This site has a lot of tree and shrub cover coming in which will hopefully start to limit future weed invasion.

6. The Loop

Cirsium arvense, *Phleum pretense* and *Lactuca serriola* were missing from the Loop in 2009. *Lactuca serriola* was, however, found within the vicinity of the shuttle stop near the parking area. *Poa pratensis* increased from medium to medium-high cover this year and *Hypericum perforatum* increased dramatically from no cover in 2007 to low cover in 2008 to medium-high cover in 2009. *Trifolium sp.* was found this year with low cover. Disturbance was greatly increased at this site in 2008, mostly due to the road construction (PP06_2008, PP06_2009) (Appendix C). An untreated patch of *H. perforatum* on a cliff above the Loop combined with road construction has led to the high increase of this species at this site.

7. Logan Pass

The Logan Pass shuttle stop seems to still be in constant transition. In 2007, the stop was built to the southwest side of the main entrance of the visitor center along with the addition of a few benches. In 2008, one of the signs was moved to the east below the restrooms of the visitor center and benches were added around its new location and in its previous location. A new photopoint (PP9B) was added in 2008 to monitor the disturbance (Appendix C). In 2009, the original site had all of the vegetation removed and the shuttle stop is being re-done again (PP9A, PP08_2008, PP08_2009) (Appendix C). This constant disturbance and moving of structures is making the Logan Pass stop susceptible to weeds. While no weeds were inventoried in 2007, *Taraxacum officinale* and *Poa compressa* were observed with low cover in 2008 at the disturbed area around the new sign. In 2009, both species had increased in cover and *Phleum pratense* was found with low cover. In terms of trampling, the Logan Pass transit stop is maintaining vegetation cover, likely due to chain fencing that was installed around areas of vegetation.

8. Siyeh Bend

Siyeh Bend (west) has seen a dramatic increase in *Bromus inermis* cover from low in 2007 to high in 2008 and 2009. Six new non-native species were introduced in 2008. In 2009, *Leucanthemum vulgare* was found with low cover in 2009. It was mostly down the side of the hill and is most likely due to the general spread of *L. vulgare* along this area of the GTSR and not necessarily due to activity at the transit stop itself. Overall disturbance seems to be the same.

Siyeh Bend (east) had no weed cover in 2007. In 2008, it had low cover of *Phalaris arundinacea* and one *Plantago major* plant. *Phalaris arundinacea* increased to medium-low cover in 2009, while *Agrostis stolonifera* and *Phleum pratense* became established with low cover. *Plantago major* could not be relocated. Overall, this stop has seen very minimal disturbance. A native species listed on the potential species of concern list was found near the Siyeh Bend (east) transit stop. *Pinguicula vulgaris* (common butterwort), Glacier's only carnivorous alpine plant and a Montana Natural Heritage program Potential Species of Concern, is found nearby. It exists only in fragile seepy areas similar to the one next to this stop and should receive protection.

9. Gunsight Pass

From 2007 to 2008, Gunsight Pass saw weed cover remain the same except for the addition of *Centaurea maculosa* and *Bromus inermis* in 2008, both with low cover. In 2009, cover remained the same except *Trifolium sp.* and *Bromus inermis* both increased from low to medium cover. There are still wide, well traveled social trails here. The one leading into the woods from the shuttle stop (PP25) seems to have seen increased in size this year (Appendix C).

10. St. Mary Falls

Since the benches have been added here, there has been a reduction in social trails since 2008. The benches have made the social trails difficult to access. Two new species, *Poa compressa* and *Trifolium sp.*, became established in 2009 with low cover. *Centaurea maculosa* was found in 2007 and 2008 but could not be located in 2009. Monitoring of the roadside social trail (PP15A) that leads from the St Mary Falls transit stop to the St. Mary Falls trailhead and parking area was expanded upon this year (Appendix C). A separate non-native species list was made due to its size and the amount of disturbance. In 2008, it had nine non-native species present. In 2009, two additional weeds were observed, including *Trifolium sp.* with low cover and *Tragopogon dubius* with medium-low cover. Most of the other covers remained the same except *Poa pratensis* increased from low to medium-low, *Agrostis stolonifera* increased from medium-low to medium, and *Centaurea maculosa* decreased from medium to medium-low.

11. Sunrift Gorge

In 2008, benches were added to the Sunrift Gorge (north) transit stop. Disturbance seems to have been reduced since the addition of the benches. Covers remained the same for all species except *Dactylis glomerata* that increased from medium to high cover and *Hypericum perforatum* that decreased from medium-high to medium cover.

In 2008, two benches were also added to Sunrift Gorge (south), reducing the trampling along the forest edge. This year gravel was put around the benches where there was concern about weed establishment. Weed cover remained the same with the exception of *Dactylis glomerata* and *Poa pratensis* which both increased from low to medium-low cover.

12. Sun Point

Sun Point was not monitored for weeds in 2008 due to construction of a restroom at the 2007 photomonitoring site. This year the bathroom construction was complete and PP18 and PP 19 were modified to include the new stops and disturbance around the restrooms (Appendix C). Six new non-native species were added from the area between the restrooms and the shuttle stop. These include *Bromus inermis*, *Dactylis glomerata*, *Phleum pratense*, *Taraxacum officinale*, *Trifolium sp.*, and *Verbascum thapsus*, each with low to medium covers.

13. Rising Sun

Unlike other transit stop areas, the addition of new benches at Rising Sun in 2008 did not prevent the establishment of a new social trail from the westernmost bench toward Rose Creek. While it appears that there are more grasses and less bare ground this year, it may be beneficial to formalize a trail to the creek (PP22_2008, PP22_2009) (Appendix C). Unfortunately, some of the increased grass cover was due to weedy grasses that increased in cover this year. *Bromus inermis*, *Bromus tectorum*, and *Poa pratensis* each increased in cover at this transit stop. Two new species, *Trifolium sp.* and *Verbascum thapsus*, also became established with low cover.

14. St. Mary Visitors Center

The St. Mary Visitor Center has had no vegetation around the transit stop since construction. Currently, it consists of trampled bare soil that needs revegetation or gravel fill (PP23). This year, weeds are moving into the area, including at least eight new species. A tepee has been removed that was another site of extensive trampling. Weeds remain present around the tepee area with particularly high cover of *Trifolium sp.* (PP23A) (Appendix C).

D. CONCLUSIONS

Overall, there was a large increase in the number of non-native species at all sites in 2008. This year there were a lot fewer new weed species, mainly because most of the common weedy species became established last year. There was a slight increase in many of the new species from 2008 and the appearance of *Trifolium sp.* at many of the sites. *Centaurea maculosa* decreased or disappeared at most of the sites where it was found in 2008. It may have been pulled or treated with herbicide.

Most of the transit stops did not significantly add to local resource impacts over the course of these three seasons. Most social trails around transit stops existed before the stops were established with only a few exceptions. Sprague Creek, Apgar and Rising Sun stops showed considerable signs of increased social trail establishment. At Rising Sun, it is recommended to formalize the trail to the creek. Barriers may need to be installed at Apgar and Sprague Creek to keep visitors in designated areas. It is also recommended that signage should not encourage visitors to participate in activities that require them to leave paved areas and handle vegetation. Further monitoring should take place to determine if more barriers need to be installed to protect vegetation resources. At the site where the potential species of concern are located (Siyeh Bend), efforts should be made to avert tourists from disturbing the area.

Transit stops should be monitored again in the fall of 2010. Photomonitoring should take place, as well as a weed survey to assess any changes in weed cover.

Figure 25. Location of Transit Stops

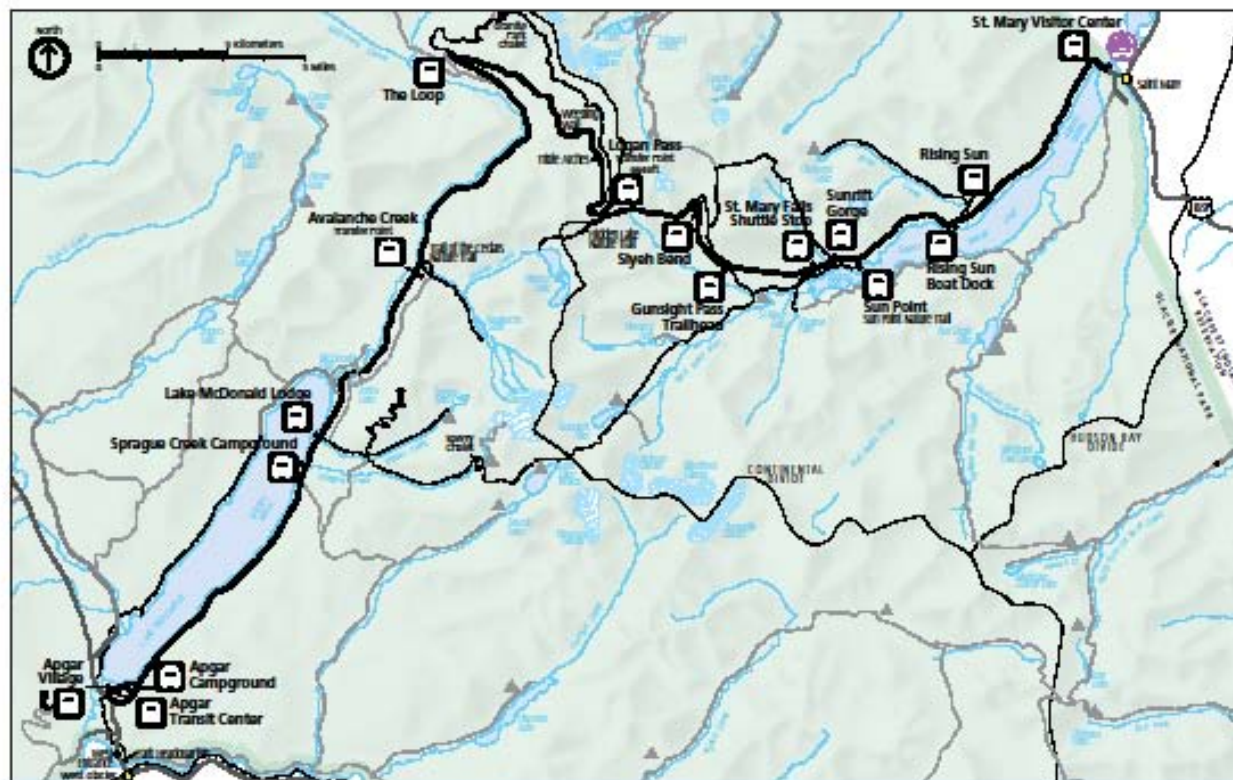
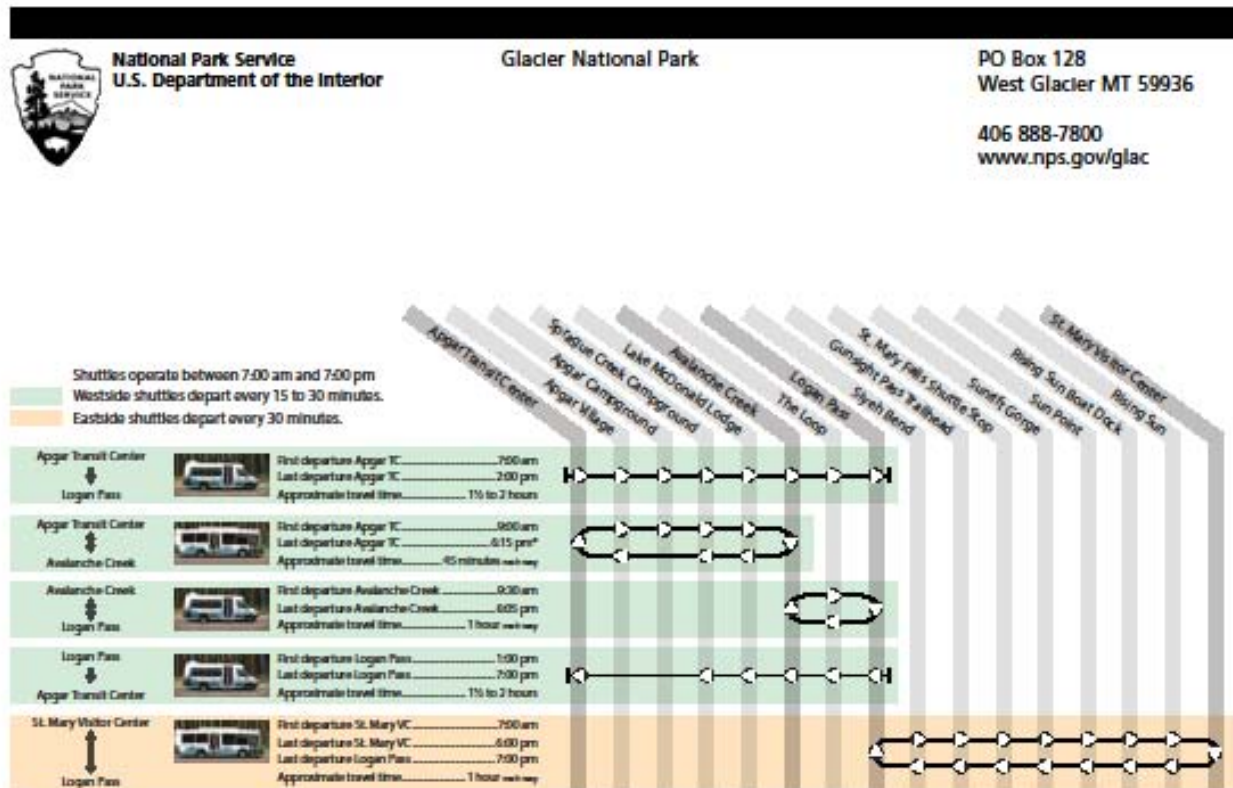


Table 34. Shuttle Stop Monitoring: Vegetation data, 2007-2009

* denotes new species as of 2009. *Black* denotes low cover *Blue* denotes medium low cover *Green* denotes medium cover *Orange* denotes medium high cover *Red* denotes high cover

Transit Stop Site	General % veg. cover	Vegetation Description	Weed species	09 Weed cover (Low,Med.,High)	08 Cover	07 Cover	Existing Disturbance
Fish Creek Campground	40%	THUPLI forest. Understory is mostly covered in needles w/ a little SYMALB.	<i>Bromus inermis</i> *	L	L	None in 2007	Campground Entrance Station.
Fish Creek Campground	60%		<i>Elymus repens</i>	H/M	H	New in 2008	Campground Entrance Station.
Road Island			<i>Melilotus officinalis</i>	M	M		
			<i>Veronica officinalis</i>	M	M/H	was not	
			<i>Medicago lupulina</i>	H	M/H	monitored	
			<i>Poa compressa</i>	L	L	in 2007	
			<i>Plantago major</i>	L	L		
			<i>Poa pratensis</i>	L	L		
			<i>Hypericum perforatum</i>	L	L		
			<i>Agrostis stolonifera</i>	L	M		
			<i>Verbascum thapsus</i>	0	L		
			<i>Linaria vulgaris</i>	L	L		
			<i>Taraxacum officinale</i> *	L	0		
			<i>Cirsium arvense</i>	L	L		
Apgar Campground	95%	Mostly SYMALB with a heavy overstory and XERTEN	<i>Taraxacum officinale</i>	L	L one point	None in 2007	Social trails from campsites to sign area
			<i>Pbleum pratense</i>	M, 26B	M, at 26B		
			<i>Trifolium sp.</i>	L/M, 26B	L, at 26B		
			<i>Plantago major</i>	L, 26B	L, at 26B		
			<i>Elymus repens</i>	M/H, 26B	M, at 26B		
			<i>Poa pratensis</i> *	L, 26B			
			<i>Agrostis stolonifera</i>	M, 26B	M, at 26B		
Sprague Creek Campground	70% (North of sign is ~40%)	High grass cover with some native forb. THUPLI/TSUHET	<i>Bromus inermis</i>	M/H	M/H	M	Two social trails from sign
			<i>Leucanthemum vulgare</i>	H, M across road	M/H	M/H	
			<i>Myosotis stricta</i>	0	0	L	
			<i>Plantago major</i>	M/H	M/H	M	
			<i>Poa pratensis</i>	L	L	M	
			<i>Taraxacum officinale</i>	L/M	L	L	
			<i>Hypericum perforatum</i>	L/M	L		
			<i>Poa compressa</i>	M	L/M		
			<i>Dactylis glomerata</i>	M	M		
			<i>Agrostis stolonifera</i>	M	L		
			<i>Pbleum pratense</i>	L	L		
			<i>Veronica officinalis</i>	L	L		
			<i>Trifolium sp.</i>	L/M	L		
			<i>Trifolium agrarium</i>	L	L		
			<i>Centaurea maculosa</i>	0	L, on social trail behind sign		
			<i>Elymus repens</i> *	L			
			<i>Cirsium arvense</i> *	L/M across road			
			<i>Linaria vulgaris</i>	M across road	L, across road		

Table 34 (cont.). Shuttle Stop Monitoring: Vegetation data, 2007-2009

* denotes new species as of 2009. *Black* denotes low cover *Blue* denotes medium low cover *Green* denotes medium cover *Orange* denotes medium high cover *Red* denotes high cover

Transit Stop Site	General % veg. cover	Vegetation Description	Weed species	09 Weed cover (Low,Med.,High)	08 Cover	07 Cover	Existing Disturbance
Lake McDonald Lodge	60%	High grass with TSUHET,	<i>Bromus inermis</i>	H	H	H	Slight social trail starting
		POPBAL and SYMALB	<i>Dactylis glomerata</i>	L	L	L	Re-veg area @new dorm full of weeds
			<i>Leucanthmum vulgare</i>	L	L	L	Thelaspis arvense (80%) and VERTHA
			<i>Poa pratensis</i>	L	L	M	
			<i>Taraxacum officinale</i>	L	L/M	L	
			<i>Elymus repens</i>	M	M		
			<i>Phleum pratense</i> *	L			
			<i>Trifolium sp. *</i>	L			
			<i>Verbascum thapsus</i> *	L			
			<i>Veronica officinalis</i> *	L			
			<i>Centaurea maculosa</i>	0	L		
Avalanche	85% shrub cover	No weeds, only natives:	None obs. Old site			None	High traffic area
		SYMALB, MAISTE,	<i>Cynoglossum officinale</i>	0	L	in 2007	Tried to pull, lots of open space
		POPBAL	<i>Cirsium sp.*</i>	L			for weeds to invade on edges.
			<i>Veronica officinalis</i> *	L			
			<i>Verbascum thapsus</i> *	L			
			<i>Poa pratensis</i> *	L			
			<i>Plantago major</i> *	L			
			<i>Dactylis glomerata</i> *	L/M			
			<i>Trifolium sp. *</i>	L			
The Loop	70%	POPBAL, POPTRE,	<i>Cirsium arvense</i>	0	L	L	High traffic area, rock wall
		SYMALB, CORSER,	<i>Poa pratensis</i>	M/H	M	M	preventing social trails
		SPIBET, CARMIC	<i>Phleum pratense</i>	0	L		PHPR,VETH, LASE behind
			<i>Verbascum thapsus</i>	L found pulled on ground	L		restroom
			<i>Lactuca serriola</i>	0; L by parking area	L		
			<i>Poa compressa</i>	M	L		
			<i>Trifolium sp. *</i>	L			
			<i>Hypericum perforatum</i> *	M/H	L		
Logan Pass	60%	Very low profile grass/forb	<i>Taraxacum officinale</i> *	M	L/M	None	High traffic area; low-lying area
		CARNIG (?), ERYGRA,	<i>Poa compressa</i>	M	L	in 2007	adj. to sign subject to trampling.
		HERMAX, OXYDIG	<i>Phleum pratense</i> *	L			Some already on E. side of
							easternmost sign. Bare ground
							near newsign has potential
							for weed invasion

Table 34 (cont.). Shuttle Stop Monitoring: Vegetation data, 2007-2009

* denotes new species as of 2009. *Black* denotes low cover *Blue* denotes medium low cover *Green* denotes medium cover *Orange* denotes medium high cover *Red* denotes high cover

Transit Stop Site	General % veg. cover	Vegetation Description	Weed species	09 Weed cover (Low,Med.,High)	08 Cover	07 Cover	Existing Disturbance
Siyeh Bend (West)	20%	Grasses and some small shrubs. Krummholz	<i>Bromus inermis</i>	H	H, down slope	L	Social trails to creek and construction disturbance.
		ABILAS and PICENG.	<i>Centaurea maculosa</i>	L	L	L	
		Abundant gravel.	<i>Taraxacum officinale</i>	L	L	L	
		Social trail already exists	<i>Phleum pratense</i>	L	L		
		on the west side of the	<i>Cirsium arvense</i>	L	L		
		rock barrier.	<i>Cirsium vulgare</i>	L	L		
			<i>Poa compressa</i>	L	L		
			<i>Poa pratensis</i>	L	L		
			<i>Leucanthmum vulgare</i> *	L			
			<i>Tragopogon dubius</i>	0	L		
Siyeh Bend (East)	50%	Seepy area. High moss cover. Salix, Equisetum,	<i>Phalaris arundinacea</i>	L/M	L, S of sign	None	Low disturbance due to
		CARHEY	<i>Plantago major</i> *	0	L, 1 plant	in 2007	stream/ seep, but fragile!
		PINVUL obs. North of this site.	<i>Agrastis stolonifera</i> *	L			
			<i>Phleum pratense</i> *	L			
Gunsight Pass	50%	Weedy grasses	<i>Dactylis glomerata</i>	L/M	L	L	Social trail going down slope.
			<i>Leucanthmum vulgare</i>	L	L	L	
			<i>Phleum pratense</i>	L/M	L/M	L	
			<i>Poa compressa</i>	L/M	L/M	M	
			<i>Poa pratensis</i>	L/M	L/M	M	
			<i>Taraxacum officinale</i>	L/M	L	L	
			<i>Trifolium sp.</i>	M	L	L	
			<i>Bromus inermis</i>	M, H near culvert	L		
			<i>Centaurea maculosa</i>	L	L, NW of sign near culvert		
			<i>Cirsium arvense</i> *	L			
St. Mary Falls	95%	High shrub cover	<i>Bromus inermis</i>	L	L	L	Social trail between first and
		(SYMALB). Some grasses	<i>Centaurea maculosa</i>	0	L	L	second rocks. Grassland
		and sedges.	<i>Hypericum perforatum</i>	L	L	L	susceptible to weed invasion.
			<i>Phleum pratense</i>	L/M	L		BRIN, CEBI, HYPE, way east
			<i>Poa pratensis</i>	L	L		of sign near horse loading zone
			<i>Dactylis glomerata</i>	L/M	L		
			<i>Poa compressa</i> *	L			
			<i>Trifolium sp.*</i>	L			
St. Mary Falls social trail			<i>Bromus tectorum</i>	M/H	M/H	New in	Weeds present along social trail
			<i>Centaurea maculosa</i>	L/M	M	2008	from St Mary falls trailhead
			<i>Hypericum perforatum</i>	M/H	M/H	weeds	parking lot Transit Stop
			<i>Phleum pratense</i>	H	H	were	
			<i>Verbascum thapsus</i>	L	L	monitored	
			<i>Poa pratensis</i>	L/M	L	along	
			<i>Agrastis stolonifera</i>	M	L/M	trail	
			<i>Elymus repens</i>	L	L	in 2007	
			<i>Dactylis glomerata</i>	M	M		
			<i>Trifolium sp.*</i>	L			
			<i>Tragopogon dubius</i>	L			

Table 34 (cont.). Shuttle Stop Monitoring: Vegetation data, 2007-2009

* denotes new species as of 2009. *Black* denotes low cover *Blue* denotes medium low cover *Green* denotes medium cover *Orange* denotes medium high cover *Red* denotes high cover

Transit Stop Site	General % veg. cover	Vegetation Description	Weed species	09 Weed cover (Low,Med.,High)	08 Cover	07 Cover	Existing Disturbance
Sunrift Gorge North	50%	Weedy grasses with some	<i>Bromus inermis</i>	M	M	M	
		native forbs and grasses	<i>Dactylis glomerata</i>	H	M	L/M	
			<i>Pbleum pratense</i>	L	L	L/M	
			<i>Hypericum perforatum</i> *	M	M/H		
			<i>Verbascum thapsus</i> *	L	L		
			<i>Poa pratensis</i> *	L	L		
Sunrift Gorge South	50%	Low shrubs (SPIBET,	<i>Dactylis glomerata</i>	M	M	L	Culvert already here; low
		PAXMYR) and FRAVIR and	<i>Hypericum perforatum</i>	H, down hill	H	M/H	trampling potential beyond
		EURCON under PICENG	<i>Pbleum pratense</i>	M	M	L	gravel.
		canopy	<i>Taraxacum officinale</i>	L	L	L	
			<i>Poa pratensis</i>	L/M	L		
			<i>Verbascum thapsus</i>	L	L		
			<i>Dactylis glomerata</i>	L/M	L		
			<i>Poa compressa</i>	L	L		
			<i>Bromus inermis</i>	L	L		
Sun Point	80%	ARCUVA, FRAVIR,	<i>Centaurea maculosa</i>	0	Not monitored	L	Restroom built in old re-veg area
			<i>Pbleum pratense</i> *	L	due to construction		area between transit benches and
			<i>Taraxacum officinale</i> *	L			restroom now being monitord.
			<i>Dactylis glomerata</i> *	M			
			<i>Bromus inermis</i> *	L			
			<i>Verbascum thapsus</i> *	L/M			
			<i>Trifolium sp.*</i>	L/M			
		PAXMYR	<i>Poa pratensis</i>	L		L	
Rising Sun	70%	High weedy grass cover,	<i>Bromus inermis</i>	M/H	L	H	Social trail to river.
		with some ROSWOO and	<i>Bromus tectorum</i>	M/H	L/M	H	Another access to social trail
		SYMALB. POPBAL	<i>Centaurea maculosa</i>	L/M	L/M	M	forming next to western bench.
		seedlings with FESIDA.	<i>Elymus repens</i>	H, down hill	H	M/H	
			<i>Poa pratensis</i>	M	L		
			<i>Verbascum thapsus</i> *	L			
			<i>Trifolium sp.*</i>	L			
			<i>Pbleum pratense</i>	L	L		
St. Mary	80%	Lawn	<i>Centaurea maculosa</i>	L	L	L	Bare patches from trampling.
			<i>Bromus tectorum</i> *	L			Tepee disturbance gone in 08
			<i>Elymus repens</i> *	L			area filling in with <i>Trifolium</i>
			<i>Trifolium sp.*</i>	M/H			
			<i>Pbleum pratense</i> *	L			
			<i>Taraxacum officinale</i> *	L			
			<i>Thlaspi arvense</i> *	L			
			<i>Chenopodium sp.*</i>	L			
			<i>Sisymbrium altissimum</i> *	L			

X. 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.

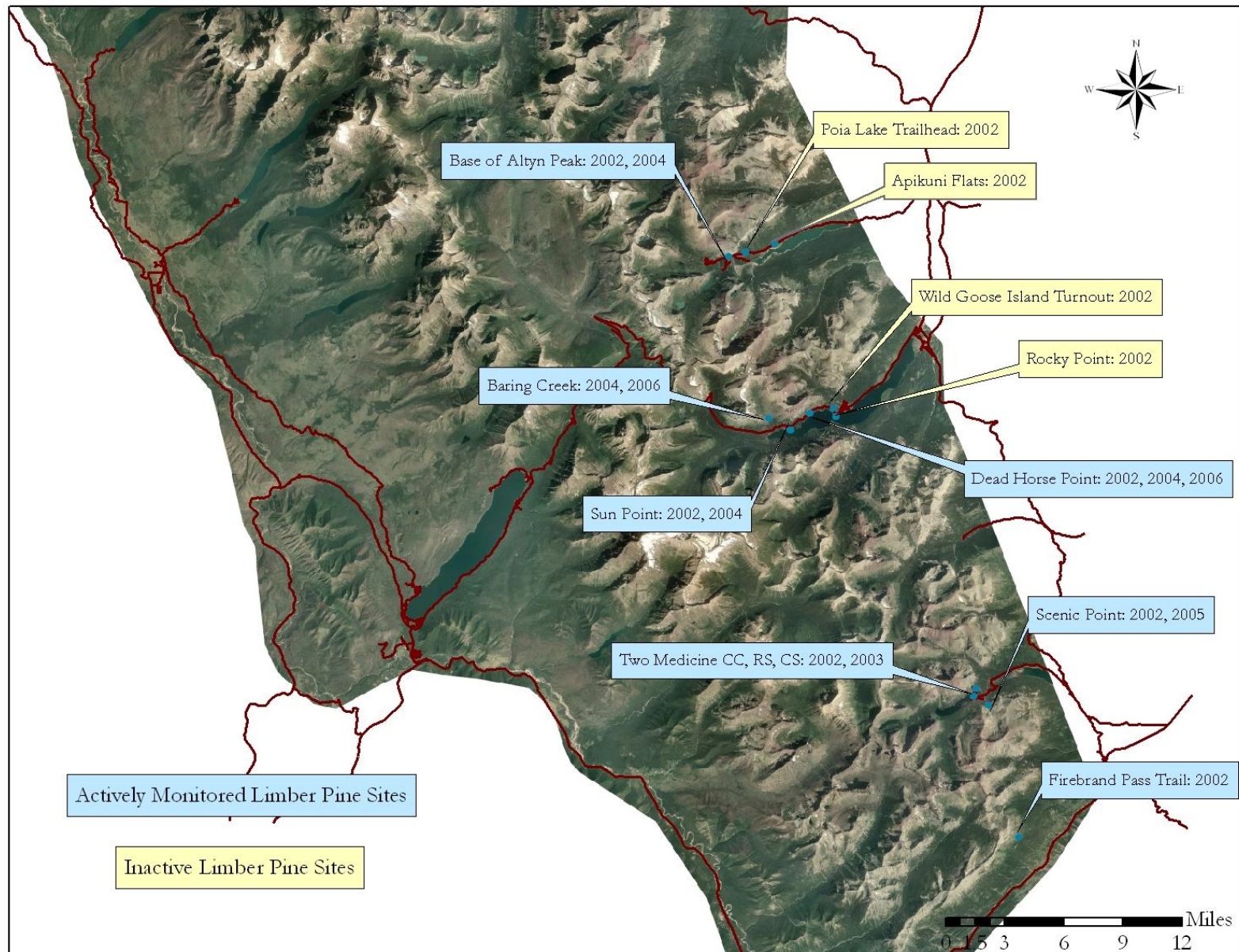
1. Limber Pine

Limber pine seedlings have been planted on thirteen sites, seven of which are still active (Table 35 & Figure 26). A total of 4,778 seedlings have been planted in the park between 2002 and 2006. Plantings

Table 35. 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 26. Limber Pine Seedling Monitoring Sites



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 35).

2. *Whitebark Pine*

Whitebark pine seedlings have been planted at four sites between 2000 and 2007 (Table 36 & Figure 27). Monitoring plots captured 21% of total planted seedlings (Table 36). 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 36. 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	349	23%
	2001 (fall)	11	1,438	285	20%
	2002 (fall)	11	2,222	287	13%
Total		38	5,160	921	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	421	21%
Total		9	2,000	421	21%
Overall Total		56	7,395	1,577	21%

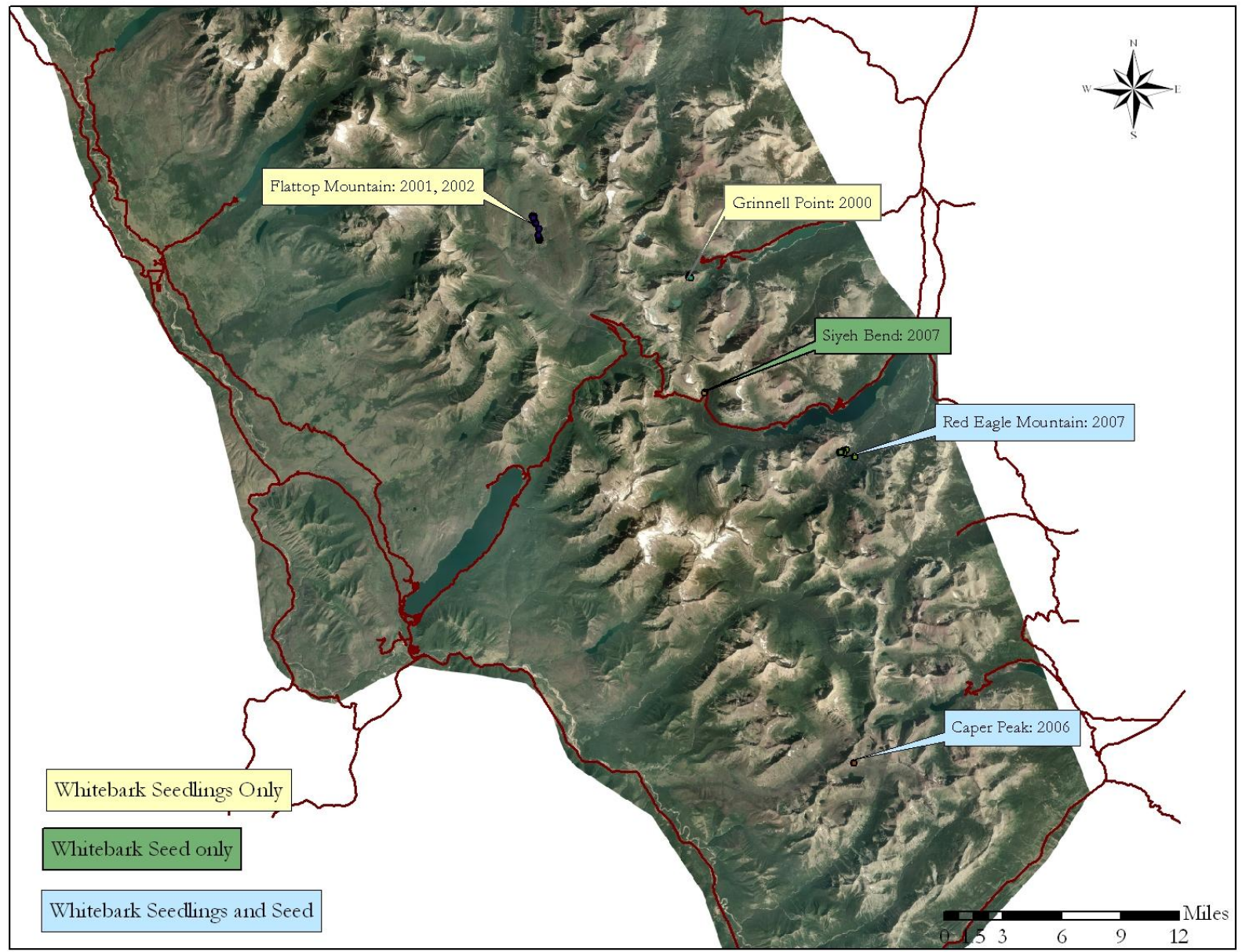
In the fall of 2000, 96 seedlings were planted at Grinnell Point, after the Grinnell Point Fire passed through the site earlier in the season. Plantings in this area range in elevation from 6,560 – 7,320 feet. All seedlings planted at this site were incorporated into monitoring plots. These plots have 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 36). 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 27 & Table 37). 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.

Finally, 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 27). 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 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 37).

Figure 27. Whitebark Pine Seedling and Seed Monitoring Sites



Using the same methodology, there were three additional transects 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 27). 31 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 37).

Table 37. 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	

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, 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.

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, and microsite conditions) 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 sometimes width of whitebark pine seedlings started to be measured (in cm). Size measurements are being recorded for trees at the Flattop Mountain site, Caper Peak and the Red Eagle

site. 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 stake was located and tagged with the location, 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 38). Due to their remote location, these plots were not monitored in 2007 but were monitored in 2009, at year 3 after planting.

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 38). 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 38. 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

A total of four limber pine planting sites were revisited in 2009 with 15 plots monitored. Plots monitored were planted in 2002, 2004 and 2006. "Survival" was determined based on all trees that were rated a 5 (good), 4 (fair), or 3 (almost dead). Two sites, the Two Medicine Camp Store that was planted in 2003

and Scenic Point that had a second planting in 2005, were not scheduled for monitoring in 2009 at year six and year four after planting.

Of the eleven sites planted in 2002, three were still active at the start of 2009. Although these sites were not scheduled for monitoring this year (year seven after planting), two of the three sites were monitored due to the fact that other nearby plots were monitored this year. Data was collected at the base of Altyn Peak and Sun Point, while data was not collected at the third site, Firebrand Pass. Both sites had no live trees left from the 2002 planting. With the assumption that the lone tree at Firebrand Pass is still alive, seven year survival for the 2002 planting is 0.2% (Table 39).

Table 39. 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%

All four sites planted in 2004 were monitored this year, including Baring Creek, Dead Horse Point, and second plantings at the base of Altyn Peak and Sun Point. Overall five year survival is 15% with 36 of

the 238 monitored trees still alive. This is a 10% decrease from year three survival when there was 25% survival in 2007 (Table 40). Most of the decrease occurred at Sun Point which lost 12 of the 16 remaining trees and at Dead Horse Point which lost all of the three remaining trees. The Dead Horse Point planting site is an exposed, hot slope that is also prone to regular avalanche activity, experiencing some level of disturbance on a nearly yearly basis and large scale disturbance on a fairly regular basis. Due to the harshness of the site, and as stated in past reports, this site should not be utilized as a planting site in the future. Sun Point is another dry, semi-exposed site that sees a considerable amount of human disturbance. Survival of limber pine at Baring Creek remained steady at 22% and only one out of 12 trees died at the base of Altyn Peak.

Table 40. 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%

Of the two sites planted in 2006, only Baring Creek is still active and was monitored this year. Baring Creek remained unchanged from 2008 at 4% survival with 3 out of 71 monitored trees still alive (Table 41). All of the trees at Dead Horse Point were dead or missing in 2007, one year after planting, due primarily to avalanche activity. As mentioned above, this site should no longer be considered for future plantings. The considerable decline in survival at Baring Creek after the first year, especially in comparison to the 2004 planting at the same location, is thought to be due to two major influences. First, the area planted in 2006 is an open site with less shade and few microsites, particularly in comparison to the 2004 planting site here that had more microsites. Many seedlings were likely highly exposed with little shade or protection. Second, some of the decrease in survival may be due to the use of seedling protector nets that have been used experimentally to see if they offer seedlings additional shade. One hundred percent of limber pine seedlings monitored in 2006 were planted within nets in comparison to 30% of the monitored limber pine trees planted in 2004. While this also has not been formally tested, it has been observed that these nets appear to negatively impact seedlings, compacting their needles until they turn black and die. Over time, nets have been

opened or removed all together during monitoring events, as they appear to “suffocate” the seedlings. Overall, there appears to be no benefit from using the nets and their use should be discontinued.

Table 41. 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%

Overall survival of limber pine trees at all sites over all years in our monitoring plots is 6%. There should be some anticipation of a small amount of additional mortality given that 2 of the remaining live trees were rated ‘almost dead’ in 2009. Very rarely do trees rated almost dead survive to the following year. Thirty three percent of the remaining live trees have been rated ‘fair’ and 64% of the trees have been rated ‘good’. This is an improvement from 2008 when only 48% of the surviving trees were rated good. Overall, 94% of all planted limber pine trees have died, a 2% increase in mortality since 2008 (Table 42)¹.

Table 42. Health and Survival of Limber Pine Seedlings Monitored in 2009

<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>
Base of Altyn Peak	2002	27	0	0	0	0	0	27	0%
Dead Horse Point	2002	188	0	0	0	0	0	188	0%
Firebrand Pass (Monitored in 2008)	2002	37	0	0	1	0	1	38	3%
Total 2002		584	0	0	1	0	1	585	0.2%
Two Med Camp Store (Monitored in 2008)	2003	24	1	0	1	0	2	26	8%
Total 2003		24	1	0	1	0	2	26	8%
Baring Creek	2004	71	0	7	13	1	20	91	22%
Base of Altyn Peak	2004	28	0	7	5	0	12	40	30%
Dead Horse Point	2004	52	0	0	1	0	1	53	2%
Sun Point	2004	51	0	1	3	0	4	55	7%
Total 2004		202	0	15	22	1	37	239	15%
Scenic Point (Monitored in 2008)	2005	128	1	5	15	0	21	149	14%
Total 2005		128	1	5	15	0	21	149	14%
Baring Creek	2006	68	0	1	2	0	3	71	4%
Dead Horse Point	2006	20	0	0	0	0	0	20	0%
Total 2006		88	0	1	2	0	3	91	3%
Subtotal		1026	2	21	41	1	64	1090	6%
Percentage of Surviving Trees			3%	33%	64%	2%			
Percentage of Monitored Trees		94%	0.2%	2%	4%	0%	6%		6%

¹ Note: there are live trees monitored in 2008 that weren’t monitored this year but included in the counts for survival. There is also one additional tree that was accidentally missed this year and rated ‘unknown’.

2. Whitebark Pine Seedling Results

Two of the four whitebark pine seedling sites were monitored this year near Red Eagle Campground and at Flattop Mountain. Nine plots at Red Eagle were read in 2009 to monitor the success of 2,000 seedlings planted there in 2007. Seven plots were located on the flanks of Red Eagle Mountain while two plots were located near Red Eagle Campground. There were 420 seedlings, or 21% of the planted material, 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. There were 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, we did not capture any seedlings grown from Scenic Point seed (Table 43).

In addition, some new planting amendments are currently being evaluated at Red Eagle. To test their impact on tree survival and growth, 4 planting treatments were tested: (1) Osmocote 13-13-13 fertilizer and watered in when planted; (2) Soil Moist² 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 just 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. Treatments by plot are presented in Table 43. The initial height of these trees is also listed here by treatment. The percent of trees monitored by site and treatment are presented in Table 44.

Table 43. Red Eagle Campground: Planting Amendments & Seed Source

Plot #	Seed Source	# Trees/Plot	Planting Treatment	Average Height (cm)
WB-07-01	Preston Park	49	Water polymer + watered in	12.55
WB-07-07	Preston Park	44	Water polymer + watered in	
WB-07-02	Cobalt Lake	77	Watered in only (control)	11.8
WB-07-03	Preston Park	54	Fertilizer + watered in	14.74
WB-07-04	Cobalt Lake	40	Fertilizer, water polymer + watered in	9.35
WB-07-06	Cobalt Lake	45	Fertilizer + watered in	10.5
WB-07-08	Preston Park	26	Watered in only (control)	All Dead
WB-07-05	Preston Park	48	Fertilizer, water polymer + watered in	9
WB-07-09	Preston Park	37	Fertilizer, water polymer + watered in	All Dead

Table 44. Red Eagle Campground: 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	22.50%
Water polymer + watered in	22.70%
Fertilizer, water polymer + watered in	30.20%
Watered in only (control)	24.60%

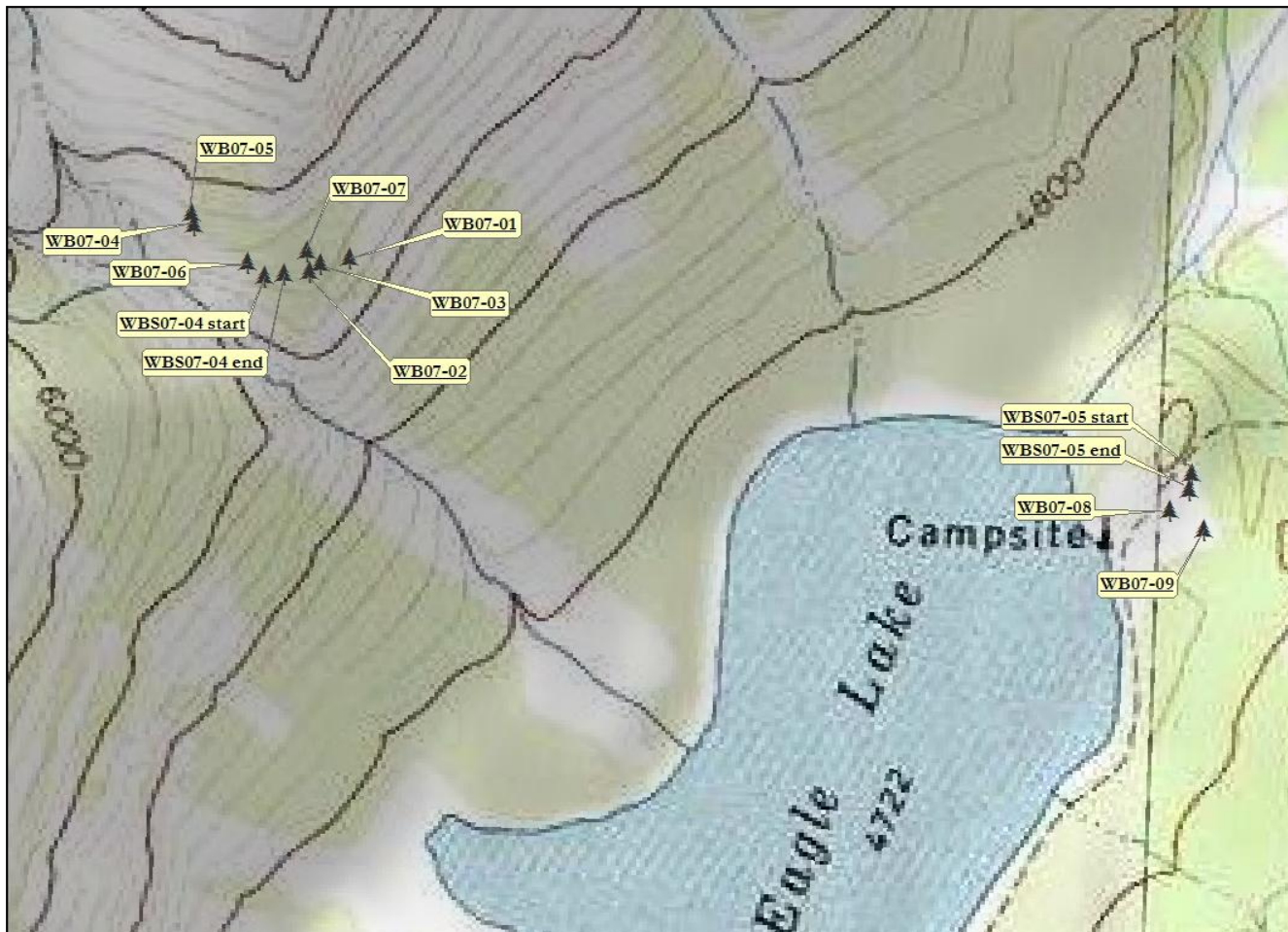
² Soil Moist is a synthetic acrylic polyacrylamide with a potassium salt base. It allows initial rapid intake of water by a portion of the polymer followed by a slower absorption of water by a balance of the polymer. It contains a 5-5-5 fertilizer made from ammonium phosphate, sulfate, and muriate of potash.

Red Eagle plots WB07-08 and WB07-09 are located 85 to 150 meters northeast of the Red Eagle Campground (Figure 28). They are located in a very different habitat from the Red Eagle Mountain sites, thus survival is reported separately. First year survival for the Red Eagle Campground plots was high at 91% in which 86% of the surviving plants were in good condition (Tables 45 and 46). This year all of the trees in both plots were either dead or missing. Overall, this rocky site with little soil and few microsites may not have been a good choice for planting whitebark pine. In the end, the seedlings appeared brittle and dry, in addition to some competition from regenerating herbaceous plants. This site is also susceptible to more human disturbance. The rocky substrate, lack of good planting medium, lack of good microsites, human use, and competing vegetation all contributed to the failure of whitebark seedlings in this area.

Plots WB07-01 through WB07-07 are located on the flanks of Red Eagle Mountain (Figure 28). Although survival rates for whitebark seedlings were much higher at this site in comparison to the campground, average second year survival decreased to 58% this year from 74% average first year survival in 2008 (Table 46). Soil sliding and subsequent seedling burial on the steeper slopes was the main cause of mortality within several plots. Plot WB07-01 had the largest decline in survival from 96% to 31% (Table 45), due primarily to soil slides that buried many of the seedlings. This plot also had fewer microsites than other plots in flatter areas. 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%.

Overall first year survival for all of the plots in the Red Eagle area was 71% with 64% of the surviving trees in good health (Table 46). Second year overall survival was 49% with all of the surviving trees rated as fair or good.

Figure 28. Location of Red Eagle Whitebark Pine Seedling and Seed Plots.



Average height of seedlings in the Red Eagle Mountain plots was 12.3 cm and average width was 14 cm. This is an increase from 2008 when average height was 8.92 cm and width was 9.57 cm. WB07-03, treated with fertilizer, was one of the two plots with the largest trees with heights averaging 14.74 cm and widths averaging 16.06 cm (Table 45). Plot WB07-01, treated with water polymer, also had large trees with heights averaging 14.87cm and widths averaging 16cm. Currently, due to environmental factors such as soil slides, no inferences can be made about the influence of planting treatment on growth or survival. Typically, the seedlings planted in the flatter areas with more microsites had higher survival and greater growth rates.

Table 45. Red Eagle Campground: Percent Survival and Dimensions of Whitebark Pine Seedlings

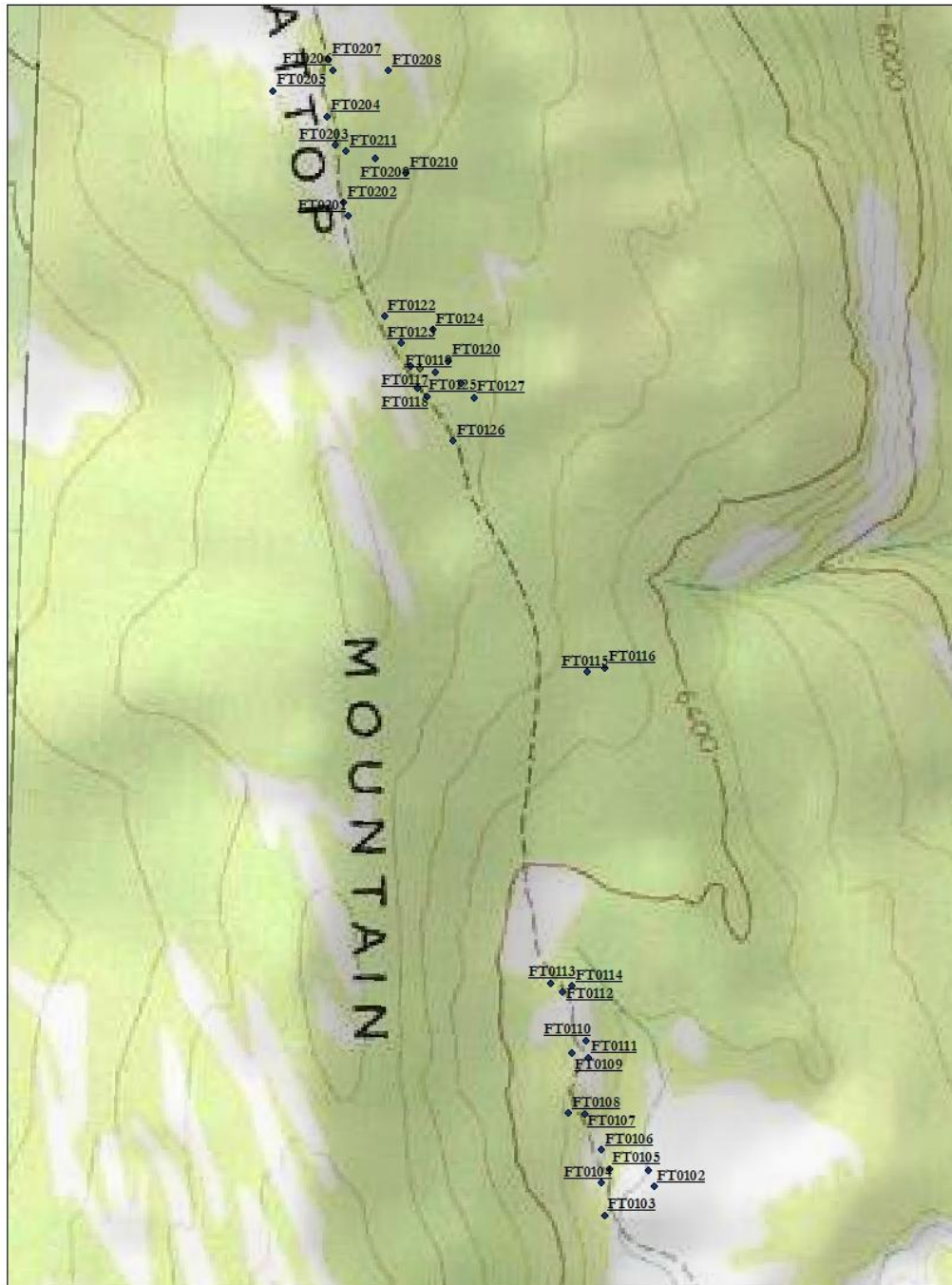
Plot #	Seed Source	# Trees Planted	# Live Trees	08 Survival	09 Survival	Planting Treatment	Avg Height (cm)	Avg Width (cm)
WB-07-01	Preston Park	49	15	96%	31%	Water polymer + watered in	14.87	16
WB-07-07	Preston Park	44	34	89%	77%	Water polymer + watered in	11.53	12.8
WB-07-02	Cobalt Lake	77	64	88%	83%	Watered in only (control)	11.8	13.67
WB-07-03	Preston Park	54	53	98%	98%	Fertilizer + watered in	14.74	16.06
WB-07-04	Cobalt Lake	40	17	53%	43%	Fert, water polymer + watered in	9.35	11.82
WB-07-06	Cobalt Lake	45	12	64%	27%	Fertilizer + watered in	10.5	13.08
WB-07-08	Preston Park	26	0	81%	0%	Watered in only (control)	All Dead or Missing	
WB-07-05	Preston Park	48	12	40%	25%	Fert, water polymer + watered in	9	11.5
WB-07-09	Preston Park	37	0	97%	0%	Fert, water polymer + watered in	All Dead or Missing	

Table 46. Red Eagle Campground: Health and Survival of Whitebark Pine Seedlings Monitored in 2009

Site	Year Planted	Dead / Missing	Almost Dead	Fair	Good	Unk.	# Survived	# of Trees Monitored	% Survival
Flattop	2001	436	0	30	168	0	198	634	31%
Total 2001		69%	0	5%	26%	0	31%	634	0%
Flattop	2002	169	0	12	106	0	118	287	41%
Total 2002		169	0	12	106	0	118	287	41%
Red Eagle Campground	2007	63	0	0	0	0	0	63	0%
Red Eagle Mountain	2007	151	0	47	160	0	207	358	58%
Total 2007		214	0	47	160	0	207	421	49%
Total		383.69	0	59.05	266.26	0	325.31	1342	24%
Surviving Trees (%)			0%	18%	82%	0%			
Overall Trees (%)		29%	0%	4%	20%	0%	24%		24%

All 38 plots established on Flattop Mountain were revisited in the fall of 2009 (Figure 29). Seedlings at this site were planted in either July 2001 for plots FT01-01 through FT01-16, August 2001 for plots FT01-17 through FT01-27, or August 2002 for plots FT02-01 through FT02-11. 2009 marks the seventh and eighth year of monitoring, respectively.

Figure 29. Location of Flattop Whitebark Pine Seedling Plots



The average survival rate for seedlings planted on Flattop Mountain was 36% with seven year survival from the 2002 planting at 41% and eight year survival from the 2001 planting at 31% (Table 47). Survival rates for individual plots ranged from 7% to 87%. All of the surviving seedlings were in good condition with 15% rated as fair and 85% rated as good. The majority of the trees rated fair were done so due to broken limbs or tops, but were in generally good health otherwise.

Overall, survival rates were slightly higher for the 2002 seedlings which were planted at the far north end of the project (Figure 29). This area is at a slightly higher elevation and experienced more intense burn severity, resulting in less competition from other species. Temperature may also play a role as August 2002

had higher precipitation and slightly cooler temperatures than July and August of 2001, preventing the desiccation of newly planted seedlings (Appendix A).

Many of the dead or missing trees in some of the plots, particularly the 2002 plots, were due to bark falling off the larger snags and smothering the seedlings or seedlings being crushed by deadfall. We do not expect a large increase in mortality because all of the remaining trees were in good or fair condition. The surviving trees grew dramatically in the last three years with many doubling in size. The July 2001 plots grew an average of 18cm in height, from 20cm to 38cm, while average width increased 10cm from 14cm to 24cm. The tallest tree from this planting event grew 40cm and is now 72cm in height. The August 2001 planting sites also grew an average of 18cm in height from 20cm to 38cm and 13cm in width from 17cm to 30cm. The tallest tree from this planting event grew by 57cm and is now 97cm tall. The trees from the 2002 planting sites more than doubled in average height from 13cm to 28cm and increased in width from 14cm to 26cm. The largest tree in the 2002 planting was 78cm by 59cm (Table 48).

Only 17 of the 27 plots established in 2001 were located in 2002, so data collected in that year is from a subset of plots located at the lower elevations. There was a large data gap from 2002 to 2005 where these sites were inaccessible due to weather and fire events. Despite this gap, there is enough information from subsequent years to begin to make some generalizations about this site. It seems that the greatest mortality occurs initially, within the first few years, and then diminishes over time. From the 2001 and 2002 plantings until 2005, mortality averaged about 50%. After 2005, the two following monitoring events suggest that mortality was about 1% per year for the 2001 planting and 2% per year for the 2002 planting (Table 47). Mortality is likely to be low in the following years, especially due to the size and condition of the remaining trees.

Table 47. Flattop Mtn: Percent Survival of Whitebark Pine Seedlings Monitored in 2009

<i>Site</i>	<i>Monitoring Year</i>	<i>Total # Trees Monitored</i>	<i># Trees Survived</i>	<i>% of Trees Survived</i>
Flattop (2001)	2001 (Spring)	349	337	97%
	2001 (Fall)	286	286	100%
	2002	392	202	52%
	2005	634	223	35%
	2006	634	215	34%
	2009	634	198	31%
Flattop (2002)	2002	287	279	97%
	2005	287	137	48%
	2006	287	131	46%
	2009	287	118	41%
Total One Year Survival	2002	392	202	52%
Total Three Year Survival	2005	287	137	48%
Total Four Year Survival	2005/2006	921	354	38%
Total Five Year Survival	2006	634	215	34%
Total Seven Year Survival	2009	287	118	41%
Total Eight Year Survival	2009	634	198	31%

Table 48. Flattop Mtn: Size of Whitebark Pine Seedlings Monitored in 2009

<i>Site</i>	<i>Monitoring Year</i>	<i>Average Height (cm)</i>	<i>Average Width (cm)</i>	<i>Largest Tree Height x Width</i>	<i>Smallest Tree Height x Width</i>
Flattop (2001 spring)	2006	20	14	45 x 22	5 x 5
	2009	38	24	72 x 40	14 x 12
Flattop (2001 fall)	2006	20	17	37 x 29	2.5 x 2
	2009	38	30	97 x 75 (same tree)	9 x 8
Flattop 2002	2006	13	14	50 x 41	5 x 4
	2009	28	26	78 x 59 (same tree)	5 x 7

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 this year. Transect WBS07-04 at the Red Eagle Mountain site had two germinants this year. Average height was 3.5cm and average width was 3cm. Along transect WBS07-05 at the Red Eagle campground site, one germinant was found but it had died earlier in the year. 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 pretty low for this site.

There were no germinants found along the Siyeh Bend transect. 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 2009. 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%. Of the trees monitored in 2009, the 2004 planting has a 15% five year survival rate and the trees planted in 2006 have a 4% three year survival rate. Trees planted in 2004 show the best results, benefitting from learned experience about planting in microsites that greatly improve limber pine seedling survival. While trees planted in 2006 have a slightly higher survival rate than those planted in 2002, survival for this cohort of trees is less than 2004 and still very low. Overall, this was due to two factors. First, almost all of the seedlings planted at Dead Horse Point in 2006 were wiped out the first year due to slide activity. Second, trees planted at Baring Creek in 2006 were planted in a highly exposed area with few microsites. Based on success at WLNP, many of these trees also had shade netting around them, which in GNP, resulted in higher mortality of seedlings due to rotting of the needles. Temperatures for July 2007 were above normal but temperature and precipitation data for St. Mary were typical during planting and for most of the following year, indicating that climate patterns did not influence survival of these seedlings.

Results from a smaller planting of limber pine seedlings at Waterton Lakes National Park (WLNP) may shed some light on our results. First, 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.

Second, Smith et al. 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. It should be noted that 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).

Finally, seedling health was marginally better in burned areas than unburned areas within this experimental area in WLNP. 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 2010, limber pine trees planted in 2005 at Scenic Point are scheduled for monitoring (Table 49). If there is extra time available, sites at Firebrand Pass and Baring Creek 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. Seven year survival is 41% and eight year survival is 31% for the trees planted at Flattop in 2001 and 2002, while second year survival is 49% for trees planted at Red Eagle in 2006. 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. Finally, year one survival at Red Eagle equaled the compiled average at 74% with 49% year two survival. If you remove the trees at 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. It is lastly 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.

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 2010, Red Eagle seed and seedling plots should be revisited (year 3). Siyeh Bend seed plots should also be monitored for year three results. Grinnell Point is scheduled for 2010 but due to logistics and lack of site information it may or may not be monitored. Dutch Creek will most likely not be read in 2010 due to the lack of proper site information to navigate to the planting site (Table 49).

Table 49. Whitebark and Limber Pine Monitoring Schedule

Plot(s)	Location	Planted	Monitored: 2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	Dutch Creek	2000?											X (year 10)?		
GP00 -01 to -07	Grinnell Point	2000	X (year 0)						X (year 6)				X (year 10)?		
FT01 -01 to -27	Flattop	2001		X (year 0)	X (year 1)			X (year 4)	X (year 5)			X (year 8)		X (year 10)	
FT02 -01 to -11	Flattop	2002			X (year 0)			X (year 3)	X (year 4)			X (year 7)		X (year 9)	
LP02 -01 to -25	Various	2002			X (year 0)	X (year 1)	X (year 2)	ALL DEAD							
LP02-05	Many Glacier Hotel Slope	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE	X (year 5) 1 TREE		X (year 7) ALL DEAD			
LP02-22	Sun Point	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE	X (year 5) 1 TREE		X (year 7) ALL DEAD			
LP02-24	Firebrand Pass	2002			X (year 0)	X (year 1)	X (year 2)		X (year 4) 1 TREE		X (year 6) 1 TREE				X (year 10)
LP03-01	Two Med Camp Store	2003				X (year 0)	X (year 1)		X (year 3)		X (year 5)				
LP04 -01 to -05	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	Many Glacier Hotel Slope	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)			
LP04 -08	Sun Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5) ALL DEAD			
LP04-09	Sun Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)			
LP04-10	Dead Horse Point	2004					X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)			
LP04 -11	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	Scenic Point	2005						X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)		
LP06 -01 and -03	Baring Creek	2006							X (year 0)	X (year 1)	X (year 2)	X (year 3) ALL DEAD			
LP06-02									X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)	
LP06 -04	Dead Horse Point	2006							X (year 0)	X (year 1)	All dead , 1 missing	X (year 3) ALL DEAD			
WB06 -01 to -02	Caper Peak (seeds + trees)	2006							X (year 0)		X (year 2)	X? (year 3)		X (year 5)	
WB07 -01 to -09	Red Eagle (seeds + trees)	2007								X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)
WBS07 -01 to -03	Siyeh Bend (seeds)	2007								X (year 0)	X (year 1)	X (year 2)	X (year 3)		X (year 5)
Plot(s)	Location	Planted	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	Dutch Creek	2000?			X (year 15)					X (year 20)					
GP00 -01 to -07	Grinnell Point	2000			X (year 15)					X (year 20)					
FT01 -01 to -27	Flattop	2001			X (year 15)						X (year 20)				
FT02 -01 to -11	Flattop	2002			X (year 14)						X (year 19)				
LP02 -01 to -25	Various	2002													
LP02-05	Many Glacier Hotel Slope	2002													
LP02-22	Sun Point	2002													
LP02-24	Firebrand Pass	2002					X (year 15)					X (year 20)			
LP03-01	Two Med Camp Store	2003	X (year 10)					X (year 15)					X (year 20)		
LP04 -01 to -05	Baring Creek	2004			X (year 10)				X (year 15)					X (year 20)	
LP04 -06 to -07	Many Glacier Hotel Slope	2004			X (year 10)				X (year 15)					X (year 20)	
LP04-08	Sun Point	2004													
LP04 -09	Sun Point	2005			X (year 10)				X (year 15)					X (year 20)	
LP04-10	Dead Horse Point	2004			X (year 10)				X (year 15)					X (year 20)	
LP04 -11	Dead Horse Point	2004													
LP05 -01 to -06	Scenic Point	2005			X (year 10)					X (year 15)					X (year 20)
LP06 -01 and -03	Baring Creek	2006													
LP06-02	Baring Creek	2007			X (year 10)						X (year 15)				
LP06 -04	Dead Horse Point	2006													
WB06 -01 to -02	Caper Peak (seeds + trees)	2006			X (year 10)						X (year 15)				
WB07 -01 to -09	Red Eagle (seeds + trees)	2007					X (year 10)					X (year 15)			
WBS07 -01 to -03	Siyeh Bend (seeds)	2007					X (year 10)					X (year 15)			

XI. 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 12 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 2009 begins 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 73 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, and 13 were identified in 2009 (Figure 30 and Table 50). 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. This year, 5 additional trees were added at Scenic Point, 5 additional trees were added at Numa Lookout and three additional trees were added at Preston Park. This year the revegetation crew took 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 in Scenic Point, Numa Lookout, Rising Wolf and Preston Park. Cone trees were monitored at all of these sites, as well as one limber pine tree at Dead Horse Point.

Table 50. Whitebark Pine Plus Trees: Health and Cone Production, 2009.

<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 Trail	8/20/07	7	5	1*	2*	0	2
Otokomi Lake	8/27/07	6	4	0	0	2	4
Preston Park	8/31/09	23	12	4*	8*	3*	18
Rising Wolf	9/24/09	6	2	3*	4*	1	3
Scenic Point	9/16/09	12	3	6*	6*	2*	8
Siyeh Bend	8/14/08	3	0	3*	3*	0	1
Triple Divide	8/13/08	4	3	1	0	0	3
	TOTAL	73	35	23	27	9	46
% AS OF LAST SURVEY			48%	32%	37%	12%	63%

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 2009, of the 73 whitebark pine trees in the monitoring pool, 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 50). This is 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 51). In 2007, 66% of plus trees were healthy with even lower blister rust infection rates (Table 51). Data from 2007 and 2008 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.

Table 51. Whitebark Pine Plus Trees: Comparison of Health and Cone Production, 2007-2009.

<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
Otokomi Lake	2007	6	4	0	0	2	4
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
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
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
TOTAL 2007		56	37	10	9	8	42
TOTAL 2008		60	36	16	13	7	31
TOTAL 2009		73	35	23	27	9	45
% 2007			66%	18%	16%	14%	75%
% 2008			60%	27%	22%	12%	52%
% 2009			48%	32%	37%	12%	63%

Whitebark pine cone production was greatly reduced from 2007 to 2008. In 2007, 75% of trees had cones with an average of 34 cones per tree while only 52% of trees had cones in 2008 with a very low average of 6 cones per tree (Tables 51 and 52). More trees in 2009 had cones compared to 2008 but numbers were not as high as 2007. Overall, 63% of whitebark pine plus trees had cones but cone production was typically low with an average of only 11 cones per tree (Tables 51 and 52). 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 432 cones were collected by the revegetation crew this year (Table 53).

Table 52. Whitebark Pine Plus Trees: Cone Frequency, 2007 - 2009.

<i>Site</i>	<i># of Trees Monitored</i>	<i># of Cones in 2007</i>	<i>Avg Cones per Tree 07</i>	<i># of Cones in 2008</i>	<i>Avg Cones per tree 08</i>	<i># of Cones in 2009</i>	<i>Avg Cones per tree 09</i>
Preston Park	20/23	925	46	176	9	267	12
Numa	7/6	165	24	5	1	52	9
Rising Wolf	6	16	3	N/A	N/A	89	15
Scenic Point	7/10	237	34	10	1	109	11
TOTAL	40/45	1343	34	191	6	517	11

Table 53. Caged Whitebark Pine Trees and Cones Collected, 2009.

Site	Trees Caged	Cones Collected
Numa	6	52
Rising Wolf	1	81
Preston Park	6	197
Scenic Point	6	102
Total	19	432
Average Cones Per Tree		23

Lastly, two limber pine trees have also been entered into the plus tree monitoring pool since 2007 (Figure 30 and Table 54). One tree is located at Dead Horse Point and one is located at Scenic Point. Both trees were monitored this year and have continuously been healthy with no active, inactive or potential cankers. The tree at Scenic Point had 10 cones in 2007 and 20 cones in 2008 but no cones this year. The tree at Dead Horse Point has always been a prolific cone producer with 110 cones in 2007, 50 cones in 2008, and over 200 cones this year (Table 55).

Table 54. Limber Pine Plus Trees: Health and Cone Production, 2009.

<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>
Dead Horse Point	9/1/09	1	1	0	0	0	1
Scenic Point	9/16/09	1	1	0	0	0	0
	TOTAL	2	2	0	0	0	1
	2007 PERCENT		100%	0%	0%	0%	100%
	2008 PERCENT		100%	0%	0%	0%	100%
	2009 PERCENT		100%	0%	0%	0%	50%

Table 55. Limber Pine Plus Trees: Cone Frequency, 2007 - 2009.

<i>Site</i>	<i>Date</i>	<i># of Trees Monitored</i>	<i># of Cones in 2007</i>	<i>Avg Cones per Tree 07</i>	<i># of Cones in 2008</i>	<i>Avg Cones per tree 08</i>	<i># of Cones in 2009</i>	<i>Avg Cones per tree 09</i>
Dead Horse Point	9/9/08	1	100	100	50	50	200	200
Scenic Point LP	9/10/08	1	10	10	20	20	0	0
TOTAL		2	110	55	70	35	200	100

D. CONCLUSIONS AND RECOMMENDATIONS

The most predominant trend found throughout 2008 and 2009 was the dramatic decline in whitebark pine cone production throughout the park. Cone production over the last two years has been less than in 2007. With only three years of data on cone production, it is likely that this is part of a natural cycle for whitebark pine trees but it is possible that increased blister rust on some of these monitoring trees is having a negative impact. It is also important to note that this season's overall park-wide cone production was likely even lower, since the healthiest trees were targeted for cone collection and thus monitoring. Future monitoring of cone production over the next several years will likely begin to address this trend.

Another predominant trend is 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 48% in 2009 with an increase of trees that currently have active and inactive blister rust cankers. In addition, while not all trees within healthy stands have been scouted, there appear to be fewer healthy whitebark pine trees to add to the monitoring pool. In particular, in 2009, many of the sites had abundant trees with yellowing needles or trees that appeared to have dying tops. 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. 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.

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 and 2009, 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. 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 Old Man Lake Trail, the Otokomi Lake Trail, and 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 three sites to assess cone production and tree health in the future. At Rising Wolf, four out of the six healthy trees from 2007 are now infected with blister rust. One healthy tree continues to be a prolific cone producer, while the largest healthy tree has very low cone production. The Rising Wolf area in general seems to have lot of dead and dying trees and may not offer many healthy whitebark plus trees in the future. 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 both Rising Wolf and Siyeh Bend will continue to be monitored, however, it is possible that these areas may not be included as seed collection

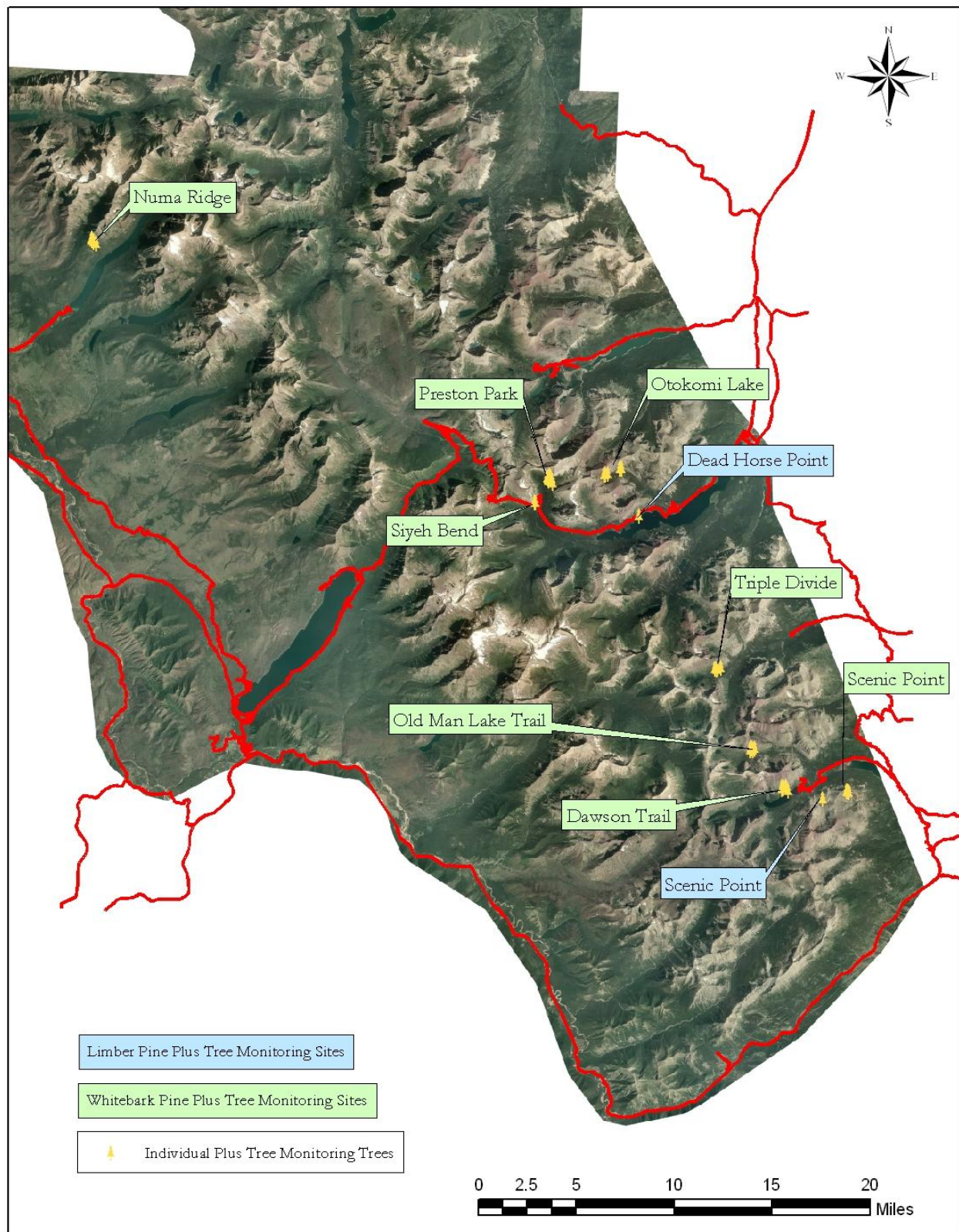
sites in the future. Other possible sites to search for healthy whitebark pine in 2010 include the Firebrand Pass Trail, trails in the Many Glacier subdistrict, the Morning Star Lake trail, and Bighorn Basin.

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 Glacier National 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 30. Location of Whitebark and Limber Pine Plus Trees for Monitoring



XII. BLISTER RUST SURVEY AND MONITORING PROJECT

A. INTRODUCTION

Whitebark pine (*Pinus albicaulis*) grows in the upper subalpine zones of Glacier National Park (GNP). It typically occurs in small stands on steep, windswept slopes and ridges where competition from other conifers is limited. It is an important food source for nutcrackers, bears and squirrels and is considered a keystone species of the upper subalpine ecosystem (Tomback et al. 2001). Once common in the park, whitebark pine populations have significantly declined due to a combination of fire suppression, insect infestation, disease and successional replacement of more opportunistic tree species (Tomback et al. 2001). It is the non-native fungal disease, white pine blister rust (*Cronartium ribicola*) that is primarily responsible for the rapid reduction of this pine (Tomback et al. 2001). Research has been initiated in Glacier to better understand the population dynamics of the fungus, blister rust infection and mortality rates of whitebark pine.

Between 1995 and 1996, Kate Kendall of the U.S. Geological Survey conducted a study of whitebark pine population status from Wyoming to Alberta. Numerous plots were established in Glacier National Park, Waterton Lakes National Park, the Blackfoot Reservation, Grand Teton National Park and the Greater Yellowstone Ecosystem. Plots were surveyed for a variety of habitat attributes and population trends. From these data, it was determined that whitebark pine trees in Waterton Lakes National Park, Glacier National Park and on the Blackfoot Reservation have suffered serious declines. As stated in previous sections of this report, whitebark pine mortality has been estimated at 44% within GNP 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.

In 2001, Cyndi Smith of Waterton Lakes National Park submitted a grant to the Whitebark Pine Ecosystem Foundation to re-survey Kendall's plots as well as establish additional permanent monitoring plots. These plots were to be installed according to a new monitoring methodology outlined in "Methods for Surveying and Monitoring Whitebark Pine for Blister Rust Infection and Damage" (Tomback et al. 2003). The project received a grant from the Yellowstone to Yukon (Y2Y) Science Grants Program that is supported by the Wiburforce Foundation. A portion of the funding was allotted to Glacier National Park to install new plots in some of the survey areas conducted by Kendall's crews in 1995-97. Fifty six blister rust plots have been established in these areas. Surveys were mainly completed during the 2003 and 2004 field seasons with 26 plots completed in 2003 and 28 plots completed in 2004. One additional plot was installed in 2005 and one additional plot was installed in 2007 (Figure 31).

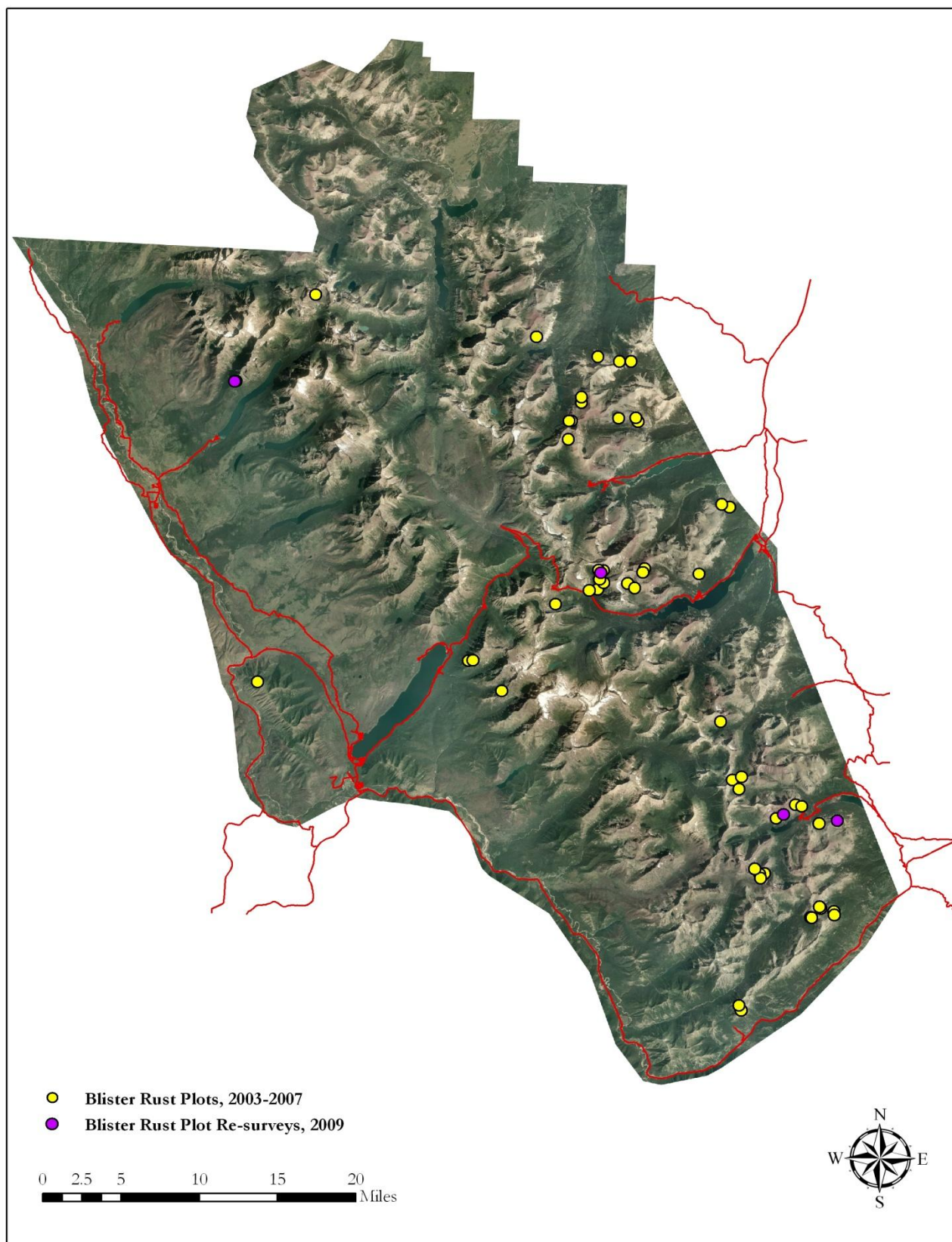
This year, four blister rust plots that were installed according to the new methodology were re-surveyed in 2009. Two of these plots were installed in 2003 while the remaining two plots were installed in 2004. These plots were re-read in order to determine current health of populations of trees in areas of recent cone collection for whitebark pine restoration. These sites were located at Preston Park, Numa Ridge, Scenic Point and Rising Wolf slope (Figure 31).

B. METHODS

As stated above, whitebark pine surveys were done in accordance to "Methods for Surveying and Monitoring Whitebark Pine for Blister Rust Infection and Damage" (Tomback et al. 2003). Plot locations were to coordinate with the plots previously established by Kendall's crew. Most of Kendall's plots had no permanent markers and were not the same dimensions as those outlined by Tomback (2003). It was not the intention of this project to duplicate Kendall's plots exactly, but rather to assess the same general stands as were previously surveyed to give some bases for comparison.

To install a new plot, crews navigated to a GPS point for a target plot that Kendall's crew had surveyed. Once the stand was reached, a determination of site establishment for the new plot was made based on the prevalence of live trees. The start of each transect was monumented with a nail, tagged and a GPS point was taken. Ten-meter-wide belt transects were laid to follow an elevation contour as best as possible. A compass azimuth was followed, roughly following the contour, to a center point or end point.

Figure 31. Location of Whitebark Pine Blister Rust Plots Surveyed in 2003-2009.



Transect direction could change in the center of the plot to adjust with the contour. Transect lengths were a minimum of 50m, but the plot was extended if the required number of live trees was not obtained. Protocol required that at least 30 live or recently dead trees were captured in the transect, with a minimum of fifty trees overall. Later in the project, this criterion was amended due to logistical difficulties in Glacier where so few live trees persist. The end point of each transect was also monumented and a GPS point was again taken. For all trees with a dbh (diameter at breast height) greater than 1.4 meters, health was assessed. Presence of active and inactive cankers was noted for the stem and for branches. Percent canopy kill was recorded, as well as any evidence of bark stripping and/or mountain pine beetle.

Cause of death for dead trees was noted if possible. In the beginning of the project, trees were not tagged, but were mapped with a distance along and from the center tape. To avoid confusion, trees were tagged in subsequent plots. Within the 10m belt (5m on either side of the tape), all seedlings (trees <1.4 m tall) were also tallied. Seedlings were grouped as less than 50cm or greater than 50cm, and tallies were made for the number of seedlings with active cankers, inactive cankers or no cankers for each category.

In 2009, existing plots were located as near to a seed collection site as possible. The nearest plot was then reconstructed and surveyed using the same methodology as was employed in 2003 or 2004. In the event of lack of time, only 50m of the transect was re-surveyed. This was only the case at Preston Park.

C. RESULTS AND DISCUSSION

All four plots monitored in 2009 had a higher number of dead trees than when the plots were installed, either in 2003 or in 2004. Between one and five more trees were dead in each of these plots with a percentage of dead trees in these plots now ranging from 48-67% (Table 56). Overall, 109 trees were dead in 2009, while 96 were dead in 2003/2004. A few trees were considered “healthy” in 2009 that had initially been considered sick, increasing the percentage of healthy trees in two of the four plots. A potential cause for this could be that branches infected during the previous monitoring event may have since died and broken off, or that the inactive canker was no longer identifiable after the bark had peeled off. Even with the small rise in “healthy” trees, only 3 - 8% of trees were designated as healthy in each plot in 2009. Fewer trees showed signs of active cankers in 2009 (15 overall in 2009 in comparison to 31 in previous monitoring event), but more trees contained inactive cankers (57 in comparison to 32). It is likely that during initial surveys, infection was newer and blister rust cankers were in the fruiting process. By 2009, it appears that infection had progressed in most trees to have either killed the tree, or so that mostly old, inactive cankers were outwardly visible. Additionally, 2009 surveys were all completed later in the season than in the previous monitoring event. Active cankers from earlier in the season may have matured to inactive cankers in some trees.

Table 56. Blister Rust Plots: Health of Whitebark Pine Trees from Plots Re-surveyed in 2009.

Plot #	Location		# healthy trees	# sick trees	# dead trees	Total trees	% healthy	% infected	% dead	# of trees with active canker*	# of trees with inactive canker*
WB03-01	Preston Park	7/9/2003	0	18	15	33	0	55	45	2	0
		9/17/2009	1	12	20	33	3	36	61	0	8
WB03-02	Scenic Point	8/3/2003	3	25	41	69	4	36	59	10	9
		9/16/2009	3	20	46	69	4	29	67	6	15
WB04-04	Numa	8/10/2004	1	18	16	35	3	51	46	4	15
		9/14/2009	1	16	18	35	3	46	51	6	11
WB04-60	Rising Wolf	9/8/2004	3	25	24	52	6	48	46	15	8
		9/24/2009	4	23	25	52	8	44	48	3	23

*one tree can have both active and inactive canker so could be counted under both categories

Fewer seedlings were observed in 2009 with the exception of Scenic Point, where 11 more seedlings were found in 2009 (Table 57). In 2003/2004, a total number of 180 seedlings were found in the four plots monitored, while 126 seedlings were found in 2009. The percentage of healthy seedlings has also dropped slightly from 146 overall in 2003/2004 to 95 in 2009 (81% compared to 75%). It seems likely that the reduction of seedling numbers is

due to seedling death from infection. Likely some seedlings that had signs of inactive canker, which insinuates that the infection is further along, died between monitoring events, since the number of seedlings with inactive canker reduced from 25 to 17. More seedlings now have active cankers which may account for the reduction in healthy trees. Seedlings with inactive cankers increased from 9 to 14.

Results show that, overall, there are fewer sick trees and seedlings in 2009 since the 2003/2004 monitoring event, but it is likely due to tree death since the previous monitoring event (Table 58). Given these results, we can ascertain that blister rust infestation is continuing to kill trees and infect new healthy trees and seedlings.

Table 57. Blister Rust Plots: Health of Seedlings in Re-surveyed plots, 2003-2009.

Plot #	Location		Active cankers		Total Active	Inactive cankers		Total Inactive	No cankers		Total Healthy	Total seedlings	Percent Healthy
			≤ 50cm	50 to 140 cm		≤ 50cm	50 to 140 cm		≤ 50cm	50 to 140 cm			
WB03-01	Preston Park	7/9/2003	0	0	0	1	1	2	1	0	1	3*	33*
		9/17/2009	0	0	0	0	0	0	1	0	1	1*	100*
WB03-02	Scenic Point	8/3/2003	1	1	2	2	6	8	20	14	24	34	71
		9/16/2009	0	6	6	2	7	9	10	30	40	55	73
WB04-04	Numa	8/10/2004	2	3	5	7	8	15	94	6	81	101	80
		9/14/2009	1	6	7	4	3	7	38	9	47	61	77
WB04-60	Rising Wolf	9/8/2004	1	1	2	0	0	0	6	5	11	13	85
		9/24/2009	1	0	1	0	1	1	3	4	7	9	78

*can't completely compare seedlings from 2003 to 2009 in Preston Park plot, since only 1st 50m were surveyed in 2009

Table 58. Blister Rust Plots: Overall Number of Healthy and Sick Trees and Seedlings in Re-surveyed Plots

SEEDLINGS		TREES	
total healthy 2003/04	146	total healthy 2003/04	7
total healthy 2009	95	total healthy 2009	9
total sick 2003/04	34	total sick 2003/04	86
total sick 2009	31	total sick 2009	71
total active canker 2003/04	9	total active canker 2003/04	31
total active canker 2009	14	total active canker 2009	15
total inactive canker 2003/04	25	total inactive canker 2003/04	32
total inactive canker 2009	17	total inactive canker 2009	57
Total # of seedlings 2003/04	180	total dead 2003/04	96
Total # of seedlings 2009	126	total dead 2009	109

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)
- Polebridge Developed Area - Level II, photomonitor (year 20)
- Polebridge Bridge - Level II, photomonitor (year 20)
- Bowman Creek Campground - Level II, photomonitor (year 20)
- River Campground - Level II, photomonitor (year 20)
- Above St. Mary Campground Weed Reveg. (year 3)
- Camas Creek Overlook Weed Reveg. (year 3)
- West Entrance (year 3)
- Lake McDonald Dorm (year 2)
- GTSR – Phase 6 (year 2)

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)

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)

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	57.6	63.8	62.5	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
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

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
Precipitation (inches)								
1981 - 2010	2.0	3.0	3.6	1.8	1.7	2.2	2.2	2.5
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#

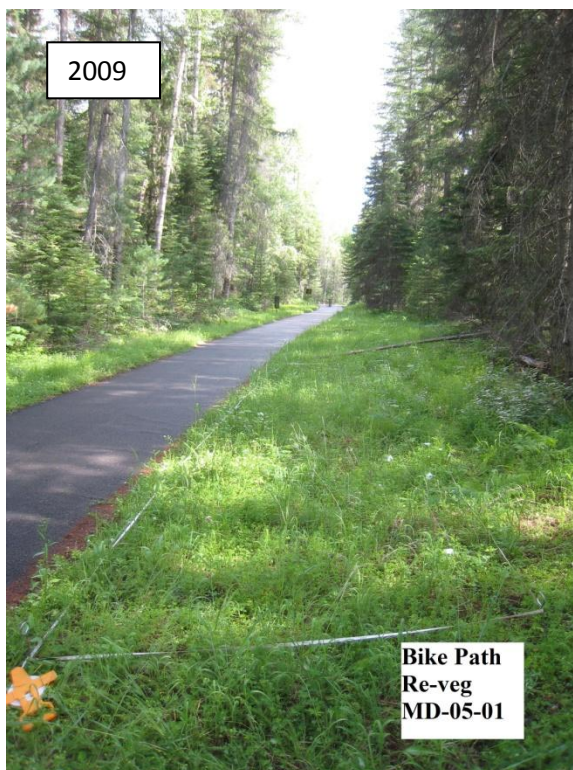
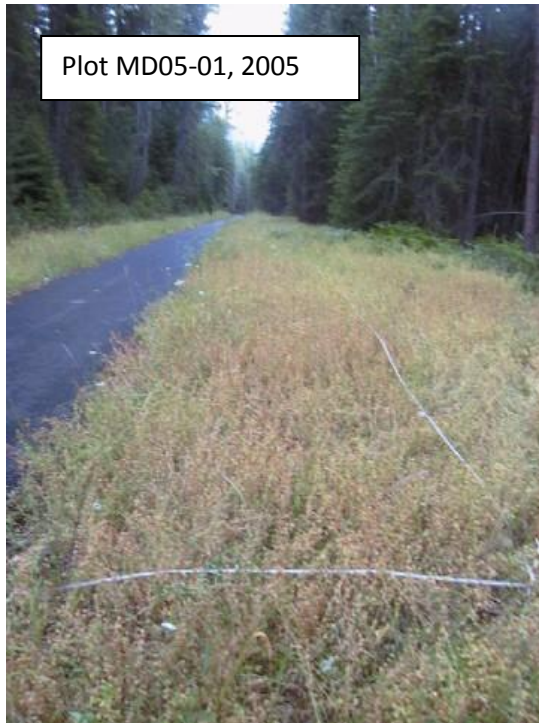
* This data was obtained from official U.S./NOAA weather stations operated by Glacier National Park, and from the Western Reg

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

Missing data

APPENDIX B. PLOT PHOTOS FOR THE BIKE PATH PROJECT.

S:\VegUnit\BikePathRevegMonitoring





Plot MD05-03, 2005



Plot MD05-03, 2007



Plot MD05-04. 2005



Plot MD05-04, 2007





APPENDIX C: PHOTOMONITORING OF SELECT SITES FROM SHUTTLE TRANSIT STOPS 2009



Photopoint 26A Apgar Campground Transit Stop



Photopoint 26B Apgar Campground Transit stop



Photopoint 2A Sprague Campground Transit stop



Photopoint 2 Sprague Campground Transit stop

Photopoint 3A Lake McDonald Lodge Transit Stop



Photopoint 5C Avalanche Transit Stop



Photopoint 5D Avalanche Transit Stop



Photopoint 06 The Loop Transit Stop Fall 2008, During Construction



Photopoint 06 The Loop Transit Stop Fall 2009 Post Construction



Photopoint 9B Logan Pass Transit Stop



Photopoint 9A Transit Stop



Photopoint 08 Logan Pass Transit Stop Fall 2008



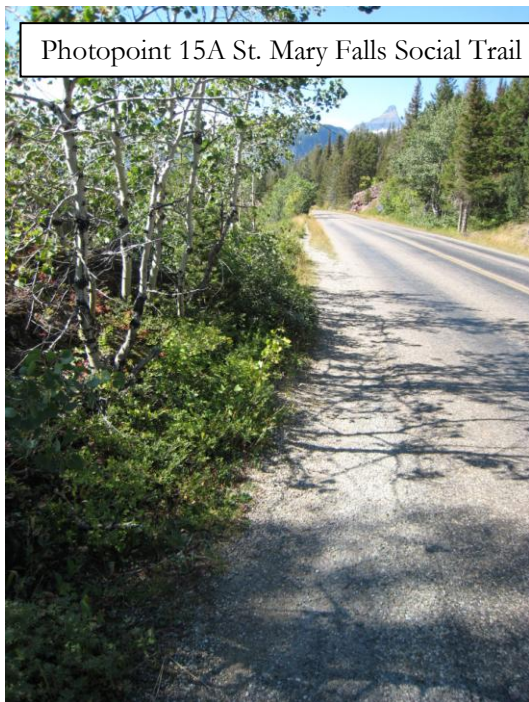
Photopoint 08 Logan Pass Transit Stop Fall 2009



Photopoint 25 Gunsight Pass Transit Stop



Photopoint 15A St. Mary Falls Social Trail



Photopoint 18 Sun Point Transit Stop



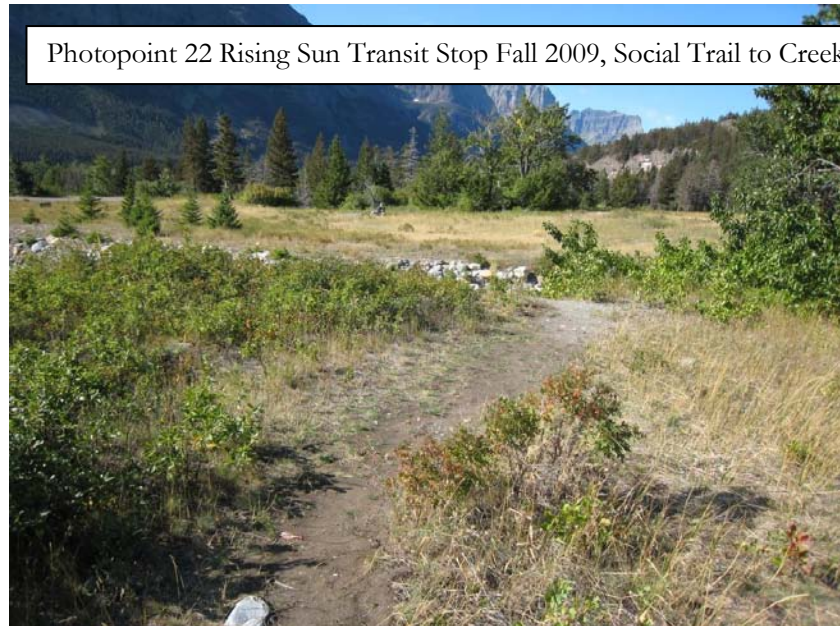
Photopoint 19 Sun Point Transit Stop, Revegetation Area



Photopoint 22 Rising Sun Transit Stop Fall 2008, Social Trail to Creek



Photopoint 22 Rising Sun Transit Stop Fall 2009, Social Trail to Creek



Photopoint 23 St Mary Visitors Center Transit Stop



Photopoint 23A St. Mary Visitors Center Transit Stop, Tepee Site

