RIPARIAN AND WETLAND CREATION ALONG A NEWLY CONSTRUCTED SEGMENT OF THE EAST FORK OF THE ARKANSAS RIVER AT THE CLIMAX MINE[1]

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Abstract. During past mining activities the East Fork of the Arkansas River was diverted through a 2000-foot long concrete pipe where it crosses Climax Molybdenum Company's Climax Mine property at approximately 11,150 ft above mean sea level (3,400 m). In 2006, the mine initiated an ambitious project to daylight the river into a newly constructed channel. The goals of the project were to engineer a hydraulically stable and aesthetically pleasing stream channel and adjoining landform and to establish self-sustaining and diverse riparian and wet meadow plant communities and viable aquatic habitats.

Revegetation was implemented in 2007 and 2008 after channel and adjacent topographic feature reconstruction was complete on the 15-acre site. Biosolids, composted on-site as a part of Climax's EPA award-winning program, were the only soil amendment added to the site. Composted biosolids were spread over the disturbance area at a rate of 400 cubic yards per acre and were incorporated into the mineral soil fill material to a depth of 12 inches. The upland areas adjacent to the river were seeded with a mixture of native subalpine species at a rate of 30 pure live seeds per square foot. Additionally, 120 Engelmann spruce and subalpine fir transplants, harvested on the property, were planted. Along the banks of the channel, around the lake, and in low-lying swales 108 willow and birch shrubs, over 500 willow stakes, and over 700 native wetland plug transplants were planted and a mixture of native subalpine wetland species was seeded at a rate of 50 pure live seeds per square foot.

After 3 years vegetative cover averages 27.4% over the entire site with 28.2% cover in upland areas and 11.6% in wetland areas. Survival of transplanted willows, birches, and cinquefoil was 100%, and spruce survival was 73%. Willow stake survival was 68% and almost all wetland plugs survived.

Additional Key Words: native revegetation, mine reclamation, biosolids, high altitude, subalpine

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Introduction

The headwaters of the East Fork of the Arkansas River flow across the Storke Yard area of the Climax Molybdenum Company's Climax Mine property in Lake County, CO. Beginning in the 1950s, the Storke Yard served as the primary underground mining and support facility for the Climax Mine. In 1980, the river was rerouted through a seven foot diameter concrete pipe and an approximately 2000-ft section of the historic river bed was buried under fill material. Upon exiting the pipe at the west end of the Storke Yard, the river was returned to its native channel and allowed to flow downstream unimpeded. Reclamation of the Storke Yard area began in the early 1990s and has included the demolition and removal of structures, regrading of the surface, and revegetation. In 2006, the mine initiated an ambitious project to daylight the river into a newly constructed channel across the Storke Yard in its approximate original location.

The goals of the project were to engineer a hydraulically stable and aesthetically pleasing stream channel and adjoining landform and to establish self-sustaining and diverse riparian and wet meadow plant communities and viable aquatic habitats. The channel design was completed by Water & Earth Technologies, Inc. and the construction oversight, revegetation design, and post-project monitoring were conducted by Habitat Management, Inc.

Site Description

This project area is approximately 15 acres along both sides of the East Fork of the Arkansas River in the Storke Yard area of the Climax Molybdenum Company's Climax Mine property (Fig. 1). The Arkansas River flows northwest across the southernmost part of the mine property in Lake County, CO at an approximate elevation of 11,150 ft (3,400 m). Reclamation activities are particularly difficult at this site due to the high altitude, short growing season, harsh winters, heavy snow pack, intense summer thunderstorms, periodic flood events and poor soils.

The climate at Climax is typical of the region and characterized by short cool summers and long cold winters. The average daily high and low temperatures in July are 65°F and 39°F, respectively, while the average daily high and low temperatures in January are 25°F and 2°F, respectively (Western Regional Climate Center, 2010). Average precipitation is approximately 25 inches of which 80 - 90% is snowfall. Snow can fall during any month of the year and

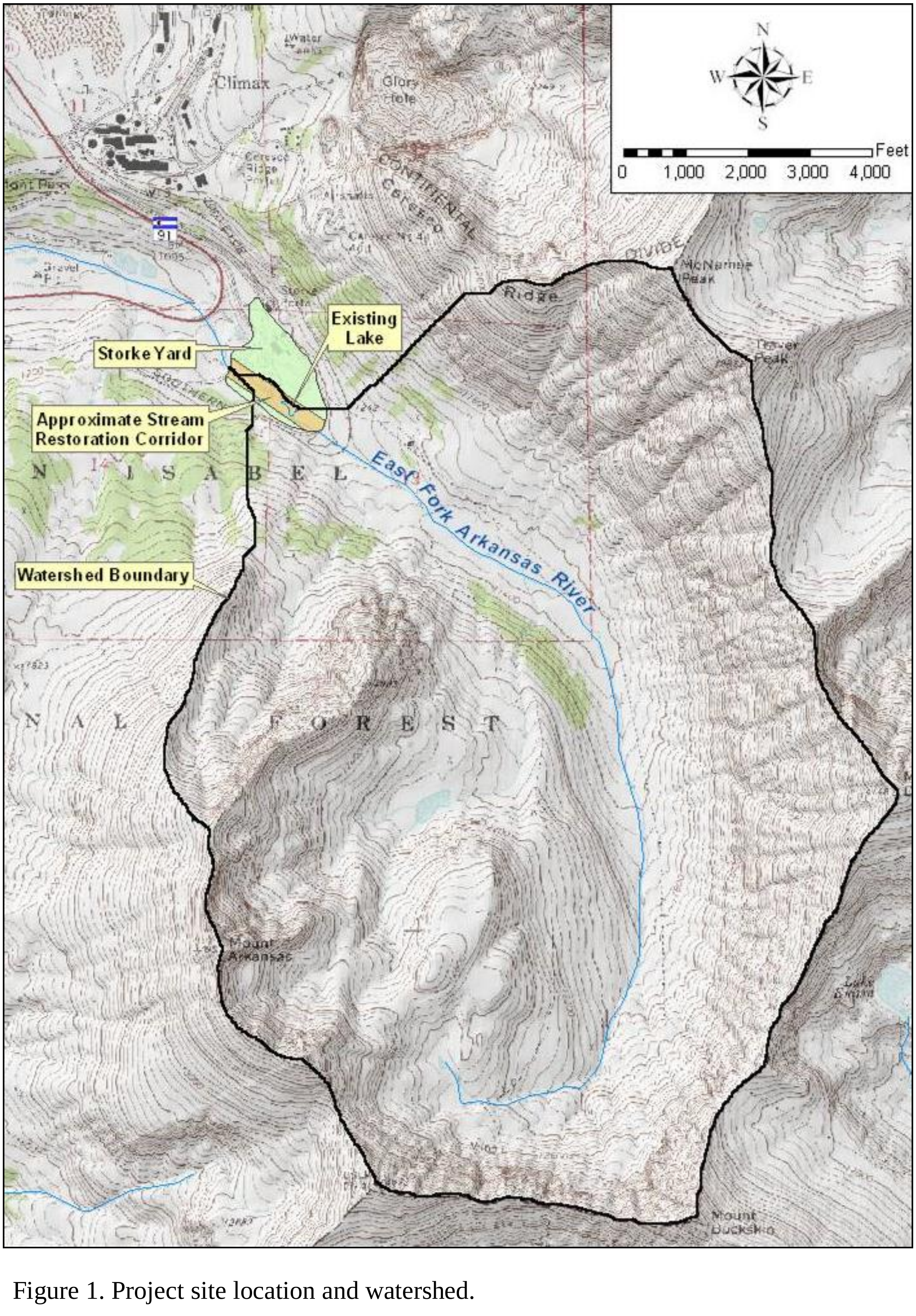

Figure 1. Project site location and watershed.

average annual snowfall is 280 inches. During the three growing seasons reported on in this paper, precipitation was unusual. Both 2008 and 2010 experienced below average rainfall in June and September and above average rainfall in July and August, while 2009 showed exactly the opposite trend (Fig. 2).

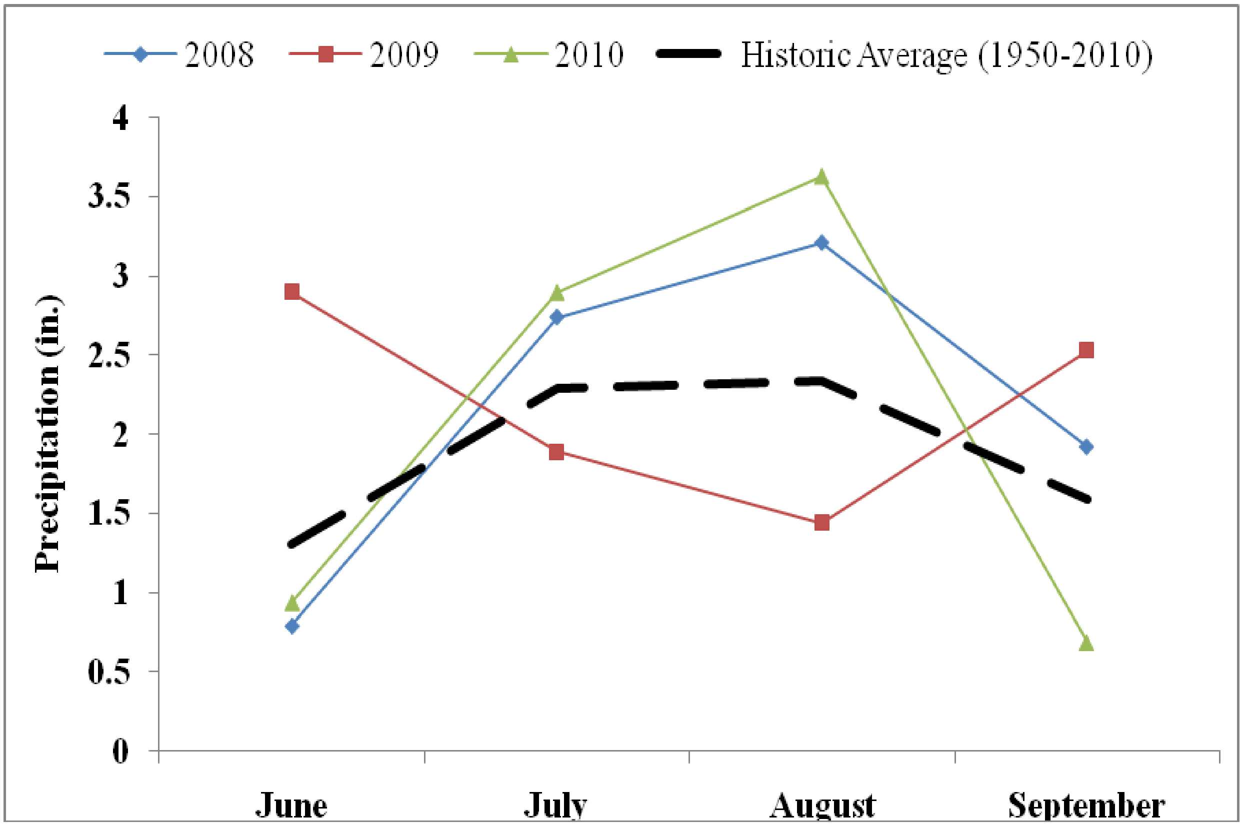

Figure 2: Growing season precipitation at the Climax Mine site.

The project area is surrounded by several differing vegetation communities. To the north on the Storke Yard is a reclaimed subalpine grassland community dominated by common timothy[1] (*Phleum pratense*), Rocky Mountain fescue (*Festuca saximontana*), Kentucky bluegrass (*Poa pratensis*), common yarrow (*Achillea millefolium*), and white clover (*Trifolium repens*). To the south is a relatively steep north-facing slope dominated by Engelmann spruce trees. Along the river, both up and downstream, relatively thick willow carrs are interspersed with subalpine grassland and wetland communities.

[1] Vegetation nomenclature follows USDA, 2011.

The Storke Yard was filled and graded during past mining and reclamation activities. The fill material is comprised of development rock from the construction of the shafts and audits in the Storke Yard area as well as construction debris from the Yard reclamation in the 1990s. An excavation originally intended to become a conveyor reclaim system in the southeast portion of the Storke Yard formed a small lake. The new channel construction was designed to utilize this existing lake to control flows and create opportunities for emergent marsh vegetation communities and fish spawning habitat.

Design and Construction

The final design plan for the East Fork of the Arkansas River reflected an interest in establishing consistency between the upland, riparian and aquatic ecosystems of the upper watershed and the newly constructed areas. Measures were taken to route and maintain floodplain connectivity, mimic natural topography, pass stormwater runoff, and include habitat for aquatic biota. The channel design incorporated Rosgen methodology and geomorphic criteria to develop a natural and sustainable meandering channel and floodplain that would mimic the conditions up and downstream. The channel was designed to pass the flows of 550 cfs expected from a 100 year 24-hour event. Primary construction of the approximately 2,000 feet of new channel was completed in summer 2007. Details of the design and construction phase of this project are included in these proceedings in Malers et al. (2011).

Revegetation Methods

The majority of the area was revegetated in September 2007 after the completion of channel construction. However, due to an early snowfall, a small area was revegetated in 2008. Prior to revegetation several rounds of soil testing were completed and biosolids were added. Revegetation activities included transplanting of large conifer trees, wetland and upland shrubs, and wetland graminoid and forb plugs as well as seeding with site-specific upland and wetland seed mixtures.

Soil Amendments

Soils tests were performed in the project area after construction was complete to determine what, if any, soil amendments were necessary for revegetation activities. Soils in the project area were analyzed for chemistry, texture, and nutrients (Table 1). The soil was primarily native material excavated from the new river channel as well as the Storke Yard fill material comprised of overburden from previous shaft and adit construction. This material was not acid producing, and had a suitable pH for reclamation. Thus, all soils were determined to not require any lime amendment.

The fill material at the site was deficient in organic matter and nutrients which were amended with the addition of biosolids. Climax runs an EPA award-winning biosolids composting program on-site to produce a topsoil alternative that is high in organic matter and other macro nutrients. Climax composts municipal waste from the region along with wood chips from trees affected by a regional epidemic of the Rocky Mountain pine beetle and development activities in neighboring counties to produce a cost-effective and environmentally sound solution for both the Mine's reclamation and the community's waste disposal needs. The biosolids placed for reclamation are a mixture of 1 part biosolids and 4 parts woodchips that have been aerobically composted for a minimum of 15 days at 131°F and have passed all regulatory testing for Class A biosolids.

A study conducted in 2005 on 120 acres reclaimed with biosolids between 1997 and 2003 at Climax found that the biosolids amendments resulted in improved revegetation success, removed soil phyto-toxicity, neutralized acidity, improved wildlife habitat, reduced compaction of the cover, and introduced the necessary constituents to sustain vegetation communities (Carlson et al., 2006). Carlson et al. (2006) further concluded that the quality of the biosolids compost produced at the site exceeds State and Federal standards.

Biosolids were applied to 13 acres of the project area in 2007 at a rate of 400 cu yd/acre. An additional 1.3 acres received biosolids treatment in 2008. A small area at the west end of the project area near a channel drop structure had received biosolids as a part of reclamation activities in 2004. Prior to channel excavation, this alternate topsoil material (i.e., biosolids incorporated with soil) with vegetation was salvaged and stockpiled. At the completion of construction activities, a small area (~ 0.25 acres) south of the lower end of the lower stream reach was covered with this stockpiled material. This area did not receive any additional biosolids. No fertilizers were needed as soil amendment due to the addition of the biosolids.

Table 1. Preliminary soil test results.

	Analysis	Sample Date 8/30/07	8/31/07	9/1/07	9/18/07
Acid/Base Accounting (t/1000t)	% Sulfur	0.06	0.07	0.05	0.1
	Acid Potential	1.2	1.7	1.3	1.56
	Neut. Potential	5	4	3	8.75
	Acid/Base Potential	4	3	2	8
Nutrients (mg/kg)	K	52	41	42	
	P	10.4	6.3	14.4	5
	NO_3	1	1	trace	10
Texture	% Sand	68	73	78	
	% Silt	20	17	16	
	% Clay	12	10	6	
Other	pH	6.2	6.8	6.3	7.2
	EC (mmhos/cm)	1.52	0.98	0.35	0.4
	Organic Matter				0.48

Tree/Shrub Transplants

Upland tree and shrub transplanting was completed after the upland areas were graded to final contour. All transplants were removed from other areas on the Climax Mine property using a tree spade. Transplants were planted in a mixture of topsoil and biosolids (4:1), mulched with woodchips, watered in within 1 week of planting, and treated with a general mycorrhizal inoculant.

A total of 120 large (5 to 12 ft tall) Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) trees were planted in the project area in 2007. Over 160 additional trees were planted in the surrounding Storke Yard to enhance the entire project area. Sixteen shrubby cinquefoil (*Dasiphora fruticosa*) and currant (*Ribes* sp.) shrubs were also transplanted in the upland areas.

Riparian species were planted along the banks of the river and around the lake in 2007. A total of 109 diamondleaf willow (*Salix planifolia*) and dwarf birch (*Betula nana*) shrubs were transplanted in riparian areas. In addition to the transplants, dormant willow and birch stakes were collected around the Climax Mine property in 2008. These stakes were planted along the stream channel and in low-lying swales throughout the project area.

Wetland Transplants

A total of 738 wetland plants of approximately 6-inch diameter and 6 to 10-inch depth were transplanted from other areas within the affected area of the Mine in August 2007. These plants were allowed to harden off in their pots at the digging site, and transplanted to the project area in early October 2007. Approximately 100 plants were transplanted along the banks of the channel upstream of the lake, about 400 were planted on the shore of the lake, and the rest were planted downstream of the lake on the banks of the channel and in several low swales that will likely receive sufficient drainage to maintain wetland species. The total area that received transplants was approximately 1 acre. Each transplant received 20 grams NPK (20-10-5) fertilizer, and was watered in with 1 to 2 gallons of water to settle the soil. Primary species used for transplanting included: Water sedge (*Carex aquatilis*), Northwest Territory sedge (*Carex utriculata*), native sedge (*Carex vernacula*), other sedge species (*Carex* spp.), bluejoint reedgrass (*Calamagrostis canadensis*), tufted hairgrass (*Deschampsia cespitosa*), elephanthead lousewort (*Pedicularis groenlandica*), Merten's rush (*Juncus mertensianus*), Tracy's rush (*Juncus tracyii*), field horsetail (*Equisetum arvense*), as well as other wetland species that may have been present in smaller quantities.

Seeding

The 12.8 acres of upland area covered with biosolids in 2007 were seeded with a native upland seed mix (Table 2) at a rate of 30 pure live seeds (PLS)/sq ft. The additional acreage treated with biosolids in 2008 was also seeded with the same mix at the same rate (1.3 acres). Additionally, rocky areas and the areas around transplanted trees were selectively seeded with Engelmann spruce, subalpine fir, and bristlecone pine (*Pinus aristata*) seed.

A native wetland seed mix (Table 3) was used in all areas that were anticipated to receive sufficient water during the growing season to support facultative wetland species. The mix also included some obligate wetland species which will do well in the wettest areas along the shore of the lake. Approximately 5 to 10 feet on either side of the river channel were seeded with wetland seed at a rate of 50 PLS/sq ft, as well as on the shore of the lake and in some low-lying swales. The total area treated with wetland seed was approximately 1 acre. Some additional wetland seed was spread in 2008 to augment already seeded areas that were not establishing well or in unanticipated wet areas.

Table 2. Upland seed mixture.

Species	Common Name	% PLS
Graminoids		
Bromus marginatus	mountain brome	5%
Deschampsia cespitosa	tufted hairgrass	20%
Elymus trachycaulus	slender wheatgrass	10%
Festuca arizonica	Arizona fescue	10%
Festuca idahoensis	Idaho fescue	5%
Poa alpina	alpine bluegrass	15%
Trisetum spicatum	spike trisetum	10%
Forbs		
Achillea millefolium	common yarrow	5%
Linum lewisii	blue flax	5%
Lupinus argenteus	slivery lupine	6%
Penstemon strictus	Rocky Mountain penstemon	6%
Vicia americana	American vetch	3%

Vegetation Monitoring Methods

Vegetation monitoring was conducted on August 31 and September 1, 2010 at the end of the third growing season for the majority of the area and the end of the second growing season for the small areas seeded in 2008. Some vegetation data were also collected at the end of the second growing season on August 19 and 20, 2009.

Table 3. Wetland seed mixture.

Species	Common Name	% PLS	Wet. Ind. Status*
Graminoids			
Calamagrostis canadensis	bluejoint reedgrass	12%	OBL
Calamagrostis stricta	slimstem reedgrass	5%	UPL
Carex aquatilis	water sedge	10%	OBL
Carex utriculata	Northwest Territory sedge	10%	FAC
Deschampsia cespitosa	tufted hairgrass	25%	FACW
Glyceria borealis	small floating mannagrass	5%	OBL
Juncus saximontanus	Rocky Mountain rush	3%	FACW
Phleum alpinum	alpine timothy	20%	FAC
Forbs			
Delphinum barbeyi	subalpine larkspur	3%	FAC
Mimulus guttatus	seep monkeyflower	3%	OBL
Senecio integerrimus	lambstongue ragwort	3%	FAC
Trollius laxus	American globeflower	1%	OBL

*OBL = obligate wetland species, FACW = facultative wetland species, FAC = facultative species based on the US Fish and Wildlife Service National Wetlands Inventory.

Transect Locations

Permanent transects were established in 2008 (Fig. 3). A baseline was established along the entire restored length of the channel and seven equally spaced transects were established. The transects were set perpendicular to the baseline spanning the width of the revegetation area across all vegetation types present. The length of the transects was variable due to variability in the width of the restored area. The transects ranged in length from 58 meters to 146 meters. The transects were marked with T-posts at each end.

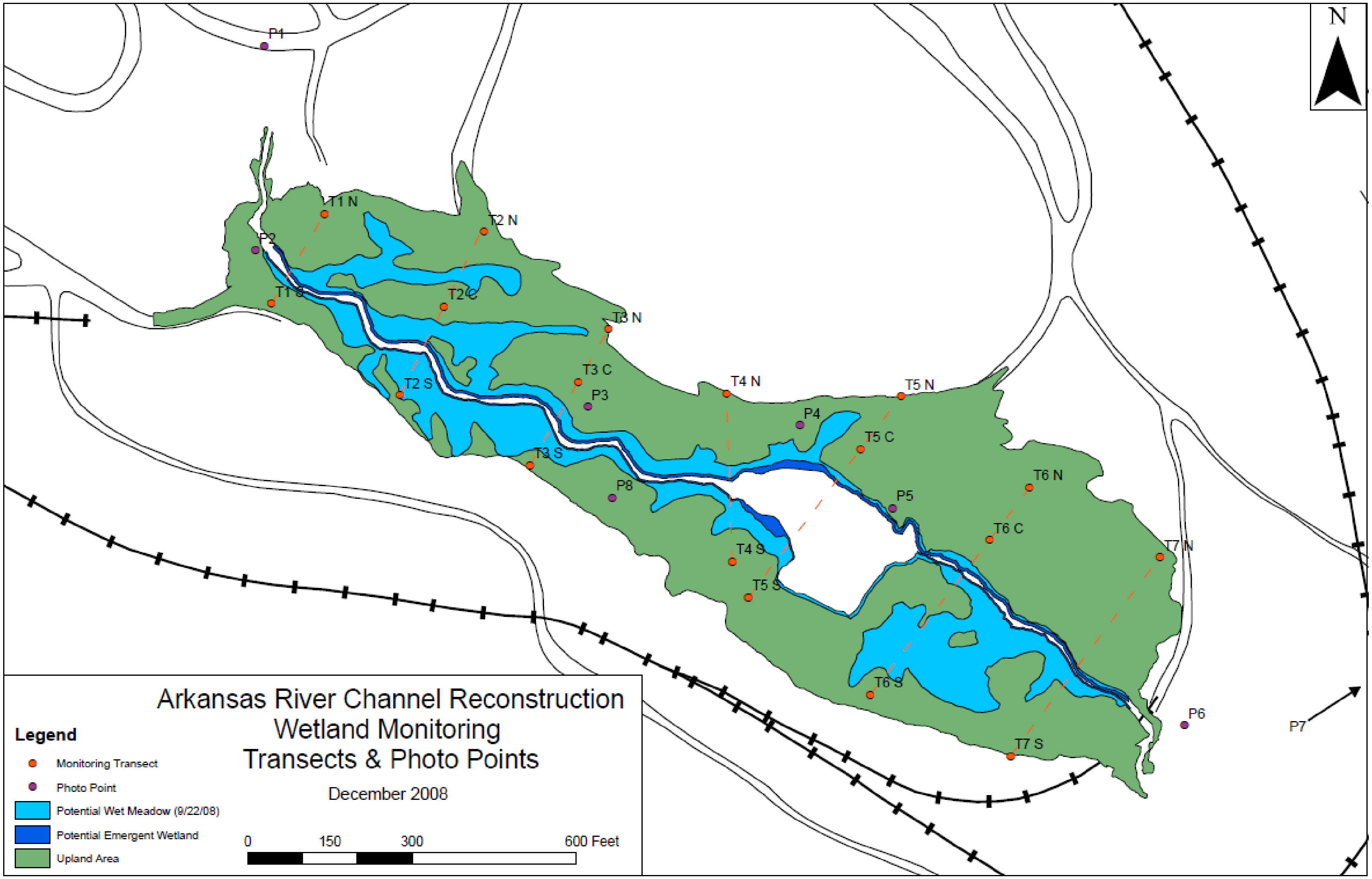

Figure 3. Vegetation monitoring transects and vegetation communities.

Vegetation Cover

Vegetation cover data were collected along each transect from the north end to the south end. A point intercept method was used for sampling. A tape measure was placed in a straight line between the permanent markers at each end of the transect and 10 data points were collected at each meter along the transect. The 10 data points at each meter mark were collected perpendicular to the transect (5 on each side of the tape measure). Each one-meter interval along the tape measure was also classified by vegetation type (i.e. upland, wetland, or water). All sample points within each vegetation type were grouped for each transect and the total was used to determine results.

First hit data were collected along each transect and used to describe the total vegetation cover and ground cover within each vegetation type. At each data point the first observation was recorded (i.e. vegetation species, rock, litter, bare ground, or water).

Transplant Survival

All trees and shrubs transplanted in the project area were monitored for survival. Wetland plug transplants were not monitored separately, but were included in vegetation cover data if they were hit during the point intercept sampling. Willow and birch stakes within one meter on either side of the vegetation cover transect were also counted and classified as alive or dead.

Results

Vegetation Cover

Vegetation cover on the entire reclamation area averaged 27.2 + 2.7% cover (Mean + 1SE) after three growing seasons (Fig. 4). This average vegetation cover is more than double the 11.8 + 1.6% cover reported in 2009 and is very good for a high altitude revegetation project after only three growing seasons. The change in absolute cover in the upland was 2.3-fold from 12.3 + 1.6% in 2009 to 27.9 + 3.0% in 2010. However, the change in absolute cover in the wetland area was only 1.5-fold from 9.7 + 2.1% in 2009 to 15.7 + 5.5% in 2010.

The lower wetland cover is likely due to the fluctuations in water level in the first two years as well as the scouring effect of run-off. In 2008 and 2009, the lake level rose from its pre-construction level to its design level and water in the channel was started and stopped several times to make adjustments and repairs. Due to the greater degree of disturbance in the wetland community, it will likely take longer for the vegetation to develop and establish.

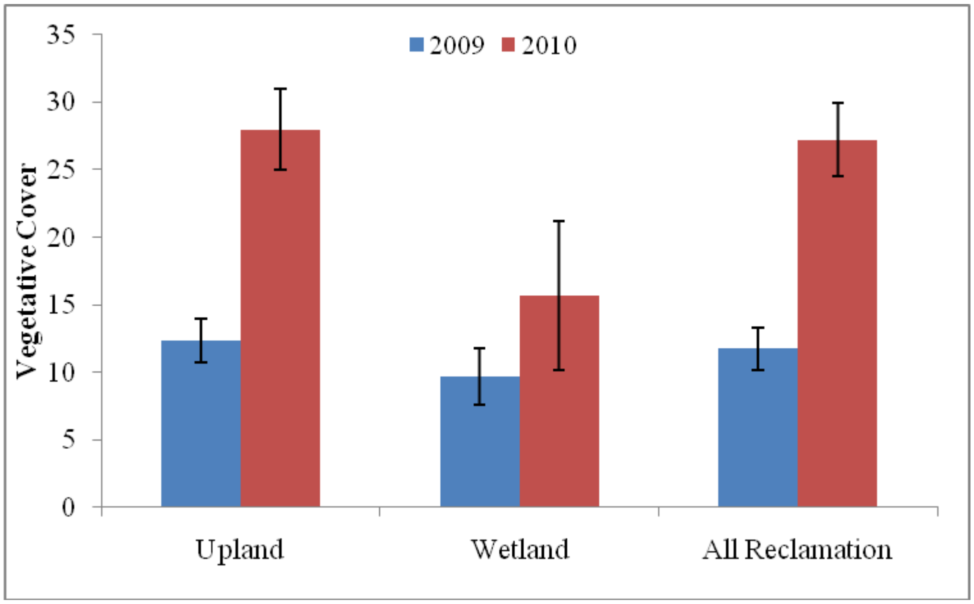

Figure 4. Vegetation cover by community type (Mean + 1SE).

The majority of the vegetation cover on the site was desirable species, defined as all native species plus other species included in one of the approved Climax Mine seed mixtures. Overall, 92.6% of the relative vegetative cover was desirable species (Fig. 5). This is an increase over 2009 when 87.4% of the relative cover was desirable. In upland areas 92.4% was desirable and in wetland areas 95.5% was desirable. Weedy species are relatively less abundant in high altitude vegetation communities than at lower elevations, and Climax has had a very aggressive noxious weed control program in place for 10 years. Thus, a low weed cover was expected and is anticipated to persist.

Ground cover (live vegetative cover, rock, and litter) was quite high on the site (89.3 + 1.6%) and differed very little between community types (Fig. 6). In the upland areas the majority of the ground cover was attributable to the wood chips that are mixed into the biosolids as part of the composting process. However the increase in upland ground cover from 2009 to 2010 suggests that vegetative litter also contributed more to ground cover in 2010 (Fig. 6). In the wetland areas ground cover was primarily woodchips and rock closer to the channel and lake. Both the wood chips and the rock are providing an effective surface armor against erosion and sediment loss while the plant community is still young. Over time the woodchips will breakdown and become less effective as a ground cover, but by that time the vegetation cover should be adequate to hold the soil.

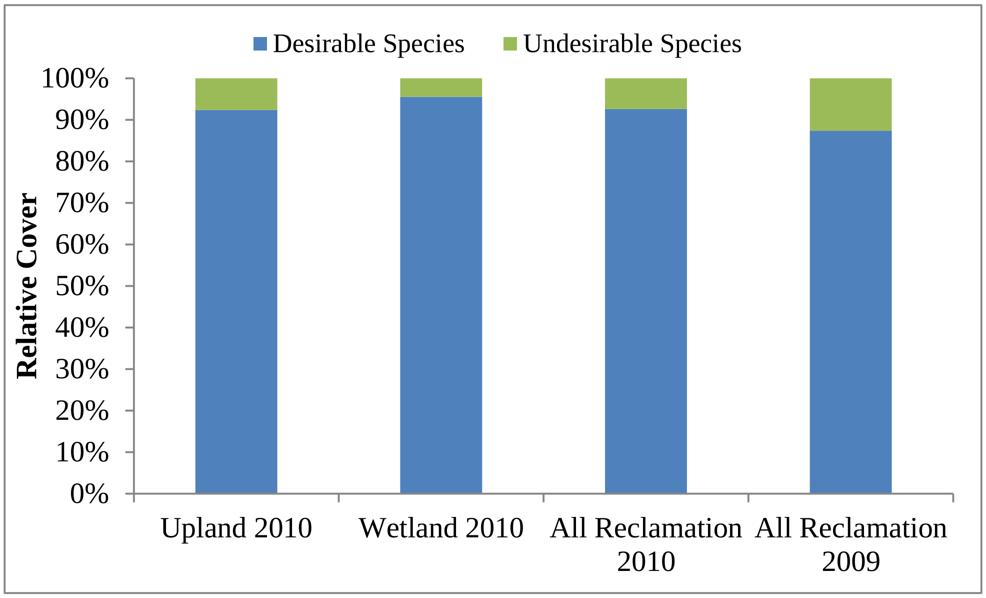

Figure 5. Relative desirable and undesirable cover by community type.

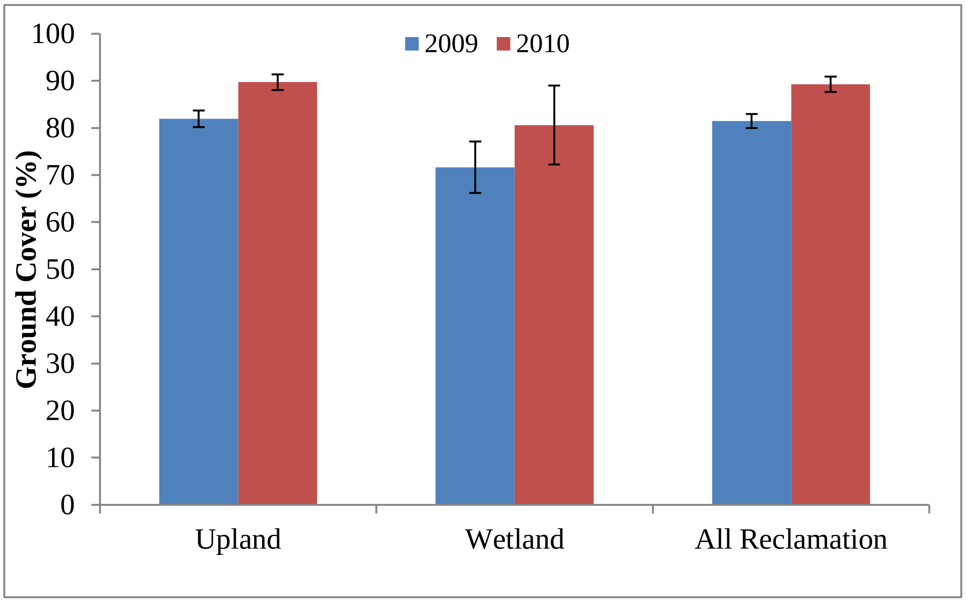

Figure 6. Ground cover by community type (Mean + 1SE)

Species Diversity & Frequency

The simplest measure of species diversity is species richness (or total number of species). The species richness for the site is quite high with a total of 81 species (Fig. 7) of which 75 species (93%) were considered desirable. The majority of the species (70 or 86%) were observed in the upland areas. In the wetland areas, 49 species (60%) were observed with 38 of those species observed in both the wetland and upland areas.

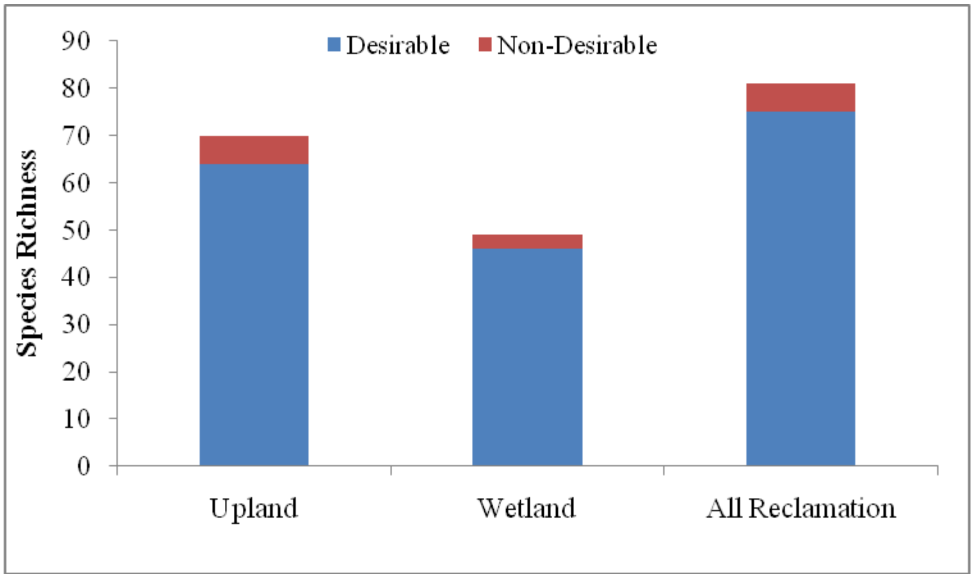

Figure 7. Species richness by vegetation community.

The 14 most common species observed along all seven transects included five grasses (tufted hairgrass, slender wheatgrass or *Elymus trachycaulus*, Idaho fescue or *Festuca idahoensis*, Rocky Mountain fescue or F. *saximontana*, and alpine bluegrass or *Poa alpina*), six desirable forbs (common yarrow, fireweed or *Chamerion angustifolia*, western tansymustard or *Descurainia pinnata*, Rocky Mountain willowherb or *Epilobium saximontana*, Rocky Mountain penstemon or *Penstemon strictus*, and willow dock or *Rumex salicifolius*) and two undesirable forbs (prostrate knotweed or *Polygonum avilculare* and common dandelion or *Taraxacum officianale*).

Transplant Survival

Tree transplant survival was relatively high within the project area especially for large Engelmann spruce transplants with 74% (83 of 113) still alive after three growing seasons (Table 4). Survival of subalpine fir was less successful with only 29% (2 of 7) surviving. Upland shrubby cinquefoil and currant shrub transplants had 100% survival and riparian willow and birch shrub transplants had 99% survival with only one willow dead after three growing seasons (Table 4).

Table 4. Tree and shrub transplant survival.

Species	Planted	Alive	% Survival
Tree Transplants			
Engelmann spruce	113	83	74
Subalpine fir	7	2	29
Total	120	85	71
Shrub Transplants			
Diamondleaf willow	97	96	99
Dwarf birch	12	12	100
Shrubby cinquefoil	15	15	100
Wax currant	1	1	100
Total	124	124	100

The survival of stakes was not as high as transplants, but still adequate for willows. Of the 38 willow stakes encountered along the vegetation cover transects, 23 (56%) of them were alive after three growing seasons (Table 5). When survival is evaluated by vegetation type, not surprisingly, it increases dramatically with more water. The willow stakes in areas evaluated to have wetland hydrology exhibited 73% survival, while the willow stakes in areas evaluated to have upland hydrology exhibited only 27% survival. At the time of construction and revegetation, some areas were anticipated to potentially have wetland hydrology that did not exhibit wetland hydrology at the time of vegetation monitoring. Thus, some willow stakes were found in areas with upland hydrology.

Table 5. Willow and birch stake survival

	Upland			Wetland		
	N	Alive	% Survival	N	Alive	% Survival
Willow	15	4	26.7	26	19	73.1
Birch	0	n/a	n/a	5	0	0.0

While wetland plugs were not quantitatively evaluated, anecdotal evidence suggests that these transplants were quite successful. Very few dead plugs were observed; however, it is possible that some plugs were washed away during spring runoff. Most plugs as well as some willow stakes also showed signs of heavy grazing by marmots and elk on the site. Both species are commonly seen in the area and elk damage was also observed on some of the spruce tree transplants.

Seeded Species Establishment

The seed mixtures used for this project were not the standard mixtures traditionally used for reclamation at Climax. These seed mixtures were also used at a lower rate; 30 PLS/sq ft for upland areas and 50 PLS/sq ft for wetland areas. The lower seeding rate was intended to improve species diversity as has been shown on other reclamation projects completed by these authors (Bay et al. 2010). This project was used as a pilot to test two new reclamation seed mixes for future reclamation. Thus, an evaluation of the success of the seed mixtures was performed as a part of the monitoring.

While the vegetation cover of the seeded species is relatively low (18.9%), they did contribute the majority (72% relative cover) of the total cover on the site (Fig. 8). Seeded species make up 71% of the relative cover in the upland areas and 79% of the relative cover in wetland areas.

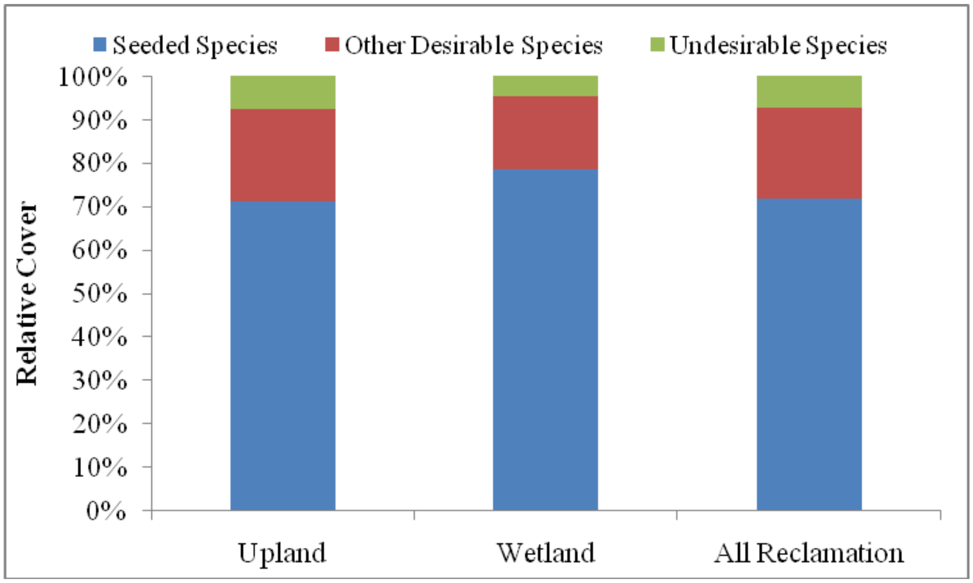

Figure 8. Seeded species relative cover.

All but two of the seeded upland species (blue flax or *Linum lewisii* and silvery lupine or *Lupinus argenteus*) were encountered during cover sampling, and these two species were observed within one meter of several of the transects. Silvery lupine was observed along six of the seven transects and blue flax was observed along two of these transects.

For each species in the mixture an establishment rating was calculated by dividing the absolute cover by the % contribution to the seed mixture. The species with the best establishment rating in the upland areas were slender wheatgrass with 59.5% and common yarrow with 57.3% (Table 6). Several of the species seeded in the upland seed mixture were also identified in wet meadow areas including: slender wheatgrass, Arizona fescue, alpine bluegrass, spike trisetum, common yarrow, and Rocky Mountain penstemon.

Table 6. Upland seed mixture species establishment ratings

Species	Common Name	% Composition	% Cover	Est. Rating
<u>Graminoids</u>				
Bromus marginatus	mountain brome	5	0.29	5.7
Deschampsia cespitosa	tufted hairgrass	20	5.57	27.9
Elymus trachycaulus	slender wheatgrass	10	5.95	59.5
Festuca arizonica	Arizona fescue	10	0.81	8.1
Festuca idahoensis	Idaho fescue	5	0.29	5.8
Poa alpina	alpine bluegrass	15	2.91	19.4
Trisetum spicatum	spike trisetum	10	0.20	2.0
<u>Forbs</u>				
Achillea millefolium	common yarrow	5	2.86	57.3
Penstemon strictus	Rocky Mountain penstemon	6	0.03	0.5
Vicia americana	American vetch	3	0.02	0.7
Total		100	18.92	

Four of the species used in the wetland seed mixture were encountered during cover sampling in the wet meadow areas (Table 7). Four of the other eight species, bluejoint reedgrass, water sedge, subalpine larkspur (*Delphinium barbeyi*), and American globeflower (*Trollius* *laxus*), were also observed on the site. Tufted hairgrass had an establishment rating of 21; alpine timothy had an establishment rating of 15.1, seep monkey flower had an establishment rating of 14.9, and meadow groundsel had an establishment rating of 6. These four species span the wetland indicator range. The monkey flower is classified as an obligate wetland species (OBL), the tufted hairgrass is classified as a facultative wetland species (FACW), and the alpine timothy and meadow groundsel are classified as facultative species (FAC).

Table 7. Wetland seed mixture species establishment ratings

Species	Common Name	% Comp	Ind. Status	% Cover	Est. Rating
<u>Graminoids</u>					
Deschampsia cespitosa	tufted hairgrass	25	FACW	5.2	21.0
Phleum alpinum	alpine timothy	20	FAC	3.0	15.1
<u>Forbs</u>					
Mimulus guttatus	seep monkeyflower	3	OBL	0.4	14.9
Senecio integerrimus	meadow groundsel	3	FAC	0.2	6.0
Total				8.9	

<u>Wetland Monitoring</u>

In general, most areas anticipated to become wetlands did exhibit wetland hydrology and some exhibited wetland vegetation. Wetland soil evaluation is not conducted for mitigation wetlands. While not formally evaluated, the majority of wetland transplants observed along the channel banks and around the lake appeared to be alive. Vegetative cover in wetland areas ranged from 0% to 34.0% with an average of 15.7%. Because the site is so newly revegetated and the cover in general is low in wetland areas, it is likely premature to evaluate the extent of wetland establishment.

Conclusions

Overall the vegetation in the project area is establishing well and is anticipated to develop into a stable, self-sustaining, diverse subalpine habitat over time. While vegetative cover is relatively low it is not lower than would be expected at this altitude after only three growing seasons. Desirable species constitute the majority of the vegetation cover and diversity and many of the dominant species are those that were included in the seed mixtures. All of the species in the upland seed mixture and eight of twelve species in the wetland seed mixture were also observed on the site. These results suggest that the site will likely develop into the desired final plant community.

Tree and shrub transplanting was very successful with 93% of conifers, and 99% of shrubs surviving the first two years. Staking was not as successful as transplanting, but survival was still quite high for willows especially in the wetland areas.

Most areas anticipated to become wetland areas over time did exhibit some indicators of wetland hydrology and/or vegetation. Although the wetland areas along only three of the seven transects were dominated by wetland vegetation and had wetland hydrology, it is still early to determine the success of wetland creation on the site. Wetland transplants are surviving and most wetland seed mixture species were observed suggesting that the wetlands can establish over time.

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