Therriault Creek Riparian Revegetation Maintenance and Monitoring 2009 Report

Task Order #0907

Prepared for:

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Introduction

This report is an addendum to the *2008 Therriault Creek Riparian Revegetation 2008 Monitoring Report* (2008 Monitoring Report) and describes the results of effectiveness monitoring conducted in July 2009. This report also describes maintenance activities and additional revegetation treatments completed in September and October 2009 (Therriault Creek Riparian Revegetation Phase II). These activities were determined based on evaluating the results of 2008 and 2009 effectiveness monitoring using an adaptive management framework. Details on the Therriault Creek riparian revegetation project including: revegetation strategies and treatments; effectiveness monitoring methods and 2008 results; and the adaptive management framework can be found in three separate documents. These documents are: *Therriault Creek Riparian Revegetation Plan* (Revegetation Plan) prepared for Kootenai River Network (Geum Environmental Consulting, Inc. 2007a); *Therriault Creek Riparian Revegetation Plan Implementation Report* (2007 Implementation Report) prepared for Montana Fish, Wildlife and Parks (Geum Environmental Consulting Inc. 2007b); and *Therriault Creek Riparian Revegetation 2008 Monitoring Report* prepared for Kootenai River Network (2008 Monitoring Report) (Geum Environmental Consulting, Inc. 2008).

As described in the 2008 Monitoring Report, three types of monitoring are necessary components of the integrated monitoring and adaptive management program. These include: baseline, as-built, and effectiveness monitoring. ***Baseline monitoring*** documents the pre-restoration condition and is described in the Revegetation Plan prepared for the project. ***As-built monitoring*** documents completed treatments and for the treatments implemented in fall 2007, is provided in the 2007 Implementation Report. ***Effectiveness monitoring*** addresses whether project objectives are being met, determines maintenance needs, and provides inputs into decision pathways for adaptive management. The results of 2008 effectiveness monitoring are provided in the 2008 Monitoring Report. This report provides the results of 2009 effectiveness monitoring for treatments implemented in 2007, compares those results with 2008 effectiveness monitoring results and describes results of as-built monitoring for revegetation treatments implemented in September and October 2009.

Effectiveness monitoring data were collected for all revegetation treatments implemented in 2007 during Phase I of the riparian revegetation project (Figures 1 and 2). The following riparian revegetation treatments were implemented during Phase I:

- Residual shrub protection
- Containerized planting
- Solarization
- Vegetated soil lifts
- Willow fascines
- Large woody debris structures
- Coir logs
- Herbicide application targeting reed canarygrass (*Phalaris arundinacea*) and Canada thistle (*Cirsium arvense*)

Table 1 provides a brief description of each treatment, the purpose of the treatment and the quantity installed. Figure 1 shows the as-built documentation for the treatments. These data provide the baseline for project effectiveness monitoring. Locations of effectiveness monitoring are shown in Figure 2. Monitoring results for 2009 and comparison of those results with 2008 effectiveness monitoring results are reported in the sections below.

As described in the reports listed above, successfully converting the riparian vegetation along Therriault Creek within the project reach to a mosaic of native riparian shrubs and trees requires a multi-year phased approach. The intention of the initial phase, implemented in fall 2007, was to implement a range of treatments based on a detailed evaluation of existing site conditions and ecological processes driving vegetation succession at the site. Monitoring the effectiveness of these treatments provides the basis for determining which treatments are most successful and appropriate for achieving project goals and therefore should be included in the next phase of revegetation. The results of 2008 and 2009 effectiveness monitoring were used to determine maintenance needs for 2007 treatments and identified some additional revegetation treatments which were implemented in September and October 2009 (Phase II). This report builds from the adaptive management framework presented in the 2008 Report and provides recommendations for 2010 maintenance activities and additional revegetation treatments that should be implemented during the 2010 project phase (Phase III).

Table 1. Overview of riparian revegetation treatments implemented in the first phase (2007) of riparian revegetation efforts along Therriault Creek.

Treatment	Treatment Description	Treatment Purpose	Quantity Installed	Photograph
Residual Shrub Protection	Woody vegetation establishment technique consisting of placing four foot tall rigid plastic mesh browse protectors and three foot by three foot brush blankets around surviving shrubs and trees planted during channel construction (2005).	Protect previously installed plant material from browse and reduce competition from aggressive pasture grasses.	250	
Containerized Planting	Woody vegetation establishment technique using one and two gallon native shrubs and trees in select areas along the channel. Treatment includes placing four foot tall rigid plastic mesh browse protectors, three foot by three foot brush blankets and eight inch rigid plastic vole protectors around each plant.	Establish native trees and shrubs along channel to provide stability and habitat, and create long term seed sources.	1,028	
Solarization	Weed control technique consisting of installing woven black fabric in target areas to heat kill live plants and seed. May be temporary (non-planted) or long term (planted with native woody vegetation).	Reduce the cover of aggressive pasture grasses and weeds such as reed canarygrass and create conditions to allow establishment of native trees and shrubs in areas otherwise dominated by undesirable species.	8,120 square feet (4,920 square feet temporary and 3,200 square feet long-term, planted)	
Vegetated Soil Lift	Streambank stabilization and woody vegetation establishment technique that incorporates layers of coir fabric, soil, and dormant willow cuttings.	Provide stability on high stress or high risk outer meander bends to encourage the establishment of native woody vegetation that will in turn provide long term natural channel stability.	120 feet	

Treatment	Treatment Description	Treatment Purpose	Quantity Installed	Photograph
Willow Fascines	Woody vegetation establishment technique using willow cuttings tied together to form a linear bundle and installed in depositional areas along the channel.	Establish native woody vegetation on depositional areas where willows and cottonwoods would naturally recruit, provide roughness to capture floating seed, debris, and fine sediments.	800 feet	
Large Woody Debris Structures	Instream and floodplain habitat enhancement technique using whole trees, logs and other large woody debris to create interlocking debris jams in the channel and extending onto adjacent floodplain surfaces.	Enhance habitat, provide roughness features to trap floating organic material and seed and encourage over-bank flooding, retention of flood waters in adjacent floodplains and deposition of fine sediments, creating microsites for woody vegetation to establish.	5 structures	
Coir Logs	Streambank woody vegetation establishment technique combining high density coir logs (twelve inch by ten foot coconut fiber bales) and dormant willow cuttings.	Provide a stable point at the land water interface and beneath the pasture grass sod to create conditions for willows to establish. Coir biodegrades over 5-7 years allowing willow roots to provide natural long-term channel stability.	400 feet	
Herbicide Application	Application of herbicide to reduce cover of noxious weeds and other undesirable species.	Reduce cover of noxious weeds and other aggressive species such as Canada thistle and reed canarygrass to reduce competition with desired grasses, forbs and planted shrubs and trees.	Infestations along approximately 4,000 feet of channel were treated	

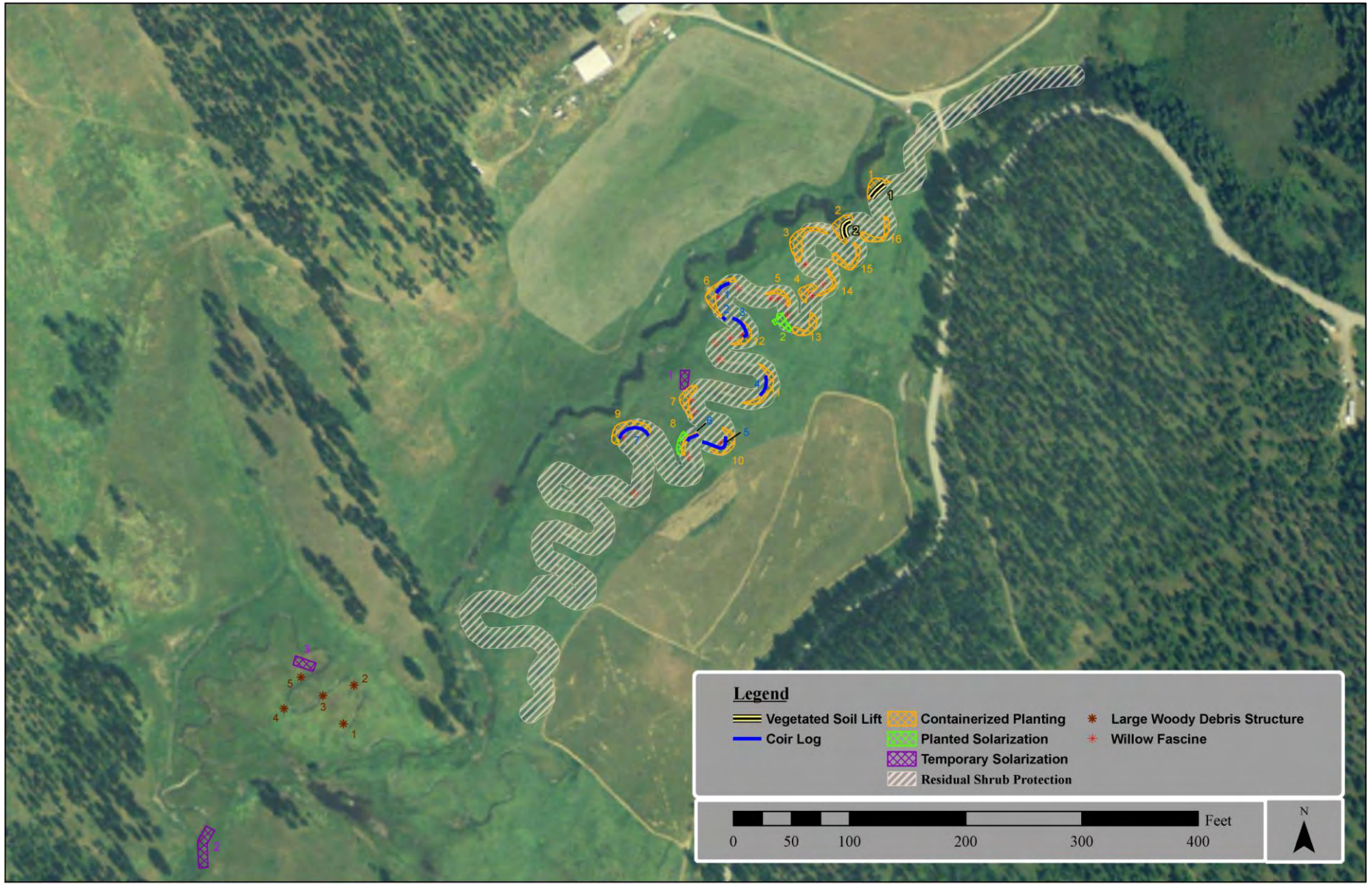

Figure 1. Locations of riparian revegetation treatments implemented in 2007 along Therriault Creek.

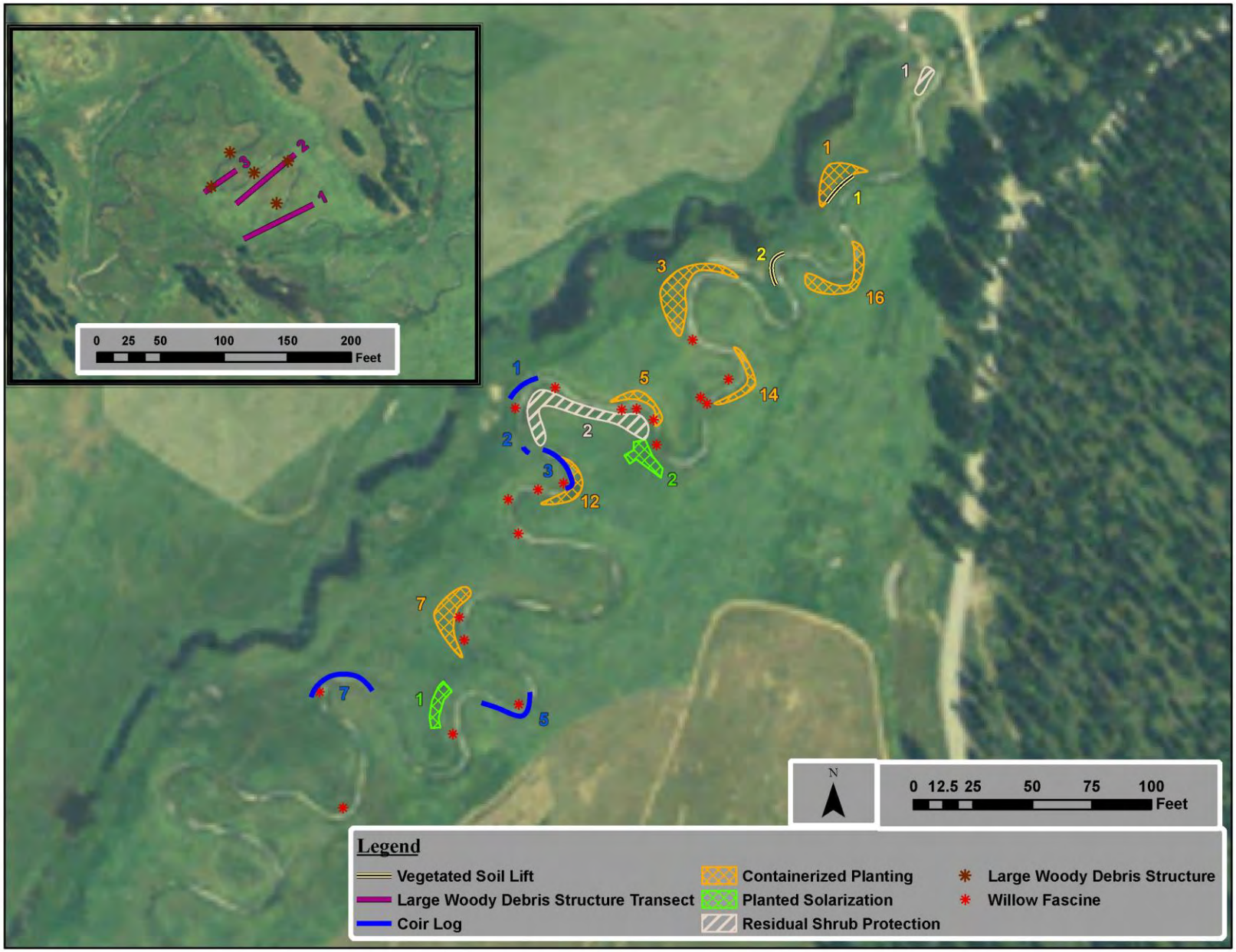

Figure 2. Locations of effectiveness monitoring completed in 2009 for riparian revegetation treatments implemented along Therriault Creek in 2007. The main figure shows the upstream portion of project area. The inset shows the downstream portion of the project area.

2009 Effectiveness Monitoring Results and Comparison with 2008 Results

Table 2 provides an overview of the metrics used to evaluate each revegetation treatment for effectiveness. Table 2 also describes any modifications made to metrics between 2008 and 2009 monitoring.

Table 2. Overview of revegetation treatment effectiveness monitoring locations and metrics.

Treatment	Monitoring Unit[1]	Monitoring Metrics	
		2008	2009 Modifications
Residual Shrub Protection	Two monitoring plots established in treatment area	Number protected shrubs with browse Number unprotected shrubs with browse	None
Containerized Planting	Seven of sixteen planting units	Survival by species Dominant herbaceous species	Willow species combined into one survival category
Solarization	Both planting units	Survival by species Average diameter of stems Height Growth Metric/Volume calculation	Willow species combined into one survival category
Vegetated Soil Lift	Both sites	Percent cover willow Percent cover herbaceous Percent cover weeds Willow stem survival Percent fabric biodegradation Number of rips/tears	Willow stem survival not recorded
Willow Fascines	All sites	Percent scour Percent survival willow cuttings Deposition and type	Percent cover by all vegetation replaced percent survival of willow cuttings
Large Woody Debris Structures	3 transects perpendicular to treatment sites	Percent cover dominant species Water depth	None
Coir Logs	Five of seven treatment sites	Willow cutting survival Water depth Coir log depth Average undercut depth Percent natural colonization Percent fine sediment deposition	None
Herbicide Application	Entire project site	2007: Weed mapping 2008: Qualitative observations of herbicide effectiveness	Weed mapping

[1]See Figure 2

Monitoring Results

Residual Shrub Protection

Two residual shrub protection plots were established to monitor effectiveness of this treatment. Both plots were monitored in July 2008 and July 2009 (Figure 2). Data are provided in the Excel workbook accompanying this report. No browse was observed on the protected portion of plants in 2008 or 2009. The portion of the plants extending above or outside of the protector showed signs of browse in 2009 (Figure 3). Residual shrubs left unprotected showed signs of continued browse in both 2008 and 2009 and continue to have a suppressed growth form (Figure 4). Protected shrubs showed increased growth between 2008 and 2009 (Figure 5). Some protected shrubs had as much as three feet of new growth.

Figure 3. Photographs showing browse occurring on portions of protected plants extending beyond protectors.

Figure 4. Photograph of unprotected residual shrub taken during July 2009 monitoring. Unprotected residual shrubs continue to be browsed and exhibit a suppressed growth form.

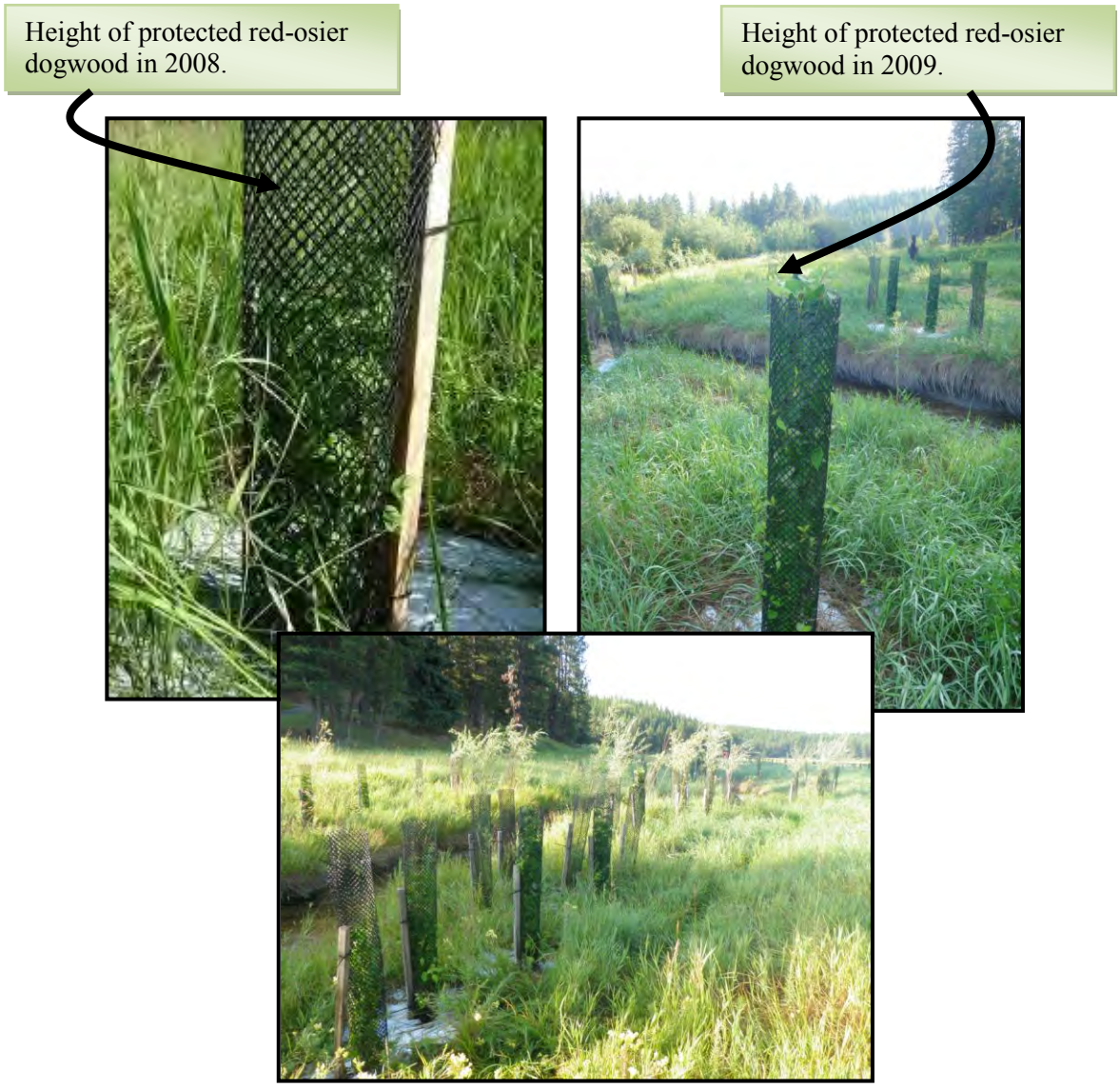

Figure 5. Photographs showing the difference in protected red-osier dogwood growth between 2008 (top photo left) and 2009 (top photo right) (the stake used to stabilize the netting is a good reference for the difference in height). Bottom photo shows the growth on protected sandbar willow plants monitored in 2009. Protected sandbar willows have grown approximately 3 feet between 2008 and 2009.

Containerized Planting

Seven of the sixteen planting units were selected for effectiveness monitoring. All seven sites (414 plants or 40 percent of total plants installed) were monitored in July 2008 and 2009 (Figure 2). Total plant survival for monitored plots in 2008 was 96 percent. Total percent survival for monitored plots in 2009 was 89 percent. Summarized results of containerized plant survival monitoring are provided in Tables 3 and 4. Appendix A provides a breakdown of results by monitored planting unit (Table A-1). The full data set for containerized planting unit monitoring including survival and dominant herbaceous species cover is provided in the Excel workbook accompanying this report.

Survival remains above 90 percent for most species (Table 4). Exceptions include: thinleaf alder (*Alnus incana*), where survival decreased from 91 percent to 68 percent between 2008 and 2009;

and water birch (*Betula occidentalis*), where survival decreased from 92 percent to 77 percent between 2008 and 2009. Engelmann spruce (*Picea engelmannii*) exhibited poor survival in 2008 and 2009 (18 percent both years).

The common herbaceous species recorded in each monitored planting unit remained relatively unchanged between 2008 and 2009. Introduced pasture grasses remain common in all planting units. The dominant herbaceous species include: common timothy (*Phleum pretense*), smooth brome (*Bromus inermis*), redtop (*Agrostis stolonifera*), quackgrass (*Elymus repens*) and Kentucky bluegrass (*Poa pratensis*). Results of 2009 monitoring show that pasture grasses were less dominant in Planting Units 7 and 12 than they were in 2008, and that there was an increase in native sedge and forb species cover. The three foot by three foot brush blankets installed around planted shrubs and trees are eliminating cover of grasses near planted shrubs and trees (Figure 6).

Canada thistle was recorded in all planting units in 2008 and 2009 but appears to have decreased in density in some units between 2008 and 2009. Houndstongue (*Cynoglossum officinale*) was not recorded in any planting units in 2008 but was recorded in Planting Units 1 and 16 in 2009.

There was no observed evidence of vole damage to any containerized plants in monitored planting units.

Many of the planted trees and shrubs had out-grown their browse protectors (Figures 6 and 7).

Table 3. Total containerized plant survival by planting unit.

Planting Unit	2008 Survival	2009 Survival
Planting Unit 1	100%	98%
Planting Unit 3	99%	90%
Planting Unit 5	98%	95%
Planting Unit 7	96%	90%
Planting Unit 12	96%	94%
Planting Unit 14	90%	85%
Planting Unit 16	93%	73%

Table 4. Total percent survival by species, combined for monitored planting units (Planting Units 1, 3, 5, 7, 12, 14, and 16).

Scientific Name	Common Name	2008 Survival	2009 Survival
Alnus incana	mountain alder	91%	68%
Amelanchier alnifolia	Western serviceberry	94%	94%
Betula occidentalis	water birch	92%	77%
Cornus sericea	red-osier dogwood	100%	100%
Crataegus douglasii	black hawthorn	100%	95%
Picea engelmannii	Engelmann spruce	18%	18%
Populus balsamifera	black cottonwood	100%	92%
Populus tremuloides	quaking aspen	100%	100%
Prunus viginiana	common chokecherry	95%	84%
Rosa woodsii	wood's rose	91%	91%
Salix bebbiana	Bebb willow	100%	N/A*
Salix drummondiana	Drummond's willow	100%	N/A*
Salix exigua	sandbar willow	100%	N/A*
Salix geyeriana	Geyer's willow	100%	N/A*
Salix spp	willow species	100%*	84%
*Spiraea betulifolia**	white spirea	100%	100%
Symphoricarpos occidentalis	common snowberry	100%	96%

****Due to the difficulty in distinguishing between willow species, some willows were placed in the *Salix spp.* category in 2008 and all willows were placed in the *Salix spp.* category in 2009 to enhance repeatability during future monitoring events.

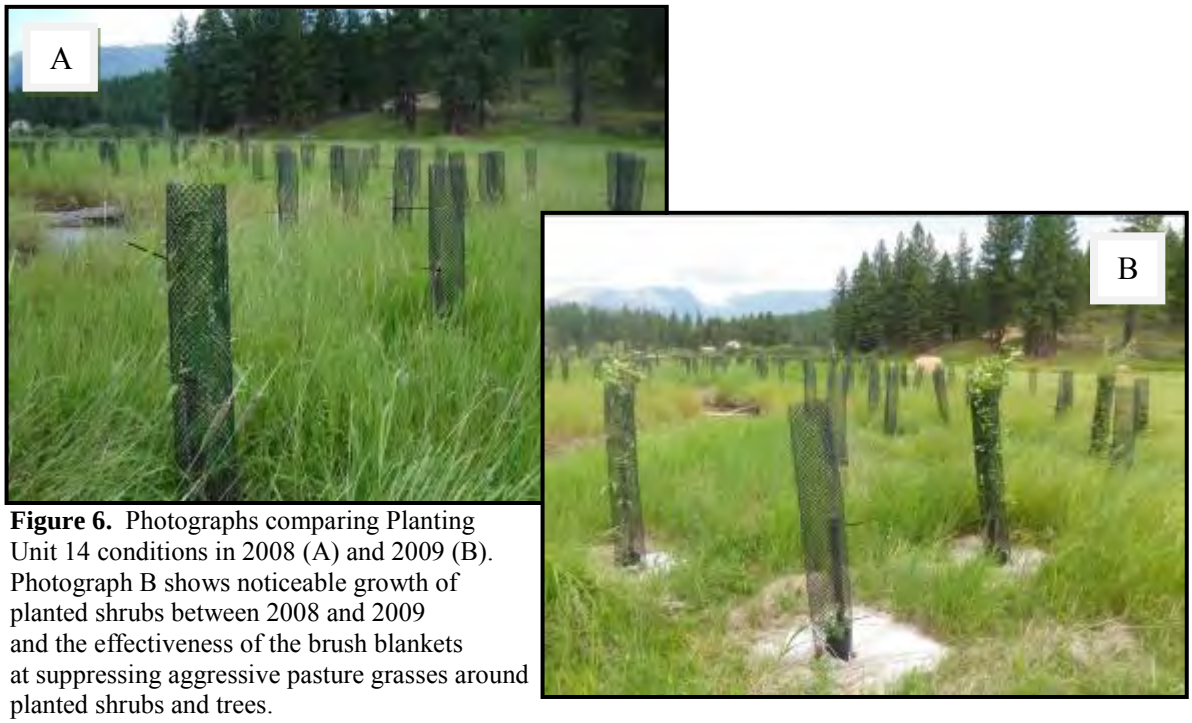

Figure 6. Photographs comparing Planting Unit 14 conditions in 2008 (A) and 2009 (B). Photograph B shows noticeable growth of planted shrubs between 2008 and 2009 and the effectiveness of the brush blankets at suppressing aggressive pasture grasses around planted shrubs and trees.

Figure 7. Photographs of plants that had out-grown their browse protectors by July 2009.

Solarization

Two planting units were treated with solarization fabric. Both solarization planting units were selected for monitoring and both were monitored in July 2008 and 2009. All data are provided in the Excel workbook accompanying this report.

Table 5 provides a summary of the total percent survival by species for planted solarization plots. Survival for all species was greater than or equal to 80 percent, except for Engelmann spruce and white spirea (0 percent and 40 percent respectively).

Table 6 and Figure 8 provide summaries of the total growth metric (height x πr^2) compared between 2008 and 2009. Total values for the growth metric varied widely by species. In general, quaking aspen (*Populus tremuloides*) and Drummond's willow (*Salix drummondiana*) showed the highest growth metric value, which is consistent with 2008 data. Engelmann spruce, white spirea and serviceberry (*Amelanchier alnifolia*) showed the lowest growth metric values. Mountain alder (*Alnus incana*), Black hawthorn (*Crataegus douglasii*), quaking aspen, and Drummond's willow had the biggest change in growth metric between 2008 and 2009.

All of the surviving plants, with the exception of white spirea, had out-grown browse protectors (Figure 9).

Table 5. Comparison of 2008 and 2009 survival for containerized plants installed within solarization plots.

Scientific Name	Common Name	2008 Survival	2009 Survival
Alnus incana	mountain alder	80%	80%
Amelanchier alnifolia	Western serviceberry	100%	100%
Betula occidentalis	water birch	100%	100%
Cornus sericea	red-osier dogwood	100%	100%
Crataegus douglasii	black hawthorn	100%	89%
Picea engelmannii	Engelmann spruce	33%	0%
Populus tremuloides	quaking aspen	100%	100%
Rosa woodsii	wood's rose	100%	100%
Salix drummondiana	Drummond's willow	100%	N/A*
Salix exigua	sandbar willow	100%	N/A*
Salix spp	willow species	100%	94%
Spiraea betulifolia	white spirea	100%	40%

*****Due to the difficulty in distinguishing between willow species, willows were combined during 2009 monitoring to enhance repeatability in during future monitoring events.

Table 6. Comparison of 2008 and 2009 total growth metric for species installed within solarization plots.

Scientific Name	Common Name	Total Growth Metric (sum)		Change
		2008	2009	
Alnus incana	mountain alder	3.29	130.21	+126.92
Amelanchier alnifolia	Western serviceberry	25.91	44.92	+19.01
Betula occidentalis	water birch	20.39	78.64	+58.25
Cornus sericea	red-osier dogwood	15.10	123.20	+108.10
Crataegus douglasii	black hawthorn	36.67	150.91	+114.24
Picea engelmannii	Engelmann spruce	0.79	0.00	N/A*
Populus tremuloides	quaking aspen	92.24	246.88	+154.64
Rosa woodsii	wood's rose	0.36	21.77	+21.41
Salix drummondiana	Drummond's willow	70.76	273.29	+202.53
Salix exigua	sandbar willow	6.15	79.87	+73.72
Salix spp	willow species	1.28	30.16	+28.88
Spiraea betulifolia	white spirea	0.69	0.34	-0.35

*No plants were alive in 2009

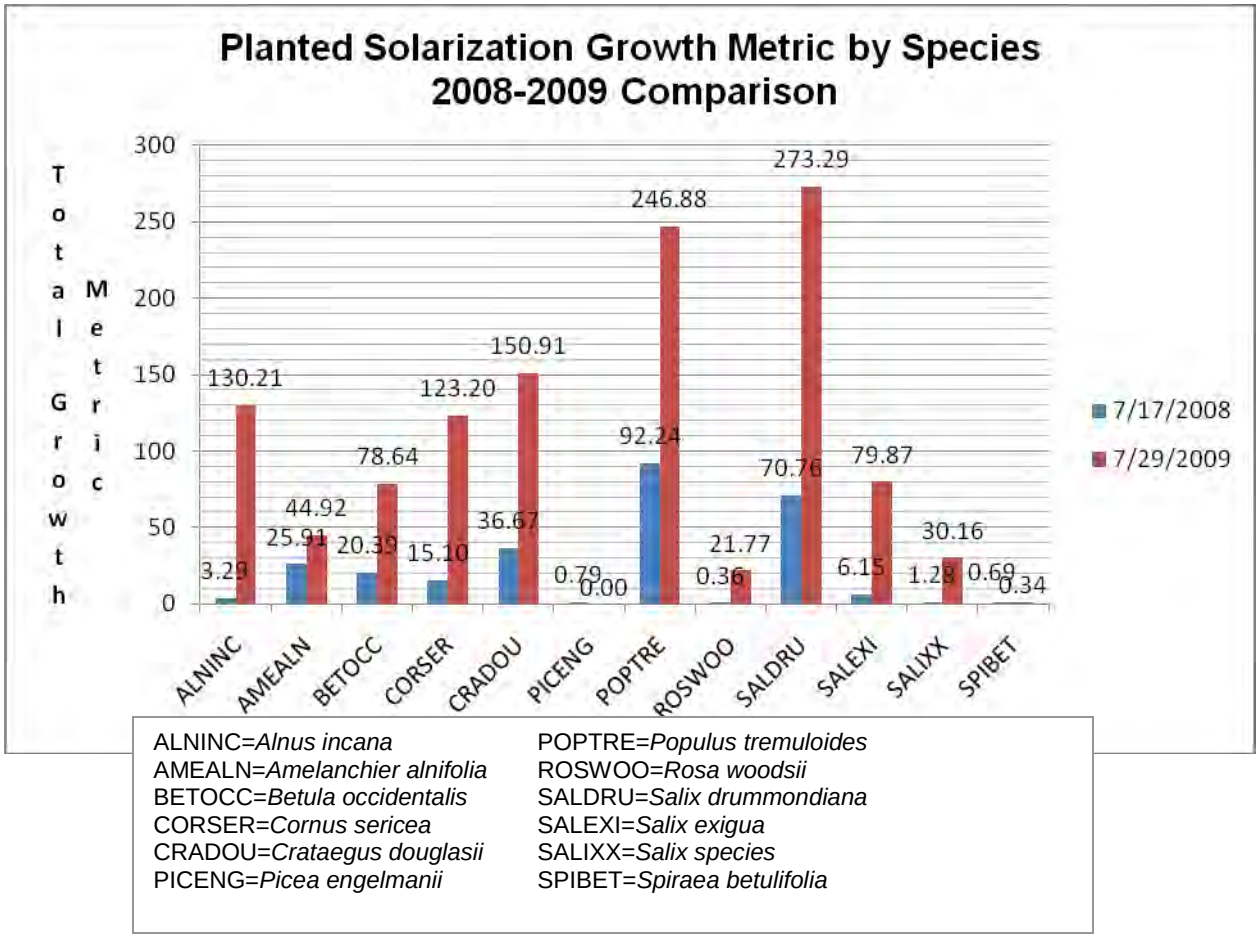

Figure 8. Comparison of growth metric values between species in planted solarization plots 1 and 2 in 2008 and 2009. Total represents the sum of growth metric values (height x πr^2) for each species.

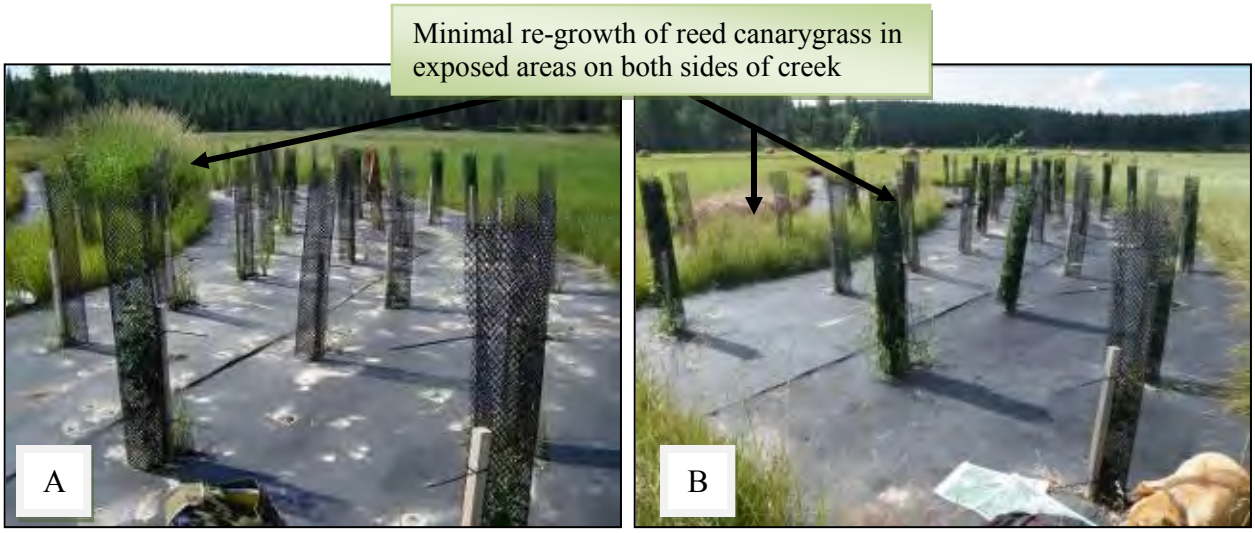

Figure 9. Planted solarization Plot 1 in 2008 (A) and 2009 (B). Most surviving plants out-grew their browse protectors in 2009. Photograph also shows the reduction in reed canarygrass adjacent to the solarization plot as a result of herbicide applications in 2008 and 2009.

Vegetated Soil Lifts

Two vegetated soil lifts were installed in 2007. Both vegetated soil lifts were monitored in July 2008 and 2009. A summary of monitoring results are provided in Table 7. Table A-2 in Appendix A provides the values of each metric by five-foot increment. All data are provided in the Excel workbook accompanying this report.

Percent cover of willows increased at both sites between 2008 and 2009 (Figures 10 and 11). Due to the inconsistency in counting willow stems, percent survival of willow stems was not recorded. Percent cover is a surrogate method for stem survival. Average willow shoot height was recorded in 2009. This metric was added to evaluate new willow growth and document the effects of browse. Shoot height ranged from a low of eight inches to a high of 30 inches.

Percent cover of herbaceous species and weeds increased at both sites between 2008 and 2009 (Figures 10 and 11). Herbaceous species consisted mainly of non-native pasture grasses such as smooth brome (*Bromus inermis*), quackgrass (*Elymus repens*), and orchard grass (*Dactylis glomerata*), but also early successional species such as yarrow (*Achillea millefolium*), clover (*Trifolium spp.*), and annual mustards (*Brassica spp.*). Weed species included Canada thistle and reed canarygrass in 2008, and included houndstongue (*Cynoglossum officinale*) in 2009.

There were no rips in the fabric and the level of fabric degradation remained the same for both lifts between 2008 and 2009.

Table 7. Comparison of data collected during July 2008 monitoring and July 2009 monitoring of Soil Lifts 1 and 2. Data is the average of all five-foot increments monitored at each site.

Metric	2008	2009	2008	2009
	Soil Lift 1(a)	Soil Lift 1(a)	Soil Lift 1(b)	Soil Lift 1(b)
Number rips/tears in fabric	0	0	N/A	N/A
Percent cover willow	8.1	15.5	22.4	31
Percent cover herbaceous species	34.5	67	N/A	N/A
Percent cover weedy species	4.4	8.5	N/A	N/A
Percent biodegradation of fabric*	10	10	N/A	N/A
Percent survival of willow stems	94	Not recorded	54	Not recorded
Average height of stems	Not recorded	8.8	Not recorded	18.6
	Soil Lift 2(a)	Soil Lift 2(a)	Soil Lift 2(b)	Soil Lift 2(b)
Number rips/tears in fabric	0	0	N/A	N/A
Percent cover willow	3.9	44.62	0	12.69
Percent cover herbaceous species	76	86.15	N/A	N/A
Percent cover weedy species	3.9	12.69	N/A	N/A
Percent biodegradation of fabric	10	0.00	N/A	N/A
Percent survival of willow stems	76	Not recorded	89	Not recorded
Average height of stems	Not recorded	19.38	Not recorded	16.77

(a) = above lift (b) = below lift

Figure 10. Photographs of Soil Lift 1 immediately after implementation (A), during July 2008 effectiveness monitoring (B), and during July 2009 effectiveness monitoring (C). Willow and herbaceous cover increased in 2009 on both the top and bottom layers of the lift.

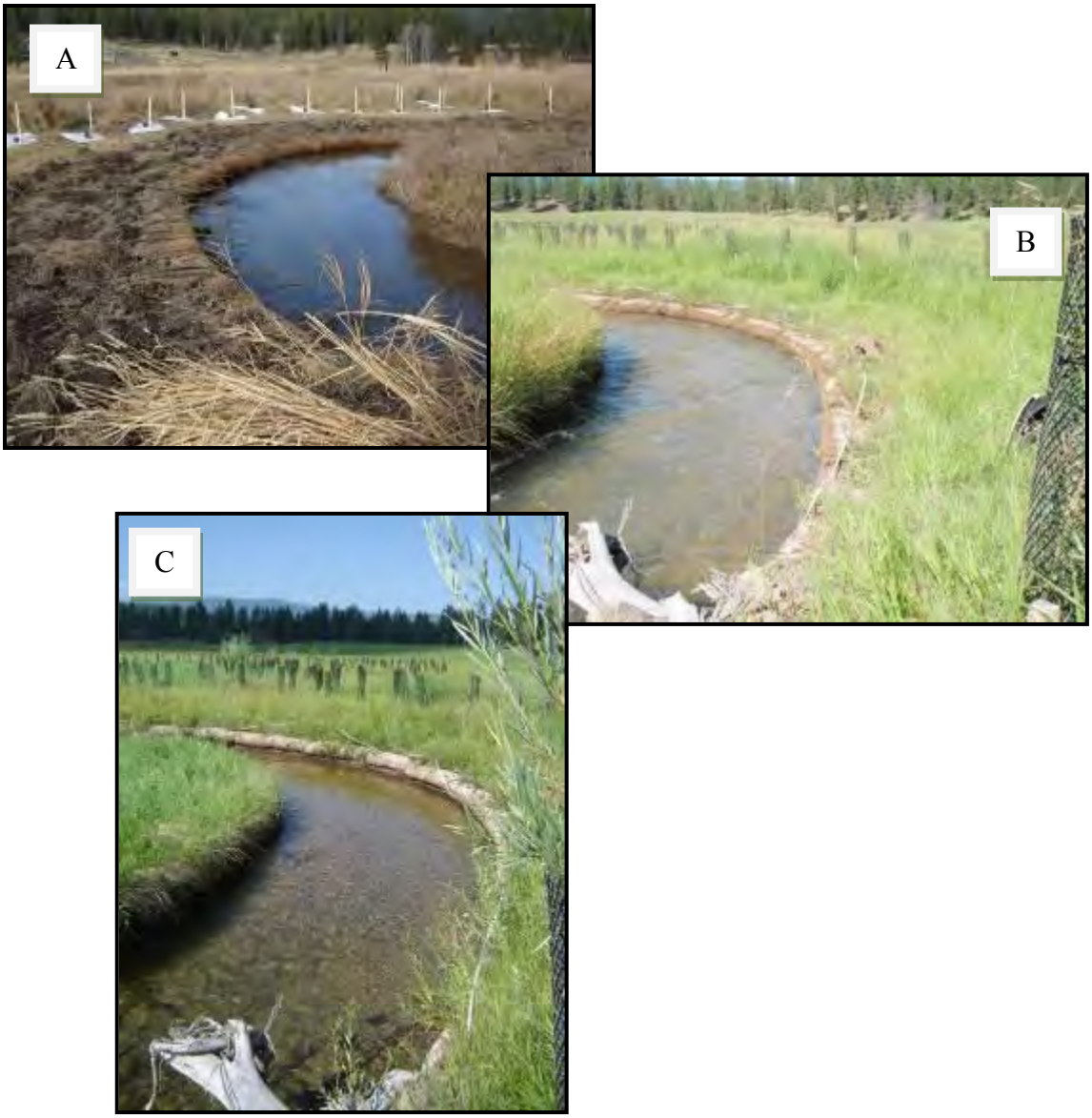

Figure 11. Photographs of Soil Lift 2 immediately after installation (A), during July 2008 effectiveness monitoring (B), and during July 2009 effectiveness monitoring (C). Willow and herbaceous cover increased in 2009 on both the top and bottom layers of the lift.

Willow Fascines

A total of 21 willow fascines sites were monitored in July 2008 and 2009. Results of willow fascine monitoring are provided in Table A-4 in Appendix A and the Excel workbook accompanying this report. In general, multiple fascines were installed at each site. Relocating individual fascines at each installation site was difficult due to the location of these sites within the active channel which is subject to change annually.

In 2008, willow survival averaged between 75 and 100 percent and was based on the estimated number of live cuttings out of the total number of cuttings observed at the site. Due to the

difficulty in counting individual willow stems this metric was not repeated in 2009. Average height of new willow shoot growth was recorded and ranged from two and 18 inches.

Percent cover of live vegetation at each site was recorded in 2009. Percent cover included all vegetation growing on the surface near the willow fascine. The desired function of this treatment is to create sites where seed can be trapped and protected while it germinates and establishes; therefore, all vegetation not just willows were included in 2009 monitoring. Percent cover recorded in 2009 was variable between sites. Twelve of the 21 fascines had one percent cover by vegetation; four had no vegetation cover, and five had cover ranging from five to 20 percent.

Fine sediment, cobble, organic matter, and woody debris deposition were observed at all of the 21 sites, either at the downstream end or throughout the entire site.

Scour occurred at one of the 21 observed willow fascine sites.

Large Woody Debris Structures

Three transects were established perpendicular to three of the five large woody debris structures for monitoring purposes. All three large woody debris structure transects were monitored in July 2008 and 2009. Results are provided in Tables A-5 through A-7 in Appendix A and in the Excel workbook accompanying this report. Figures 13 through 15 show photograph comparisons between 2008 and 2009 for portions of each transect.

Percent cover of sedges and rushes increased along Transects 1 and 2 in 2009 (Table 8; Tables A-5 through A-7 in Appendix A). The species composition along Transect 3 did not change between 2008 and 2009.

Hydrology (measured by depth of standing water or soil saturation) along Transect 1 and Transect 2 ranged from no standing water to slightly saturated soils. Standing water and soil saturation were recorded over a greater distance along Transects 1 and 2 in 2008 compared with 2009. No standing water or saturated soils were recorded along Transect 3 in 2008 or 2009.

Debris and sediment, in the form of leaves, coarse wood, root mass, and silt was accumulating around each of the structures within the channel margins (Figure 12).

Table 8. Summary of the change in the distribution of cover by sedges and rushes along each Woody Debris Transect between 2008 and 2009. High-lighted cells represent transect distances where sedges and rushes were recorded.

	Transect 1		Transect 2		Transect 3*	
Transect Distance (ft)	2008	2009	2008	2009	2008	2009
0-10	0	0	0	0	0	0
10-20	0	0	0	0	0	0
20-30	0	0	Channel	Channel	Channel	Channel
30-40	0	0	0	0	0	0
40-50	0	0	0.5	3.5	0	0
50-60	1.5	40	50	20	0	0
60-70	10	33	10	79	0	0
70-80	0	0	0	49	0	0
80-90	Channel	Channel	0	0.5	0	0
90-100	0	0	0	0	0	0
100-110	1	3	0.5	3	N/A	N/A
110-120	0.5	0	0.5	6.5	N/A	N/A
120-130	0	0	0	20.5	N/A	N/A
130-140	0	0	0	0	N/A	N/A
140-150	0	0	0	0	N/A	N/A
150-160	0	0	0	0	N/A	N/A
160-170	0	0	0	0	N/A	N/A
170-180	0	0	0	0	N/A	N/A
180-190	0	0	0	0	N/A	N/A
190-200	0	0	0	0	N/A	N/A

*Transect 3 is 100' long

Figure 12. Photographs showing the accumulation of fine sediment and organic debris on large woody debris structure 1.

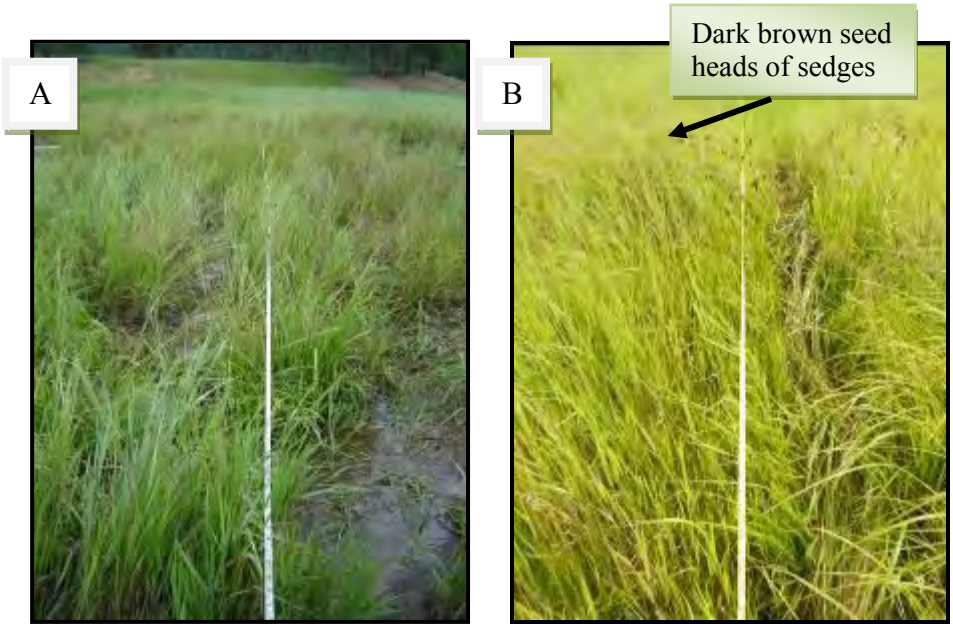

Figure 13. Photographs of Woody Debris Transect 1 at the 50-60' interval in 2008 (A) and 2009 (B). More standing water was recorded in 2008, but an increase in cover of sedges was recorded in 2009 (the dark brown in photo are sedge seed heads).

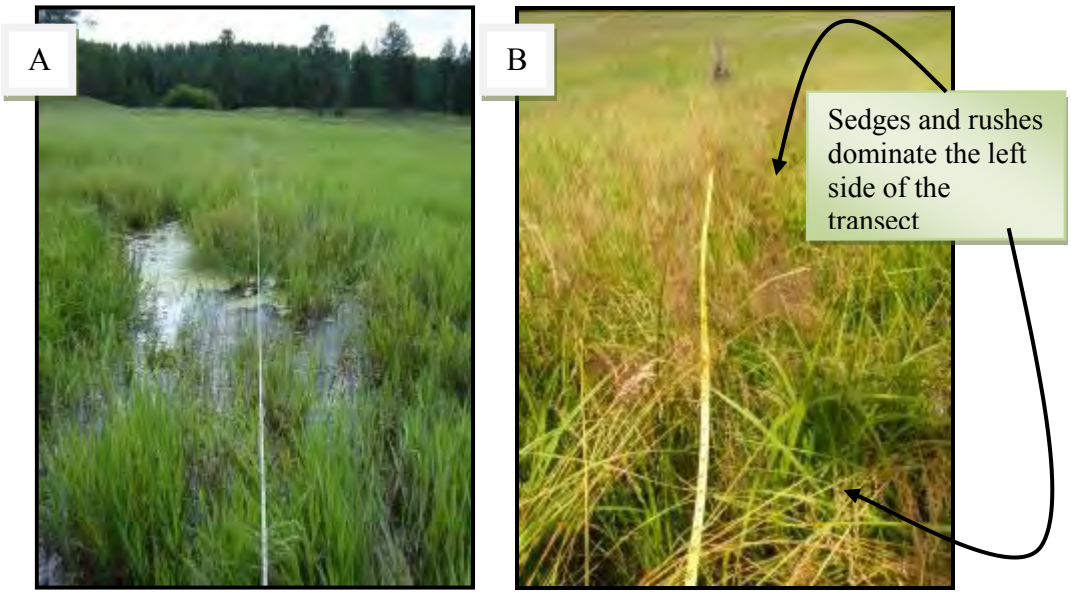

Figure 14. Photographs of Woody Debris Transect 2 at the 50-60' interval in 2008 (A) and 2009(B). More standing water was recorded in 2008, but an increase in cover of sedges and rushes was recorded in 2009.

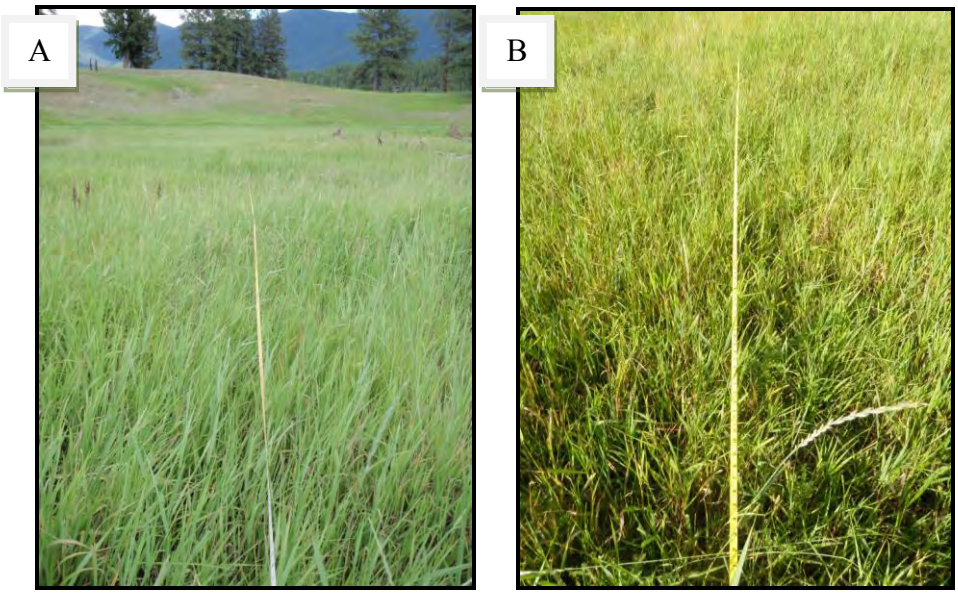

Figure 15. Photographs of Woody Debris Transect 3 at the 60-70' interval in 2008(a) and 2009(B). Species composition along this transect remained similar between 2008 and 2009.

Coir Logs

Five of the seven coir log sites were monitored in July 2008 and 2009. Results are provided in Table A-3 in Appendix A and in the Excel workbook accompanying this report. Table 9 provides a summary of coir log effectiveness monitoring results. Figures 16 and 17 provide a photo comparison of two coir log sites since installation.

Willow survival has decreased at all coir log sites (Table 8). Overall willow survival ranges from 50 to 79 percent (Table 9). Surviving willow cuttings show signs of being heavily browsed.

The average depth of undercut bank below installed coir logs was similar in 2008 and 2009, and ranges from 0 to 6 inches. The average depth from the coir log to the stream bed was also similar in 2008 and 2009, and ranges from 11 to 17 inches.

The amount of fine sediment deposition on coir logs varied between structures and years. The source of fine sediment also varies; some structures are covered by overhanging pasture grass sod mats which contribute to the soil accumulation on the log, while other logs are more exposed and appear to trap sediment during high flows.

No natural colonization was observed in 2008. In 2009 natural colonization ranged from one to thirty percent cover of coir logs (Table 8). Species naturally colonizing coir logs included: mosses, clover, horsetail (*Equisetum spp.*), pasture grasses, and Canada thistle.

Table 9. Summary of coir log treatment effectiveness monitoring data collected in July 2008 and July 2009.

Metric	CL 1		CL 2		CL3		CL 5		CL 7	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Average percent live willow cuttings	60	50	75	58	74	66	85	65	85	79
Average percent cover natural colonization	0	3	0	3	0	5	0	4	0	7
Average percent of log with fine sediment deposition	40	10	10	5	53	51	0	4	34	50
Average coir log depth (inches)*	16	16	17	14	11	11	17	14	15	14
Average total water depth (inches)	16	11	13	8	10	5	11	6	11	6
Average undercut below coir log (inches)**	2	3	4	4	2	1	4	3	3	3

*Average coir log depth is a measurement of the depth to the channel bed from the top of the coir log. The intent of this metric is to evaluate if lateral scour is occurring and pool habitat is forming at these sites. All coir logs were installed along outer meander bends.

**Average undercut is a measure of bank undercut. Undercut is measured from the front (streamside edge) of the coir log to the edge of the streambank below the coir log. The intent of this metric is to evaluate the formation of in-stream habitat in terms of over-hanging cover.

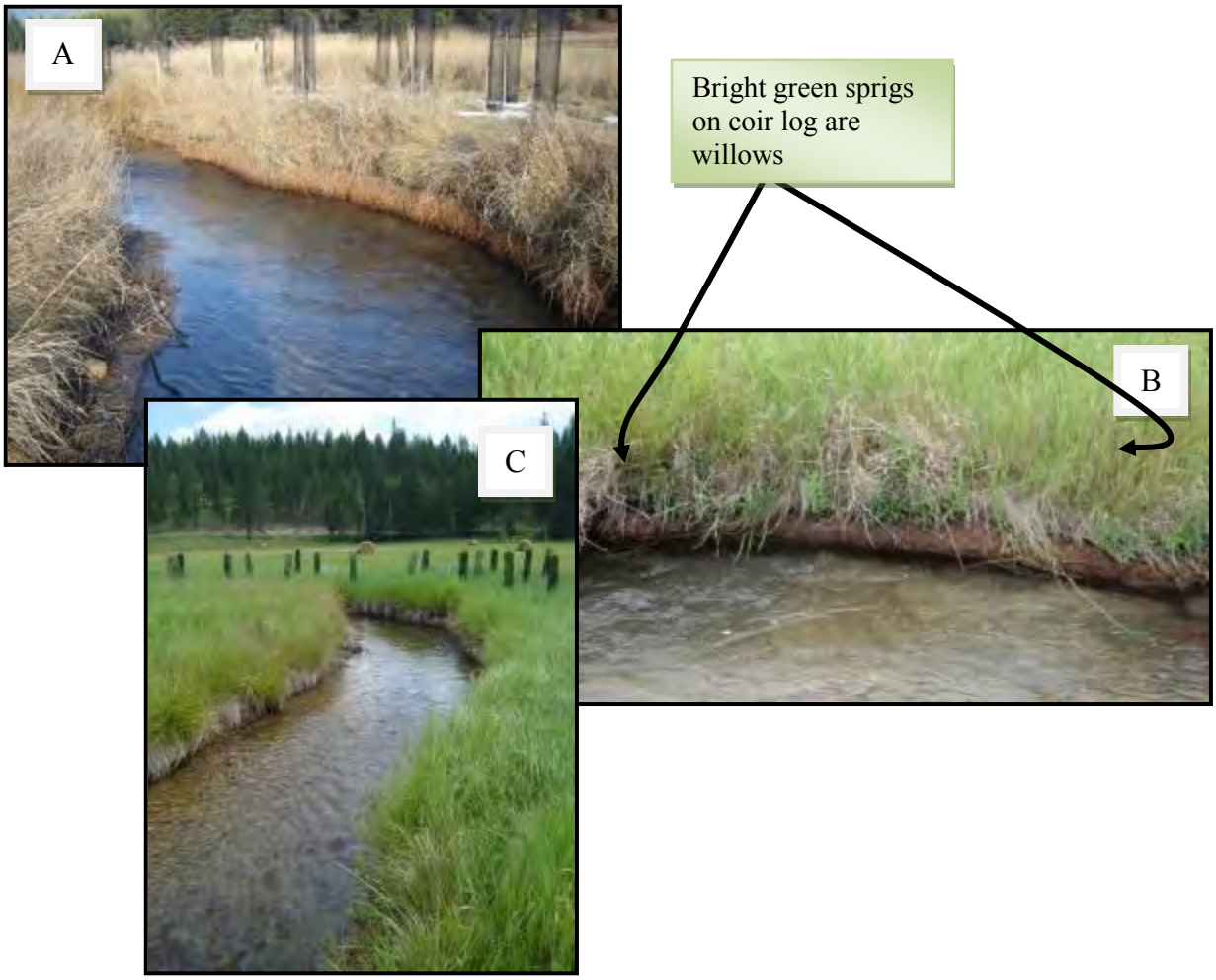

Figure 16. Coir log 5 immediately after implementation in October 2007 (A), during July 2008 effectiveness monitoring (B), and during July 2009 effectiveness monitoring (C).

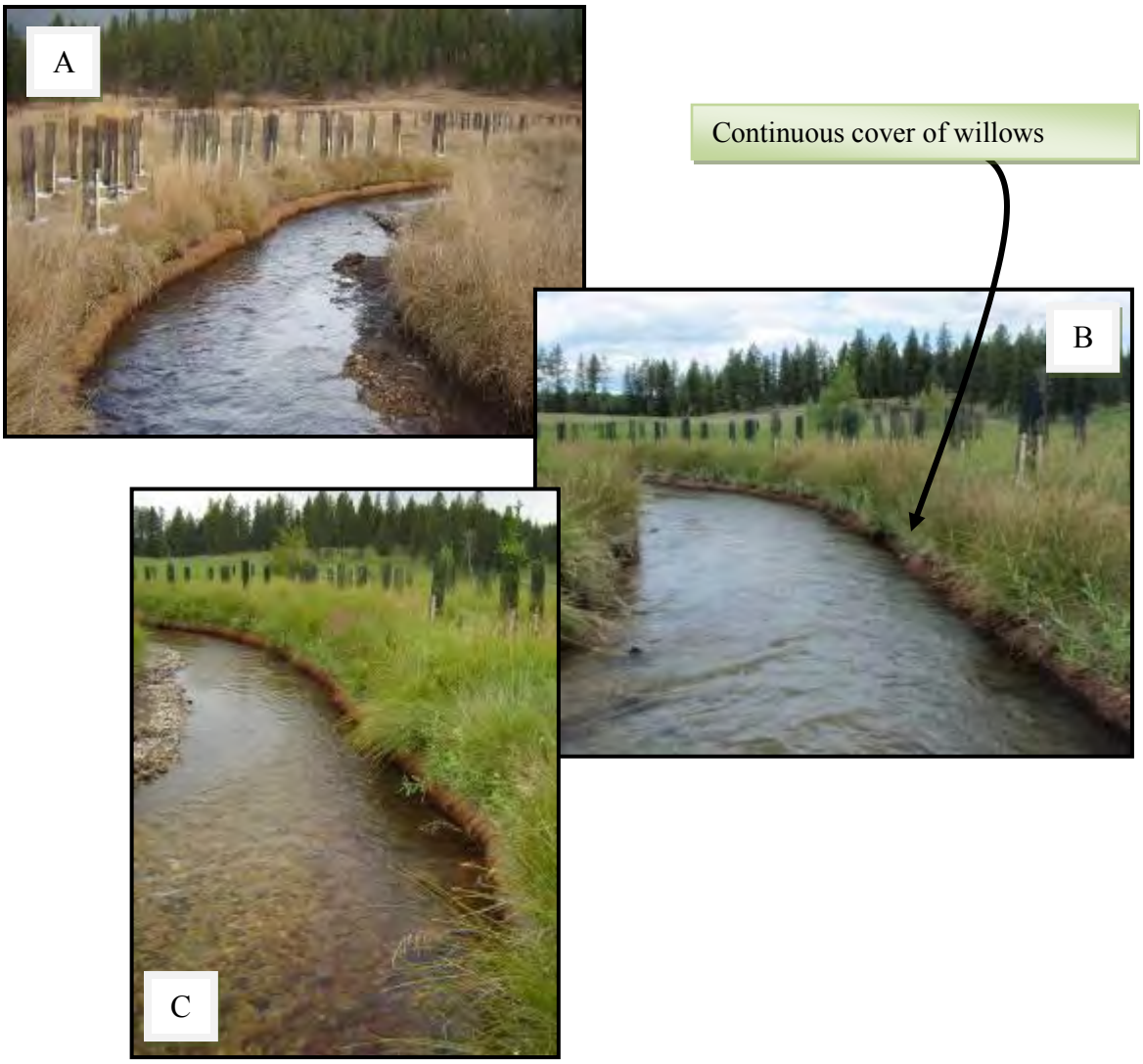

Figure 17. Coir Log 7 immediately after installation in October 2007 (A), during July 2008 effectiveness monitoring (B), and during July 2009 effectiveness monitoring (C). Willow survival on this structure is high, but cuttings are heavily browsed.

Herbicide Application

Weed mapping was completed for the project site in 2006 during development of the Revegetation Plan. Herbicide was applied at the site targeting reed canarygrass and Canada thistle twice annually in 2008 and 2009. Weed mapping was repeated for the project site in July 2009. No weed mapping was completed in 2008 but qualitative observations of herbicide effectiveness were made. Similar methods for infestation size were used in 2006 and 2009. Infestation sizes were mapped in three categories: less than 0.1 acres, 0.1 to 1 acre, and 1 to 5 acres. In addition to infestation size, infestation density was recorded in 2009. Weed density was recorded in three categories: sparse (one plant per 10 square feet), moderate (two to five plants per 10 square feet), and dense (greater than five plants per 10 square feet).

Reed canarygrass and Canada thistle continue to make up the largest infestations at the site, both in terms of density and distribution (Figures 19 through 22). The density of Canada thistle along the creek in the upper portion of the project site has decreased since 2006 (Figure 20). New and

increased density infestations have appeared at the downstream end of the project reach in areas that were not treated with herbicide (Figures 20 and 22). As a result of 2009 effectiveness monitoring, herbicide treatment of these new infestations was begun in fall 2009. Herbicide treatment of discrete reed canarygrass patches appears to be effective (Figures 18 and 19). Reed canarygrass distribution has been greatly reduced in the upper half of the project reach where it was targeted for control by herbicide (Figure 19).

Yellow toadflax (*Linaria vulgaris*) continues to be present at the project site but to a lesser extent compared with thistle and canarygrass (Figure 23). Two new weed species were discovered in 2009 that were not present in 2006, sulphur cinquefoil (*Potentilla recta*) and houndstongue (Figure 23). The distribution and densities of these infestations is currently low (Figure 23).

Figure 18. Photograph shows dead patches of reed canarygrass that were treated with herbicide in 2008.

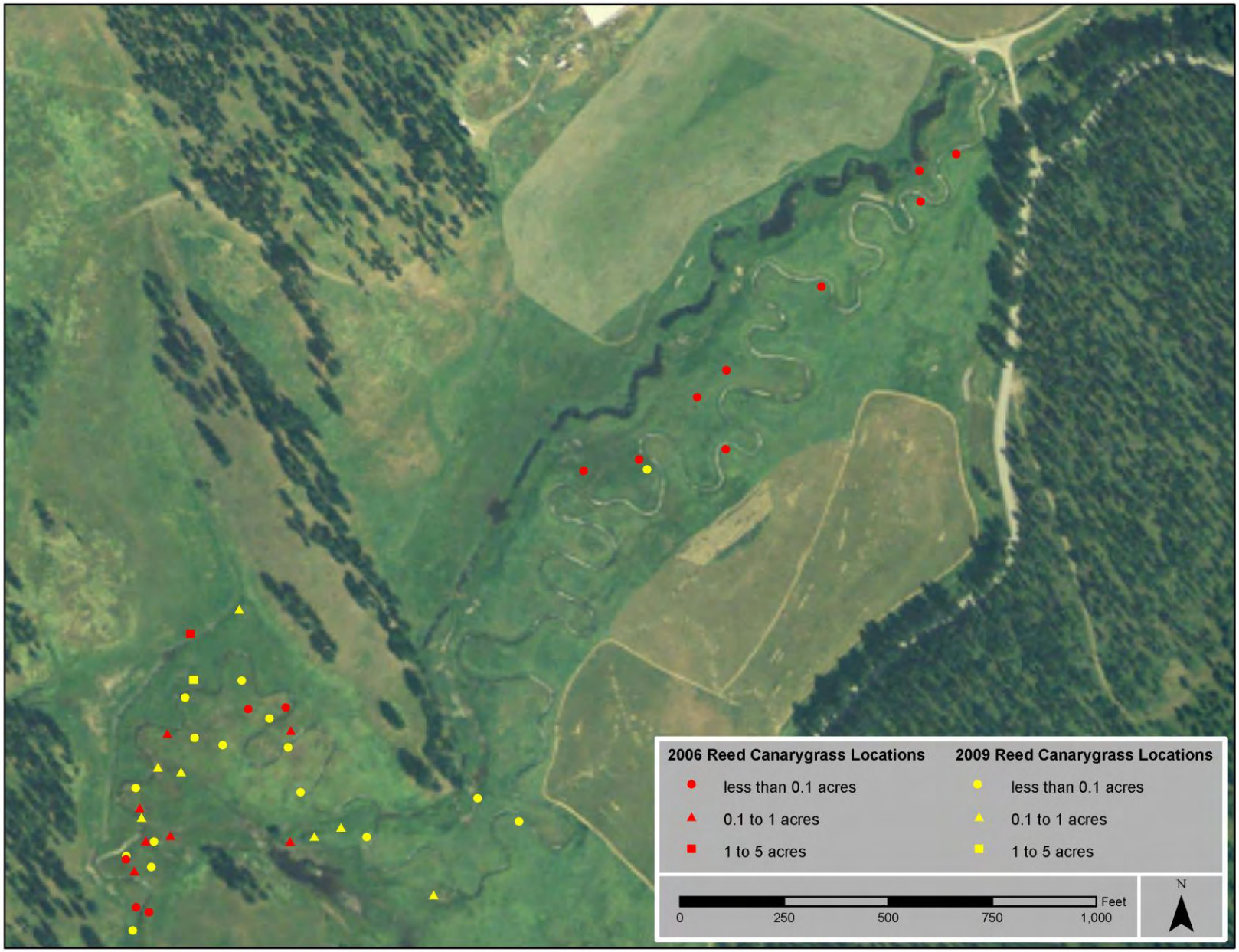

Figure 19. Therriault Creek restoration project site reed canarygrass distribution mapped in 2006 and 2009.

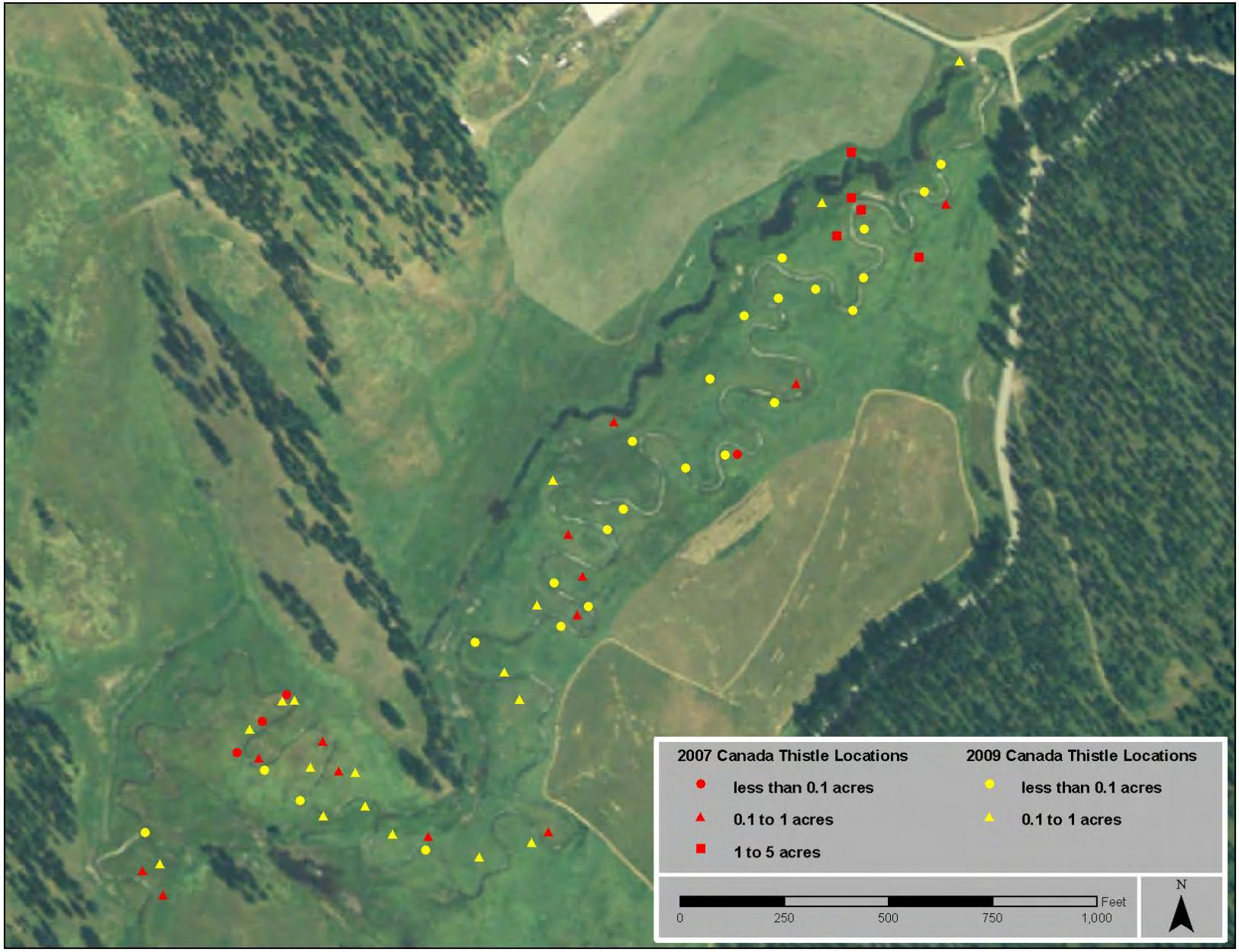

Figure 20. Therriault Creek restoration project site Canada thistle distribution mapped in 2006 and 2009.

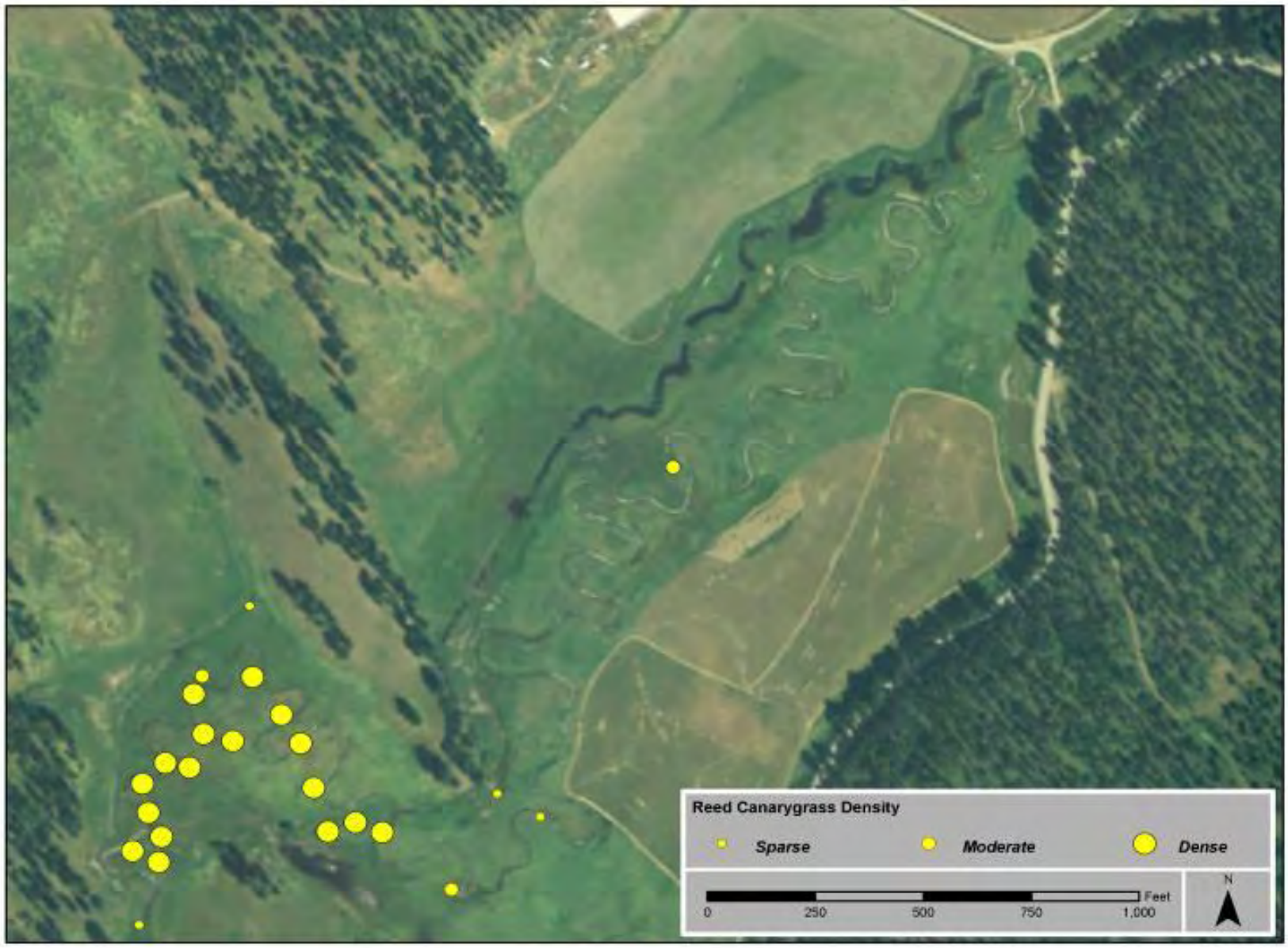

Figure 21. Therriault Creek restoration project reed canarygrass infestation densities mapped in July 2009.

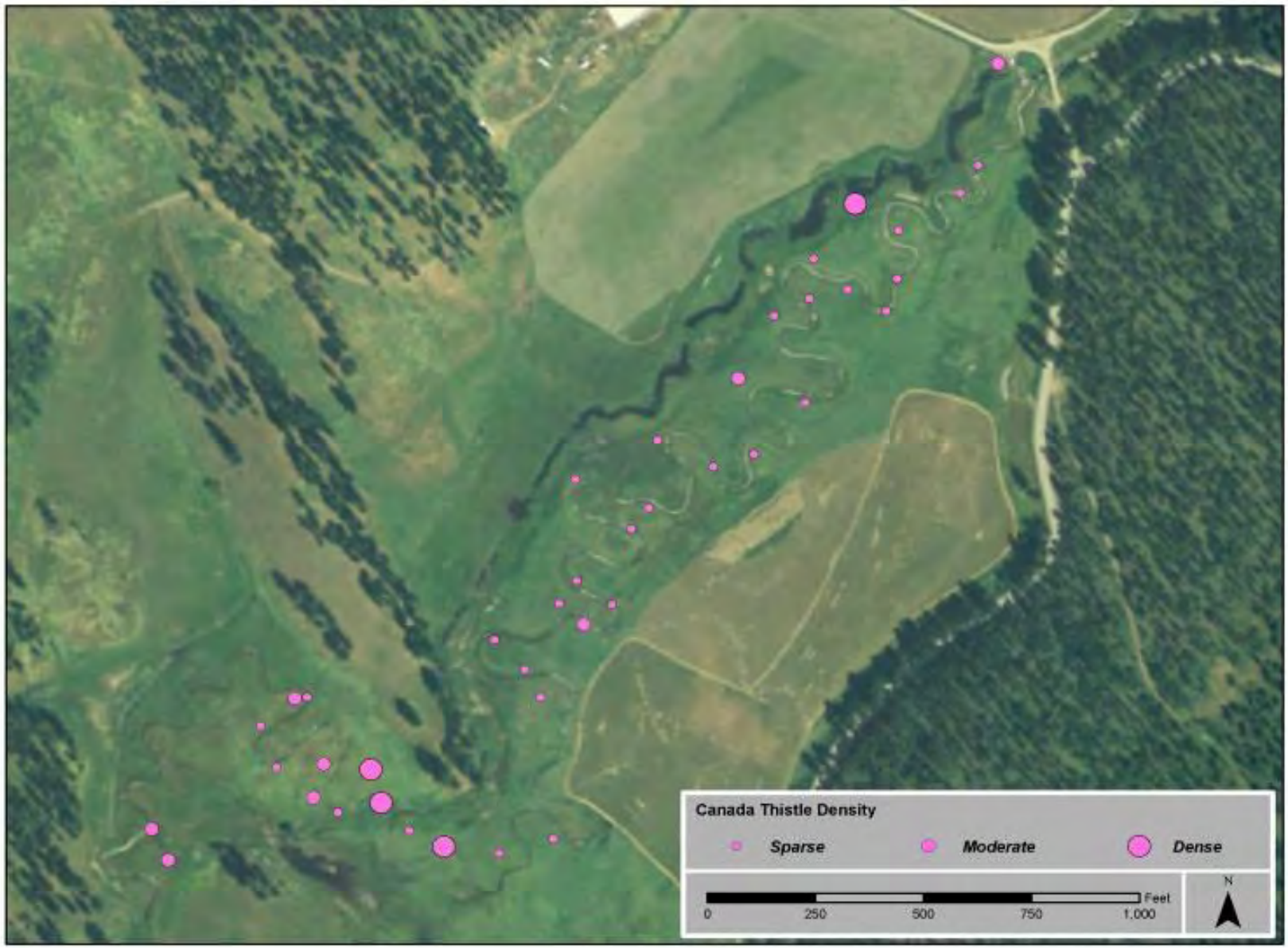

Figure 22. Therriault Creek restoration project site Canada thistle infestation densities mapped in July 2009.

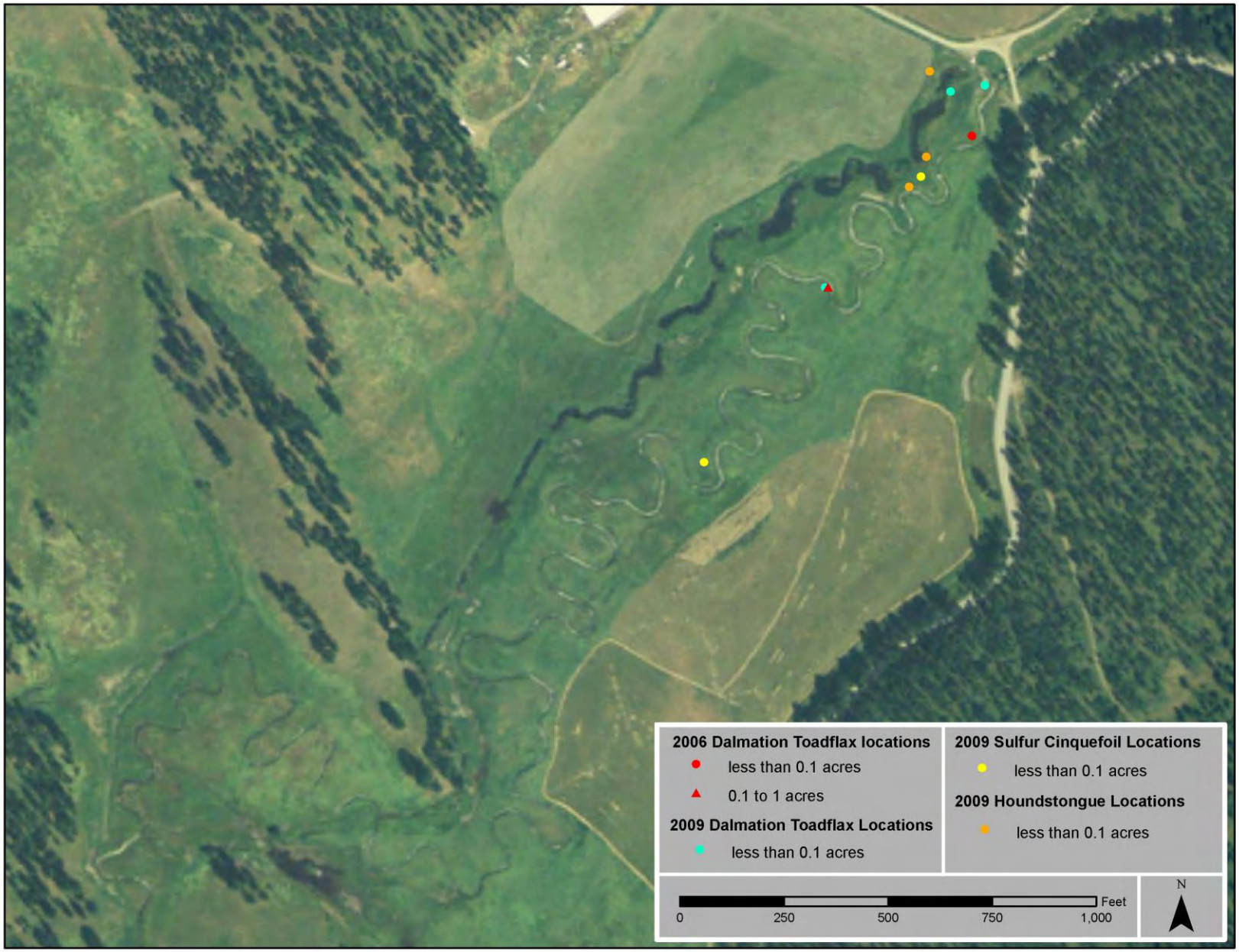

Figure 23. Therriault Creek restoration project site toadflax, sulfur cinquefoil, and houndstongue infestation and densities mapped in July 2009.

Monitoring Discussion

The purpose of monitoring is to determine the effectiveness of implemented revegetation treatments in achieving the project goal of restoring or creating conditions to support a diverse mosaic of native riparian plant communities that will be sustained long-term by natural processes along Therriault Creek. This section summarizes the key observations made about each riparian revegetation treatment monitored for effectiveness in July 2008 and 2009. The discussion provided in this section is organized by treatment. The following topics are discussed for each treatment: (1) key monitoring observations related to treatment effectiveness; (2) maintenance needs; (3) evaluation of effectiveness monitoring methods; and (4) recommendations for repeating treatment in the third phase of revegetation.

Residual Shrub Protection

Residual shrubs surviving from initial revegetation efforts (2004) had been subject to severe levels of browse resulting in arrested growth forms and contributing to poor survival. To address this issue, 250 residual shrubs were protected with four-foot tall by eight-inch diameter rigid plastic mesh browse protectors in fall 2007. This treatment was monitored in July 2008 and 2009. Observations made in 2009 were similar to those made in 2008 and indicate that protecting residual shrubs remains a relatively simple and cost-effective treatment for reducing browse and allowing shrubs to grow. The following key observations related to this revegetation treatment are summarized below:

- Most protected residual shrubs continue to show increased new growth. New growth of more than three feet was observed on some protected shrubs (Figure 24). Since protection in 2007, most residual shrubs grew to the maximum capacity of the browse protectors. For this reason, expansion of browse protectors was identified as a maintenance need for this treatment. Approximately 200 of the 250 initially protected shrubs were expanded from eight-inch diameter to 16-inch diameter browse protectors in summer and fall 2009. For any browse protectors installed in the future, the diameter should be a minimum of 16-inches to allow room for plant growth and to reduce the amount of maintenance required.
- Only those residual shrubs with heights below the surrounding grasses were fitted with mulch mats. No difference in new growth between shrubs with mulch mats and those without was observed. This indicates that the root systems of surviving residual shrubs are established enough to withstand competition from pasture grasses. This is also apparent from the amount of new growth observed on protected shrubs. For future treatments, installing mulch mats around residual shrubs is probably not necessary.
- Browse is occurring on portions of protected shrubs growing outside of browse protectors (Figure 3). The long-term effect of this on survival and overall plant health is unclear. A similar situation was observed on a riparian revegetation project in the Thompson River drainage. Similar browse protectors were installed on planted shrubs in 2003 and 2004. Hedging to the height of the browse protectors was observed the three years following installation, but by 2008 the plants were able to put on so much new growth early in the season that hedging of new shoots was no longer an issue. This early season growth may have been the result of the establishment of an extensive root system during the first three years. These plants continue to be browsed, but it does not appear to be affecting survival or plant health. It is possible that a similar chain of events will occur at

Therriault Creek and shrubs should continue to be evaluated to ensure that continued browse of portions of the plant extending outside of protectors is not having a detrimental effect.

- Anticipated 2010 maintenance needs for this treatment include re-securing or straightening browse protectors. The need for additional maintenance should be evaluated in early spring 2010 and maintenance should be completed as early as possible during the growing season.
- Future monitoring of this treatment may not be necessary. Effectiveness monitoring to date has consisted of recording the number of protected shrubs browsed and the number of unprotected shrubs browsed. At this point, qualitative observations of the effects of continued browse on the unprotected portion of protected shrubs will be more useful at determining adaptive management needs.
- Because this treatment appeared to be effective during 2008 monitoring, 60 additional residual shrubs were protected in summer and fall 2009. Moderate to severe browse is still occurring on previously planted shrubs that have not been protected.

Based on these results and observations, protection of additional residual shrubs with four-foot high by 16-inch diameter browse protectors should be part of Phase III revegetation efforts.

Figure 24. Sandbar willow planted in 2004 that was fitted with browse protection in fall 2007. Approximately four feet of new growth occurred during the 2009 growing season (photograph was taken during July 2009 effectiveness monitoring).

Containerized Planting

Initial plantings at the site had overall low survival. This was due to a number of limiting factors including: competition from grasses, browse pressure, girdling by voles and potentially a lack of maintenance watering. In 2007, 1,028 new containerized shrubs and trees were planted at the site. To address the limiting factors to plant survival, shrubs and trees were fitted with browse protectors, mulch mats and vole protectors. The results of 2009 effectiveness monitoring showed continued high survival rates for containerized shrubs and trees planted in 2007. The following key observations related to this revegetation treatment are summarized below:

- Containerized plant survival was 89 percent overall (overall plant survival was 96 percent in 2008) and remains above 80 percent for most species installed in 2007. Only three species fell below 80 percent survival; water birch, mountain alder and Engelmann spruce. Of these three species, Engelmann spruce had the lowest survival (18 percent) and is not recommended for future plantings until site conditions are more suitable for the species. Although the birch and alder survival decreased, both survival rates remain relatively high (77 percent and 68 percent respectively). All species planted in 2007 with the exception of Engelmann Spruce are appropriate to include in future phases of revegetation at the site.
- Many leaves and stems extending beyond the height or width of browse protectors are being browsed (Figure 25). As described in the discussion for the Residual Shrub Protection Treatment, this type of browse is not likely detrimental in the first years after planting because only a small percentage of the new growth of the plant is being removed. Some browse may even stimulate root system development in some species such as willows. Planted shrubs and trees should continue to be evaluated to ensure that continued browse of portions of the plant extending outside of protectors is not having a detrimental effect and prior to making decisions regarding removal of browse protection in later project phases. Approximately 700 of the plants installed in 2007 were fitted with larger browse protectors (16-inch diameter) in summer and fall 2009. Newly planted shrubs and trees should include 16-inch diameter browse protection.
- No sign of stem girdling was observed on planted shrubs or protected residual shrubs in 2008 or 2009 by voles or other animals. Because vole damage was identified as a primary cause of initial poor survival of planted shrubs at the site, new plants installed should include vole protectors. It is possible that mulch mats are also helping to protect planted shrubs and trees from vole damage by reducing hiding cover between dense grasses and planted shrubs. The effectiveness of this treatment should continue to be observed.
- Although a few planting units showed an increase in native sedge and forb cover in 2009, pasture grasses continue to dominate the understory in the planting units. However, brush blankets are effectively controlling grass cover immediately adjacent to installed plants. Grasses were growing up through the vole protectors where the ground was not covered by a brush blanket. Wood bark mulch was placed inside the vole protector to limit grass growth but is less effective than mulch mats at controlling the aggressive pasture grasses. Based on this observation, maintenance weeding and re-mulching inside the vole protectors should be included in 2010 maintenance activities. Wood chip mulch was used inside vole protectors in 2007. Use of shredded mulch which would reduce the

amount of light reaching the ground may be more effective at suppressing grasses inside the vole protectors.

- Although still present in most planting units, cover of both Canada thistle and reed canarygrass was less in 2009. This is a result of herbicide applications that occurred in 2008. New weed species including houndstongue and sulfur cinquefoil were recorded in some planting units and these species were included as target species for summer and fall 2009 herbicide applications and should continue to be integrated into weed control activities at the site.
- Cool spring temperatures and rainfall throughout the spring and summer provided a sufficient supply of water for most of the 2009 growing season. However, during July 2009 monitoring soil moisture in some areas appeared to be getting low and some plants showed signs of stress; therefore, supplemental watering was done late in the season (late August and early September). As described in the Revegetation Plan, decisions about when to use supplemental water depend on rainfall and soil moisture in a given year, and watering may be necessary in 2010.
- Some leaf damage was observed on containerized plants during July 2009 monitoring. The exact cause is unknown but may be due to a fungal disease such as leaf rust, a late spring frost or herbicide drift. Plants should be observed throughout the 2010 growing season to see if leaf damage occurs again and if the cause can be determined and addressed.
- Some signs of recent livestock use were observed during July 2009 monitoring. The damage at the time of monitoring was minimal but some bank trampling and damage to browse protectors occurred. Livestock should be excluded from the project area until monitoring determines that allowing limited access will not affect project goals.
- Anticipated 2010 maintenance needs for this treatment may include: re-securing or straightening browse protectors and mulch mats; and supplemental watering. The need for additional maintenance should be evaluated in early spring 2010 and maintenance should be completed as early as possible during the growing season to prevent damage to plants.
- Plant survival monitoring should continue in 2010 however it is not necessary to monitor all of the planting units monitored in 2008 and 2009. Overall survival has remained high (96 percent and 89 percent) for two years. While overall survival will likely continue to decrease slightly each year, these high initial survival rates are a good indication that the species and planting locations selected in 2007 are appropriate for achieving revegetation goals for the site. In 2010, general observations of plant conditions and survival monitoring of two or three planting units is recommended.

Based on these results and observations, planting additional containerized shrubs and trees should be part of Phase III revegetation efforts. All planted shrubs should be protected with four-foot high by 16-inch diameter browse protectors, three-foot by three-foot mulch mats, and vole protectors.

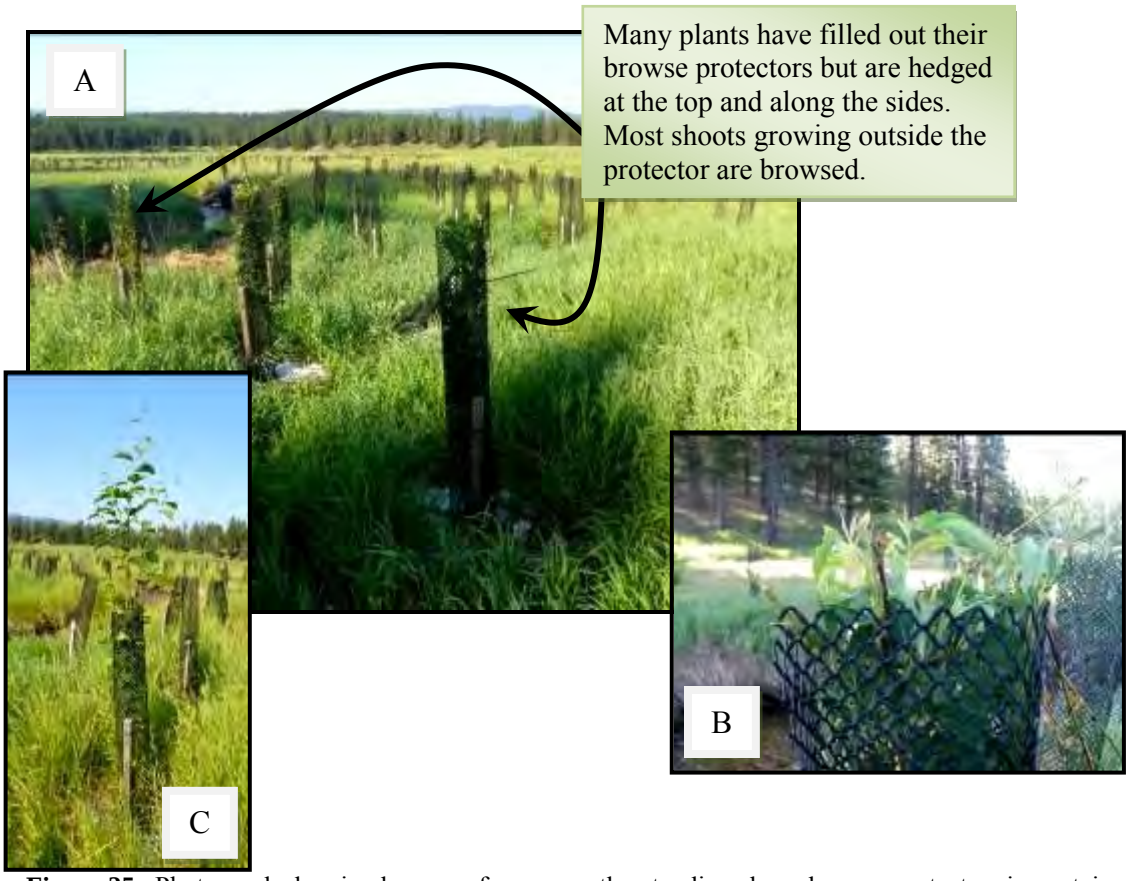

Figure 25. Photograph showing browse of new growth extending above browse protectors in containerized planting units (Photos A and B). Photo C shows an example of the height plants would be reaching after two full growing seasons if browse was eliminated.

Solarization

Competition from dense pasture grasses was identified as a primary factor limiting establishment of woody riparian vegetation at the site. For this reason, solarization fabric was installed in some planting units to see if this treatment would be more effective at eliminating competition between grasses and planted shrubs and trees compared with placing individual brush blankets around plants. Effectiveness monitoring of planted solarization plots in 2008 and 2009 showed comparable survival with other planting units. Plant growth was also monitored in solarization plots and some species showed a high level of growth between 2008 and 2009. The following key observations related to this revegetation treatment are summarized below:

- Containerized plant survival in planted solarization plots was 95 percent in 2008 and 87 percent in 2009. This is comparable with overall plant survival for all plants installed in 2007. Only two species had lower than 80 percent survival; white spirea (40 percent) and Engelmann spruce (0 percent). These species should not be included in future planting of solarization plots at the site. The poor Engelmann spruce survival is consistent with data from the non-solarization containerized planting units. Current site conditions at Therriault Creek are not suitable for Engelmann spruce, which requires at least partial shade, well-drained soils, and less competition than the current site conditions provide. As early successional species continue to grow and alter site conditions the site will

become more favorable for species such as spruce which were likely an important component of historic plant communities at the site.

- Mountain alder, Drummond's willow, black hawthorne and quaking aspen had the greatest change in growth metric value between 2008 and 2009. This may indicate that the microclimate conditions (increased heat and moisture retention and reduced grass competition) created by the solarization fabric promotes rapid growth of these species. These species should be included in future solarization plantings at the site.
- Based on observations made during July 2009 effectiveness monitoring, the following maintenance needs were identified and completed for this treatment: hand pulling weeds and grasses growing through the fabric at the base of containerized plants; watering; re-securing fabric edges and staples; and expanding browse protectors on all plants except white spirea. With the exception of browse protector expansion, it is likely that similar maintenance tasks will also be necessary in 2010.
- Although increased soil moisture has been a notable result of this treatment at other sites, planted solarization plots at Therriault Creek had to be watered twice during 2009 maintenance watering in order for the soil to become saturated. This may be the result of the fabric retaining heat and slightly drying the upper few inches of soil.
- Plant survival and growth metric monitoring of solarization plots should continue in 2010. Although some species appear to have accelerated growth in solarization plots the overall benefit of this in achieving revegetation goals has not been determined. Therefore, continuing to collect data on the effectiveness of this treatment is necessary.
- Temporary solarization plots (no plants installed) were not included in effectiveness monitoring. However, general observations made during July 2009 effectiveness monitoring showed that temporary solarization plots appear to effectively eliminate undesirable grass species (Figure 27). Based on these observations, the fabric at Temporary Solarization Site 1 was removed and the exposed ground was seeded with a diverse native seed mix. Emergence of seeded species should be monitored in 2010. Solarization fabric at the other two temporary plots was re-secured and these sites should be observed in 2010 to determine if the sites are ready for fabric removal and seeding.

Based on these results and observations, solarization fabric should be installed in areas selected for planting in 2010 that have a moderate to high percent cover of reed canarygrass. Solarization fabric is effectively controlling grass competition at the sites it has been installed. Plants installed in solarization fabric should include browse protectors but no vole protectors.

No additional temporary solarization plots should be established until treatment effectiveness has been determined.

Figure 26. Photograph showing the vigorous growth of the containerized plants installed within solarization fabric. Most plants in this unit had out-grown browse protectors. Hand-pulling of grasses and expansion of browse protectors was completed in summer and fall 2009.

Figure 27. Photograph showing conditions under temporary solarization sites in July 2009 (after two growing seasons). When the fabric is removed dry leaf litter covers the bare mineral soil indicating the treatment has effectively heat-killed grasses.

Vegetated Soil Lifts

Two vegetated soil lifts were installed at the site in 2007 in high priority areas where head-cutting between the new channel and abandoned channel was considered a risk. Based on the results of effectiveness monitoring, it appears that vegetated soil lifts have provided stable areas within the high stress land-water interface, allowing the dormant willows used in this treatment to take root and sprout. Willow cutting survival is good but new shoot growth and overall percent cover of willows is not as high as expected at either site. Effectiveness monitoring indicates that this treatment is creating stable areas for woody vegetation to establish and therefore achieving the desired function. However, future installation of this treatment is likely not necessary at the site. The following key observations related to this revegetation treatment are summarized below:

- Willow cutting survival is variable but within the expected range of survival for dormant willow cuttings. Poor survival is primarily in sections of the soil lift where willows placed under the lift are inundated for most of the year.
- Willow cover increased at both sites between 2008 and 2009, but remains patchy (Figure 28). The variable willow growth is likely due to the fluctuating hydrology at each site (i.e. the bottom lift is inundated late into the season in some locations which has either killed or reduced growth of some willow cuttings). Browse is also a factor influencing percent cover of willows at both sites. Measures to reduce browse on willows should be evaluated. Because it is difficult to limit access to soil lifts because they directly border the stream and can be accessed from both sides of the channel, use of a browse repellent such as Plant Skydd® may be an alternative.
- Herbaceous and weedy species cover increased on the top layer of both lifts between 2008 and 2009. An increase in percent cover of herbaceous species would be expected, but the presence of noxious weeds including Canada thistle and houndstongue may limit the long-term function of these treatments. Hand-pulling or spot spraying herbicide should be included in 2010 maintenance of this treatment. Supplemental seeding should be done after removal of weeds.

Figure 28. Photograph shows a soil lift in 2009 with good cover of willows above the lift but sparse cover below.

Willow Fascines

Willow fascines were installed in a number of locations in 2007 in an attempt to create areas within the active channel to naturally recruit woody vegetation. Based on the results of 2008 and 2009 monitoring, the effectiveness of this treatment has been variable in terms of achieving the intended function. The following key observations related to this revegetation treatment are summarized below:

- Willow cutting survival and percent cover is low at all observed sites. Even though willow cover and survival is low, fascines are functioning as debris and sediment traps but little natural recruitment of desirable species was observed in 2008 or 2009 (Figure 29). It is likely that woody species will begin to establish in the future as more sediment, debris, and plant propagules are trapped and retained at each site.
- Location where willow fascines were placed within the channel appears to have the most influence on survival and growth of the willows in the fascines. Fascines that were placed on well developed sediment deposits (typically on the downstream half of the inside of a meander bend) appeared to have greater survival and growth. Fascines that were placed on less developed sediment deposits (typically along riffles or the upper half of the inside of a meander bend) had lower survival and growth. These less developed sediment deposits are likely subject to more annual variability in terms of inundation, scour and deposition.
- In early spring 2008, a number of 24-inch dormant willow cuttings were directly installed into banks in the upper portion of the project reach by Eureka High School students. These cuttings were installed primarily along straight reaches of the channel. During monitoring of the willow fascine treatment sites many of these cuttings were observed. Where cuttings were observed, survival appears to be high and new growth averaging between six and 12 inches (Figure 30).
- No maintenance of willow fascine sites is anticipated in 2010.
- Given the location of this treatment within the active channel, re-locating individual fascines at treatment sites was difficult in both 2008 and 2009. For this reason, continued monitoring of these sites is not recommended. The treatment should continue to be evaluated through photo documentation and general observations.

Based on these results and observations, this treatment should not be repeated until effectiveness has been determined. In addition, most point bar locations where this treatment is appropriate were treated 2007. Well-developed point bars decrease in a downstream direction at the project site as the channel transitions from a C to an E channel. The treatment is low cost and should continue to be a considered for use in future revegetation phases. If the treatment is used in future phases willow fascines should only be installed in well established point bar features. For other features, direct installation of 24-inch dormant cuttings may be more appropriate for establishing willows below the bankfull elevation which is dominated by dense grasses.

Figure 29. Photograph shows an example of sediment and debris deposition at the downstream end of a live willow fascine.

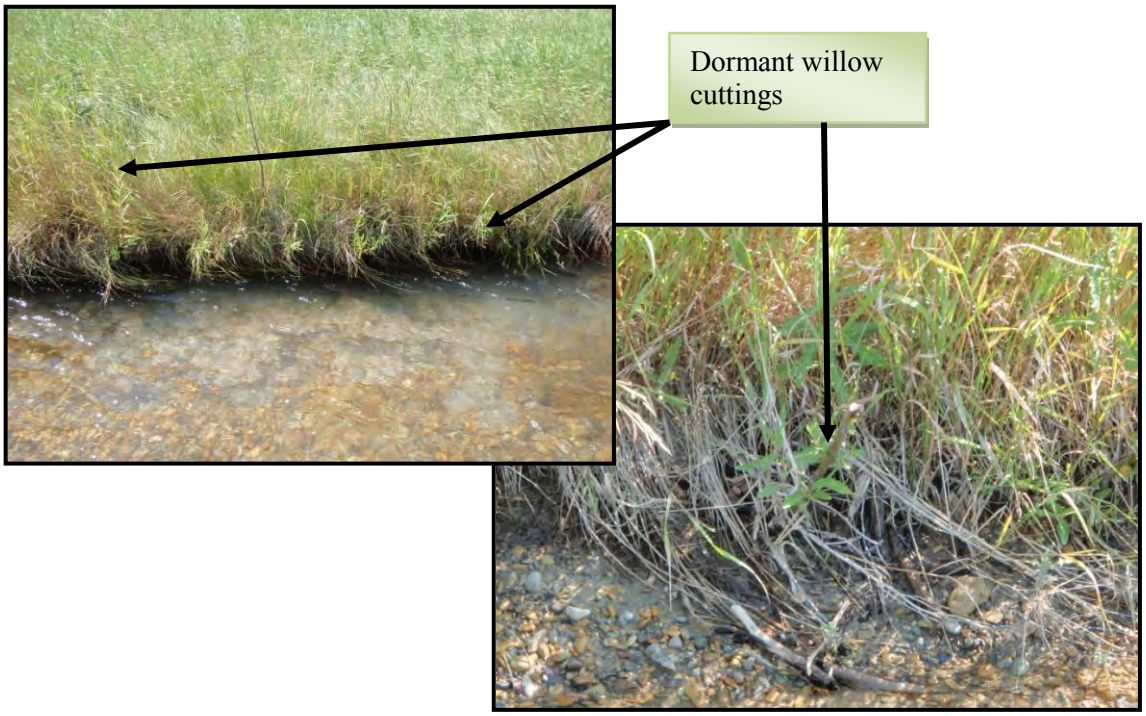

Figure 30. Photographs of dormant willow cuttings installed in early spring 2008.

Large Woody Debris Structures

Five channel spanning large woody debris structures were installed in 2007 with the intention of enhancing the hydrologic connectivity between the floodplain and channel. Based on the results of effectiveness monitoring it appears that this treatment may be improving floodplain hydrology. The following key observations related to this revegetation treatment are summarized below:

- Woody debris structures at all sites are trapping sediments and prolonging floodplain inundation by elevating the water surface upstream of each structure (Figure 31). Water depths in the reach of channel where large woody debris structures were installed are between 0.5 and one foot deeper than upstream and downstream reaches. The upstream extent of this backwater area was not measured but is estimated at between 100 and 200 feet upstream of the first structure. A significant amount of sediment has been trapped upstream of each structure which appears to have raised the channel bed elevation. Trapped sediment consists mostly of sand and the channel bottom now consists of sand instead of cobbles and gravels.
- Non-native pasture grasses remain the dominant species along each transect, although inclusions of hydrophytic species such as sedges and rushes are increasing along Transects 1 and 2. Because many of the pasture grasses are facultative (able to grow in a broad range of hydrologic conditions), it may take a number of years before a conclusive plant community shift will occur. For this reason, monitoring should continue but does not need to be repeated annually. Monitoring does not need to occur in 2010 but the treatment should be observed and photo documentation recorded.
- Canada thistle densities have increased in this reach of the project. This is not thought to be a result of installation of the large woody debris structures as this infestation was present prior to installation. This area was scheduled for herbicide treatment in 2008 but was missed by the applicator. This area was also missed in the summer 2009 herbicide application but was treated in fall 2009.
- No maintenance of the large woody debris structures is required.

Based on these results and observations, this treatment should not be repeated until effectiveness has been determined. Over time, this treatment is expected to shift the site toward more hydrophytic species, reduce cover of weedy species less tolerant of saturated conditions, and increase organic content in floodplain soils. Similar to the effects that beaver dams have on channels, this treatment also results in localized changes to channel dimensions and characteristics. All of these changes would create conditions that would contribute to converting the site to a diverse mosaic of riparian plant communities.

Figure 31. Photograph A shows debris and organic matter trapped by the large woody debris structures. Photograph B shows sediment trapped in the floodplain as a result of elevated water surfaces upstream of large woody debris structures.

Coir Logs

Four hundred feet of coir logs were installed along select outer meander bends in the upper portion of the project reach in 2007. Coir logs were used to promote woody vegetation establishment in areas that are difficult to revegetate due to lateral erosion or competition from aggressive species. Based on the results of effectiveness monitoring, coir logs appear to be creating a suitable environment on outer meander bends for the establishment of willow cuttings and natural recruitment of wetland shrubs and forbs. The following key observations related to this revegetation treatment are summarized below:

- Willow survival is within the range of expected survival for this treatment (50 to 79 percent in 2009). Based on the results of 2008 and 2009 effectiveness monitoring supplemental willow cuttings were installed in Fall 2009 in sections of coir logs where survival was low.
- All structures had evidence of browse on willow cuttings. Measures to reduce browse on willows should be evaluated. Because it is difficult to limit access to coir logs because they directly border the stream and can be accessed from both sides of the channel use of a browse repellent such as Plant Skydd® may be an alternative.
- No natural colonization on coir logs was recorded in 2008 but natural colonization was recorded in 2009 (three to seven percent cover). Natural colonization of coir logs is a highly desirable function of this treatment. Species recorded as colonizing coir logs in July 2009 included a mix of native species such as mosses and horsetail, and non-native weedy species such as Canada thistle and pasture grasses.
- The average undercut in 2009 remained similar to the undercut depth recorded in 2008 (one to four inches). However, the average depth to the channel bed decreased slightly along each structure in 2009 indicating that the lateral scour necessary to form and maintain pools at these locations is not yet occurring. Localized pockets of scour were observed at some of the coir log sites. Habitat formation in the form of lateral scour pools and the long-term maintenance of these pools by woody vegetation is an important goal of the project and this treatment.
- For future monitoring of coir logs, it may be appropriate to replace the individual willow stem survival metric with a percent cover of willows metric. After the first few growing

seasons, willow cover is a more valuable metric than survival of cuttings because it indicates how much of the channel potentially has over-hanging woody vegetation cover which is an important habitat feature. Also, as the cuttings begin to put on growth it becomes difficult to distinguish between installed cuttings and new shoots that have become established on their own. Therefore, percent cover may be a more repeatable metric to measure treatment effectiveness long-term.

- Monitoring of coir logs is not necessary in 2010. An important function of this treatment is to ensure that the formation of lateral pools continues and no change was observed between 2008 and 2009. Therefore, little change is expected to occur by summer 2010 after one more high flow event. General observations and photo documentation of the sites should be made to ensure that no additional maintenance needs are required.
- Potential 2010 maintenance needs include: applying browse repellent to willow cuttings, hand-pulling weeds that have colonized coir logs, and potentially re-securing logs if necessary.

Based on these results and observations, this treatment should not be repeated until effectiveness has been determined. Over time, this treatment is expected to create and maintain diverse lateral pool habitat.

Herbicide Application

Herbicide applications were completed twice annually in 2008 and 2009. In 2008, herbicide treatments targeted reed canarygrass, Canada thistle and yellow toadflax. In 2009, herbicide treatments also targeted sulfur cinquefoil and houndstongue. Herbicide is effectively reducing the infestations and densities of target species. The following key observations related to this revegetation treatment are summarized below:

- Herbicide applications are effectively decreasing the density of Canada thistle at the project site. The applicator missed downstream infestations of Canada thistle in 2008. This infestation increased in both size and density between 2007 and 2009 (Figures 20 and 22). This infestation was treated in the fall of 2009.
- Treating small patches of reed canarygrass has been effective (Figure 19). This treatment should be expanded to other discrete patches in the downstream portion of the project reach.
- The distribution of yellow toadflax has increased since 2007 (Figure 23). Because overall distribution remains low, this species should be treated in 2010.
- Two new weed species, sulphur cinquefoil and houndstongue were discovered during 2009 mapping. Both species should be treated in 2010.
- The increase in yellow toadflax distribution and the new species infestations are concentrated at the upper end of the project reach near the property driveway and project area parking. The driveway and parking area most likely influences the spread of weed species into the project site and precaution measures should be considered.
- Infestations were re-mapped in July 2009, prior to 2009 applications. Re-mapping of the site is not necessary in 2010 but the site should be evaluated for effectiveness of 2009 applications and to verify additional treatment locations.

Adaptive Management

The revegetation treatments implemented in 2007 were the first phase (Phase I) of a multi-year effort to convert the project reach to a mosaic of desired riparian plant communities. The Revegetation Plan describes the phased approach to revegetation and describes how additional revegetation treatments and maintenance needs should be determined using an adaptive management framework based on monitoring the response of the site to initial treatments. Appendix D in the Revegtation Plan provided a general timeline for implementing initial treatments, monitoring treatments and implementing additional phases of revegetation. Table 9 in the 2007 Implementation Report provided a more detailed decision pathway for how to interpret effectiveness monitoring data collected in 2008 to determine the next phase of revegetation treatments. This decision pathway was used after 2008 effectiveness monitoring to make decisions about Phase II treatments (see Table 9 in the 2008 Monitoring Report). Phase II treatments were implemented in August, September and October 2009 and are described in the following section.

The combined results of 2008 and 2009 effectiveness monitoring provide the necessary data to determine 2010 maintenance needs and which revegetation treatments are appropriate to include in the next phase of revegetation for the project (Phase III). Phase III treatments, including anticipated maintenance needs, are also described in this section.

2009 Maintenance Activities and Supplemental Revegetation Treatments (Phase II)

Based on the results of 2008 and 2009 effectiveness monitoring, the following maintenance tasks and supplemental revegetation treatments were identified and completed during September and October 2009. These maintenance activities and supplemental revegetation treatments are considered Phase II of revegetation for the project:

- **Watering.** All containerized plants and protected residual shrubs were watered with a minimum of five gallons of water on September 2 and 3, 2009. A Montana Conservation Corps crew watered approximately one-third of planted shrubs and trees on August 19, 2009.
- **Browse Protector Repair and Maintenance.** Browse protectors were expanded, re-secured and straightened in all planting units and residual shrub protection areas (Figure 32). For additional stability, a second four-foot wooden stake was added to each expanded browse protector. Browse protectors were enlarged for all shrubs that had out-grown the current browse protector. Approximately 700 of the 1,028 plants installed were retro-fitted with larger diameter browse protectors. Approximately 200 of the 250 residual shrubs were retro-fitted with larger browse protectors.
- **Additional Residual Shrub Protection.** Sixty additional residual shrubs were protected using four-foot tall by 16-inch diameter browse protectors. Two wooden stakes were used to secure each browse protector for additional stability (initial installations included one stake per browse protector).

- **Solarization Removal and Seeding.** Based on observations made during July 2009 effectiveness monitoring it was determined that the grass treated by solarization fabric in Temporary Solarization Plot 3 had been effectively heat killed. Solarization fabric was removed from Temporary Solarization Plot 3 (Figure 33). A native seed mix consisting of shrubs, grasses, and forbs was applied to the exposed surface. Fabric removed from the plot was placed along the edges of the plot to create a buffer around the newly exposed bare soil (Figure 33). This resulted in treating 2,370 new square feet of reed canarygrass.
- **Solarization Maintenance.** Maintenance was completed in Temporary Solarization Plots 1 and 2 and in Planted Solarization Plots 1 and 2. In planted solarization plots, staples and fabric edges were re-secured and weeds and pasture grasses that had grown through the fabric where it was cut during installation of plants were hand-pulled. Maintenance of Temporary Solarization Plot 1 included re-securing staples and fabric edges. Most of the fabric in Temporary Solarization Plot 2 had become unsecured for unknown reasons leaving the treated area exposed. The exposed area was observed to consist of a mix of both desirable (sedges) and undesirable vegetation (Canada thistle and reed canary grass). Fabric was salvaged from the site, placed and re-secured on areas with undesirable vegetation. Areas that were being colonized by desirable vegetation were left exposed.
- **Supplemental Willow Cutting Installation.** A total of 115 supplemental willow cuttings were installed in areas of poor willow cutting survival at Coir Log sites 1-7.
- **Herbicide Application.** Two herbicide applications were completed in 2009 (August and October). Based on observations made during July monitoring, sulfur cinquefoil and houndstongue were added to the list of target species which also includes Canada thistle, reed canarygrass and yellow toadflax. A large infestation of Canada thistle near the downstream end of the project area was missed by applicators in August 2009. This area was treated in October 2009.

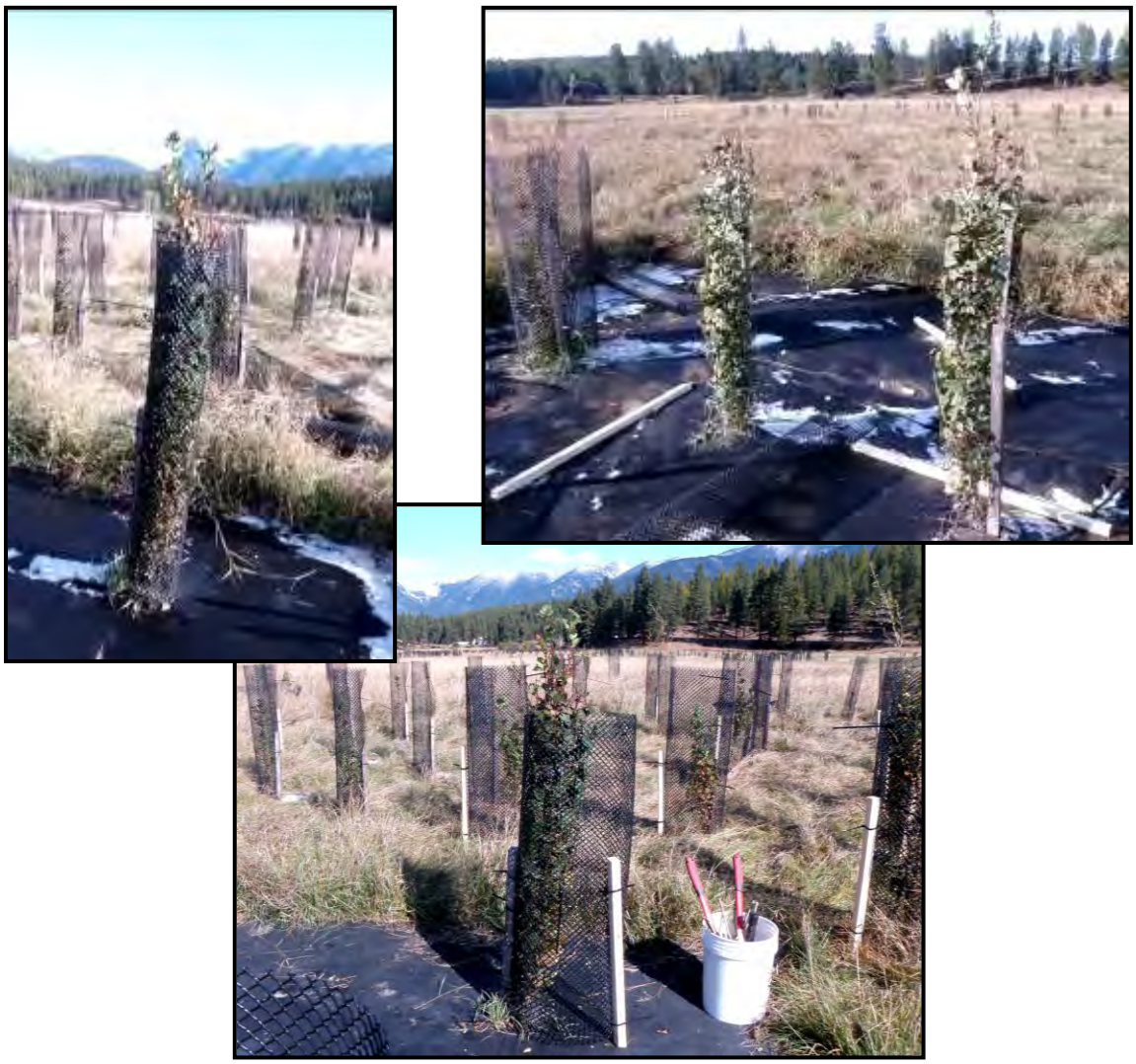

Figure 32. Photographs show the constricted growth form of plants after two full growing seasons in browse protectors (top photos) and the expanded protectors after fall 2009 maintenance (bottom photo).

Figure 33. Photograph showing temporary solarization plot 3 after a portion of the fabric was removed and re-located to act as a buffer around the newly exposed surface. The buffer will limit the potential for seed from adjacent grass areas to colonize the newly exposed soil.

Therriault Creek Riparian Revegetation Phase III

Based on the results of 2008 and 2009 effectiveness monitoring, the following activities should be included in the third phase of riparian revegetation for the Therriault Creek project site (Phase III):

- Implement maintenance needs described in Table 10.
- Conduct an effectiveness monitoring site visit. As described in the Discussion section, it is not necessary to repeat effectiveness monitoring of all the treatments monitored in 2008 and 2009. The primary purpose of this monitoring site visit would be to verify maintenance needs and finalize Phase III revegetation treatment recommendations. The site visit would include monitoring of selected treatments to ensure that no significant change in the trends observed in 2008 and 2009 is occurring. At this site visit, the following information and data should be collected:
    - General observations and notes on all treatments.
    - Photo documentation of all treatments.
    - Effectiveness monitoring data for two planting units.
    - Effectiveness monitoring data for both planted solarization plots.
    - Final Phase III treatment locations and quantities (see Table 11 for proposed treatments).
    - Final 2010 maintenance needs (see Table 10 for anticipated maintenance needs).
- Implement Phase III treatments described in Table 11. Recommended Phase III treatments should be completed in Summer and Fall 2010 and include:
    - Protect remaining residual shrubs with four-foot tall by 16-inch diameter browse protectors.
    - Install approximately 1,000 to 2,000 additional containerized plants in the downstream portion of the project site.
    - Potentially remove fabric at Temporary Solarization Sites 1 and 2 based on observations made in early summer of seeding effectiveness at Site 3.
    - Place solarization fabric in selected planting sites where reed canarygrass is a dominant species.
    - Apply herbicide targeting remaining infestations of Canada thistle, discrete patches of reed canarygrass and all occurrences of yellow toadflax, sulfur cinquefoil and houndstongue.

Table 10 provides a list of 2010 potential maintenance needs for treatments installed in 2007 and 2009. These maintenance needs are based on observations made during July 2008 and 2009 effectiveness monitoring. Maintenance needs should be verified and finalized in early summer 2010.

Table 10. Summary of maintenance needs for 2010 based on 2009 effectiveness monitoring. Maintenance needs should be finalized after 2010 spring flows recede.

Treatment	Summer 2010 Maintenance Needs
Residual Shrub Protection	-Straighten, secure or replace mulch mats and browse protectors
Containerized Planting	- Straighten, secure or replace mulch mats, browse protectors and vole protectors -Water -Eliminate livestock use of the riparian corridor
Solarization (long-term, planted)	- Straighten, secure or replace browse protectors -Water -Remove grasses that may grow through fabric openings -Add staples if necessary and secure fabric
Solarization (temporary)	-Add staples if necessary and secure fabric
Vegetated Soil Lifts	-Evaluate potential browse control measures -Hand-pull weeds on soil lift surface -Spot spray weeds adjacent to soil lifts -Seed surfaces where weeds are removed
Willow Fascines	-None
Large Woody Debris Structures	-None
Coir Logs	-Evaluate potential browse control measures -Hand-pull weeds on coir logs
Herbicide application	-None

Table 11 summarizes the adaptive management framework for the Therriault Creek riparian revegetation project. This table links 2008 and 2009 effectiveness monitoring results with an adaptive management decision making framework to provide recommendations for 2010 Phase III maintenance and revegetation treatments.

Table 11. Therriault riparian revegetation adaptive management decision making framework describing treatments and monitoring implemented during Phase I and decision pathway and recommendations for Phase III.

Treatment	Decision Pathway for Phase III[1]	Result of Decision Pathway Based on 2008 and 2009 Maintenance	Phase III Riparian Revegetation Recommendations
Residual shrub protection	(1) If new growth is observed, repeat this treatment in additional downstream reaches. (2) If browse protectors are not effective, additional measures will need to be evaluated based on observing browsed plants and animal use patterns (exclosures may be necessary, but only if the situation warrants). If mulch mats are not effective, concentrated herbicide application or larger or heavier duty weed barriers may be necessary.	A total of 310 residual shrubs have been protected. Browse protectors have proven effective at protecting residual shrubs from browse and residual shrubs had substantial new growth in 2008 and 2009. Treatment is also cost effective in terms of protecting the initial investment in containerized plants.	Protect remaining residual shrubs that can be located with four-foot high by 16-inch diameter browse protectors secured with two four-foot wooden stakes. The number of additional shrubs that require browse protection is estimated between 100 and 200.
Containerized plantings	(1) If survival of containerized shrubs is good and maintenance of shrubs (watering, weeding around plants) is effective and affordable, consider supplemental planting in downstream reaches. (2) If survival is poor determine if additional watering or weed suppression measures are needed or if other site conditions are precluding growth (e.g. soils). Do not plant additional plants.	Containerized plant survival remains high (89 percent) after the second year of monitoring. Maintenance was required in 2008 and 2009. Maintenance needs were greater in 2009 as many plants had out-grown the browse protectors prompting the need to expand browse protectors. No additional browse protector expansion should be needed. Maintenance (watering and straightening and securing browse protectors) is anticipated in 2010.	Plant additional containerized shrubs at select sites downstream of 2007 planting sites. Approximately 1,000 to 2,000 plants should be installed. Install four-foot high by 16-inch diameter browse protectors, three-foot by three-foot mulch mats and vole protectors around each plant. Remove Engelmann spruce from plant mixes.

Treatment	Decision Pathway for Phase III[1]	Result of Decision Pathway Based on 2008 and 2009 Maintenance	Phase III Riparian Revegetation Recommendations
Solarization	**Temporary Solarization Plots:** (1)If seeding at Site 3 is effective (good germination and establishment of seeded species), remove fabric from Sites 1 and 2 and continue to monitor. (2)If seeding at Site 3 is not effective and weeds or pasture grasses have re-colonized the exposed surface, re-cover the site with fabric and consider installing containerized shrubs through the fabric.	Maintenance was required at all sites. Fabric was removed from Site 3, the exposed surface seeded and fabric relocated to create a buffer around the seeded area. Fabric was secured at Sites 1 and 2.	Treatments will depend on observations of seeding effectiveness at Site 3 made during summer 2010. If seeding is effective, fabric from Plots 1 and 2 may be removed and the exposed surfaces seeded in Fall 2010.
	Planted Solarization Plots: (1) If survival is good continue to monitor and maintain plots. Do not repeat treatment until survival monitoring has been high (greater than 80%) for two years. (2) If survival is poor, try to determine causes.	Survival and growth have remained high after two growing seasons (86%). Treatment may be resulting in accelerated growth of some species. Maintenance was required at both sites in 2009. Maintenance (watering, straightening and securing browse protectors, and securing fabric) is anticipated in 2010.	Use solarization fabric in new planting sites where reed canarygrass is a dominant species. Install four-foot high by 16-inch diameter browse protectors, three-foot by three-foot mulch mats and vole protectors around each plant. Do not plant Engelmann spruce or white spirea in solarization plots.
Vegetated soil lifts	If willow survival remains patchy, consider planting containerized shrubs along the back edge of the soil lifts.	Willow survival is within expected range but growth is variable. Most cuttings are browsed which is affecting growth and potentially survival. Herbaceous cover is increasing including cover of noxious weeds.	Implement maintenance described in Table 10: hand-pull weeds and evaluate browse control methods. If percent cover of willows remains low in 2010 install containerized shrubs at each site.

Treatment	Decision Pathway for Phase III[1]	Result of Decision Pathway Based on 2008 and 2009 Maintenance	Phase III Riparian Revegetation Recommendations
Coir logs	(1) If willow survival is good and minimal scour and slumping has occurred, consider additional coir log installation. (2) If willow survival is poor, add supplemental willow cuttings to all coir logs in late fall or early spring. Do not repeat treatment, but continue to monitor supplemental cuttings. (3) If significant scour or slumping occurs, add additional earth anchors to all logs where needed. Do not repeat treatment, but continue to monitor for stability and effectiveness.	Willow survival is within expected range but growth is variable. Most cuttings are browsed which is affecting growth and potentially survival. Supplemental cuttings were installed in fall 2009. Little slumping or scour has occurred at monitored sites. Monitoring results show no definite trend in habitat/pool formation.	Implement maintenance described in Table 10: hand-pull weeds and evaluate browse control methods. Continue to monitor percent cover of willows, scour depth and depth of undercut bank (habitat formation).
Willow fascines	(1) If survival appears to be good and new growth is apparent in late spring/summer and only a small number of bundles have been scoured, repeat this treatment in depositional areas downstream of treated sites. (2) If most fascines are scoured or very little new growth is apparent, bury exposed cuttings, but do not repeat the treatment.	Willow survival is variable and little growth has been observed. Fascines are trapping sediment and debris and forming sediment deposits within the channel margins. Colonization by desirable vegetation is occurring at these sites. Placement location appears to influence treatment effectiveness.	Continue to observe colonization of desired vegetation at fascine sites. Most suitable sites were treated in 2007. No additional treatment or monitoring is recommended at this time.

Treatment	Decision Pathway for Phase III[1]	Result of Decision Pathway Based on 2008 and 2009 Maintenance	Phase III Riparian Revegetation Recommendations
Large woody debris structures	(1) If numerous positive trends (e.g. colonizing depositional areas, scour and/or deposition in the floodplain are observed in Summer 2008, consider adding more woody debris to the channel in Fall 2008 or Spring 2009. Also, consider supplemental containerized planting or dormant willow cutting installation around debris structures and in wetter areas of the floodplain adjacent to these sites. (2) If little to no change is observed, do not repeat treatment and continue to monitor.	After two monitoring events, species composition appears to be shifting toward hydrophytic vegetation along two of the monitoring transects. Structures are trapping fine sediment and organic material and sediment deposition is occurring in the floodplain adjacent to the structures. Little natural coloniziation by desired woody vegetation has been observed.	Although it appears that positive trends are occurring, this treatment should continue to be monitored before additional wood is installed in the channel.
Herbicide application	Continue to monitor new infestation of Canada thistle and reed canarygrass.	2009 weed mapping indicated that herbicide application has been effective at reducing the cover of Canada thistle and reed canarygrass (where treated). New species were identified during weed mapping and were treated in late summer and fall 2009.	Continue herbicide applications targeting Canada thistle, discrete patches of reed canarygrass and all occurrences of yellow thistle, sulfur cinquefoil and houndstongue. Continue to monitor effectiveness and whether continued treatment is necessary.

[1]Decision pathway is adapted from the Phase I decision pathway included in the Revegetation Plan (Geum 2007a) and Phase II decision pathway included in the 2008 Monitoring Report (Geum 2008).

References

Geum Environmental Consulting, Inc. 2007a. Therriault Creek Riparian Revegetation Plan. Internal report prepared for Kootenai River Network, Libby, Montana.

Geum Environmental Consulting, Inc. 2007b. Therriault Creek Implementation Report. Internal report prepared for Montana Fish, Wildlife and Parks, Libby, Montana. Contract #080067.

Geum Environmental Consulting, Inc. 2008. Therriault Creek Riparian Revegetation Monitoring Report Contract #0803. Internal Report prepared for Kootenai River Network, Libby, Montana.

Appendix A: 2009 Effectiveness Monitoring Data

Table A-1. 2009 containerized plant survival by species within monitored planting units.

Species	Data	Planting Unit 1	Planting Unit 3	Planting Unit 5	Planting Unit 7	Planting Unit 12	Planting Unit 14	Planting Unit 16
Alnus incana	Number Alive	0	3	2	4	0	4	2
Mountain alder	Number Dead	0	0	0	0	0	0	0
Amelanchier alnifolia	Number Alive	3	6	2	2	2	1	1
Western serviceberry	Number Dead	0	0	0	0	0	0	0
Betula occidentalis	Number Alive	0	6	3	0	1	0	0
Water birch	Number Dead	0	0	0	0	0	0	0
Cornus sericea	Number Alive	1	9	2	3	5	10	5
Red-osier dogwood	Number Dead	0	0	0	0	0	0	0
Crataegus douglasii	Number Alive	9	6	0	0	15	0	5
Black hawthorn	Number Dead	0	0	0	0	0	0	0
Picea engelmannii	Number Alive	0	1	0	0	0	1	0
Engelmann spruce	Number Dead	0	0	0	1	1	4	2
Populus balsamifera	Number Alive	2	1	2	3	7	6	3
Black cottonwood	Number Dead	0	0	0	0	0	0	0
Populus tremuloides	Number Alive	0	0	2	3	0	0	0
Quaking aspen	Number Dead	0	0	0	0	0	0	0
Prunus viginiana	Number Alive	0	5	1	0	1	1	8
Common chokecherry	Number Dead	0	0	0	0	0	0	0
Rosa woodsii	Number Alive	0	4	7	6	0	3	0
Wood's rose	Number Dead	0	0	1	0	0	0	0
Salix bebbiana	Number Alive	0	0	0	0	0	0	0
Bebb willow	Number Dead	0	0	0	0	0	0	0
Salix drummondiana	Number Alive	1	5	5	0	0	0	0
Drummond's willow	Number Dead	0	0	0	0	0	0	0

Species	Data	Planting Unit 1	Planting Unit 3	Planting Unit 5	Planting Unit 7	Planting Unit 12	Planting Unit 14	Planting Unit 16
Salix exigua Sandbar willow	Number Alive	12	1	0	0	0	0	0
	Number Dead	1	0	0	0	0	0	0
Salix geyeriana Geyer's willow	Number Alive	6	0	0	0	0	0	0
	Number Dead	0	0	0	0	0	0	0
Salix spp Willow species	Number Alive	0	17	9	40	1	10	9
	Number Dead	1	1	0	0	0	1	0
Spiraea betulifolia White spirea	Number Alive	0	8	4	4	18	5	8
	Number Dead	0	0	0	0	0	0	0
Symphoricarpos occidentalis Common snowberry	Number Alive	18	0	2	1	1	3	2
	Number Dead	0	0	0	0	0	0	0

Table A- 2. Vegetated soil lift effectiveness monitoring data collected in July 2009.

Soil Lift	Layer	Metric	Distance (ft)												
			0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65
SL-1	above	rips/tears	0	0	0	0	0	0	0	0	0	0			
SL-1	above	percent cover willow	0	10	10	10	5	20	70	20	10	0			
SL-1	below	percent cover willow	0	30	20	80	60	30	40	40	10	0			
SL-1	above	willow height (inches)	0	12	12	8	12	12	12	12	8	0			
SL-1	below	willow height (inches)	0	18	24	30	24	30	24	18	18	0			
SL-1	above	percent cover herbaceous	100	100	100	70	60	60	60	70	40	10			
SL-1	above	percent cover weeds	20	5	0	5	10	5	20	10	10	0			
SL-1	above	percent biodegradation	0	0	0	0	0	0	0	0	0	0			
SL-1	above	number dead stems	7	10	12	7	5	6	5	6	5	3			
SL-1	below	number dead stems	6	9	3	2	2	4	8	4	3	2			
SL-1	above	percent stem survival	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR			
SL-1	below	percent stem survival	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR			
SL-2	above	rips/tears	0	0	0	0	0	0	0	0	0	0	0	0	0
SL-2	above	percent cover willow	70	80	70	40	50	40	50	50	30	20	40	20	20
SL-2	below	percent cover willow	20	10	10	0	0	5	10	10	0	20	30	30	20
SL-2	above	willow height (inches)	30	30	18	18	18	24	18	18	18	18	12	12	18
SL-2	below	willow height (inches)	30	24	12	0	0	8	12	18	0	36	24	30	24
SL-2	above	percent cover herbaceous	100	100	100	70	70	80	90	90	90	80	90	80	80
SL-2	above	percent cover weeds	20	10	20	20	10	30	5	10	5	5	5	20	5
SL-2	above	percent biodegradation	0	0	0	0	0	0	0	0	0	0	0	0	0
SL-2	above	number dead stems	2	0	2	6	3	3	3	2	4	5	4	6	6
SL-2	below	number dead stems	2	4	2	7	2	0	1	2	0	4	1	1	1
SL-2	above	percent stem survival	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SL-2	below	percent stem survival	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table A- 3. Coir log effectiveness monitoring data collected in July 2009.

Coir Log	Metric	Distance (ft)									
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
1	Number alive willow cuttings/total number of installed willow cuttings	7/10	3/10								
	Total water depth (inches)	9	13								
	Coir log depth (inches)	15	16								
	Undercut below coir log (inches)	2	4								
	Percent cover natural colonization	1	5								
	Percent of log with fine sediment deposition	10	10								
2	Number alive willow cuttings/total number of installed willow cuttings	7/12									
	Total water depth (inches)	8									
	Coir log depth (inches)	14									
	Undercut below coir log (inches)	4									
	Percent cover natural colonization	3									
	Percent of log with fine sediment deposition	3									
3	Number alive willow cuttings/total number of installed willow cuttings	3/8	8/10	7/8	5/10	5/6	5/6	3/8			
	Total water depth (inches)	1	3	3	5	7	8	9			
	Coir log depth (inches)	8	11	9	11	11	11	14			
	Undercut below coir log (inches)	0	0	0	1	2	2	4			
	Percent cover natural colonization	1	5	5	5	10	5	1			
	Percent of log with fine sediment deposition	80	70	50	50	50	20	40			

Coir Log	Metric	Distance (ft)									
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
5	Number alive willow cuttings/total number of installed willow cuttings	4/9	8/9	8/10	5/9	4/9	8/11	7/8	2/9	7/8	
	Total water depth (inches)	3	6	6	7	9	6	8	7	4	
	Coir log depth (inches)	15	16	13	14	15	12	16	16	12	
	Undercut below coir log (inches)	4	2	2	2	2	2	6	3	3	
	Percent cover natural colonization	5	1	20	1	1	1	1	1	1	
	Percent of log with fine sediment deposition	5	1	1	1	5	5	10	5	5	
7	Number alive willow cuttings/total number of installed willow cuttings	9/9	7/8	12/12	11/12	12/12	8/12	9/15	16/18	6/11	5/12
	Total water depth (inches)	5	4	6	5	3	6	6	5	9	11
	Coir log depth (inches)	14	14	14	15	15	13	12	14	15	15
	Undercut below coir log (inches)	3	3	2	3	1	2	3	5	4	3
	Percent cover natural colonization	5	5	1	1	5	10	1	5	5	30
	Percent of log with fine sediment deposition	50	50	50	50	50	50	50	50	50	50

Table A- 4. Willow fascine effectiveness monitoring data collected in July 2009.

Fascine	Percent Scour	Percent Live Cover	Deposition Type	New Willow Growth (in)
1	0	1	20% silt, 20% cobble, heavy organic and small woody debris	2
2	0	1	100% silt, organic material	4
3	0	1 - upstream end underwater	50% silt on downstream end, small woody debris	4
4	0	1	40% silt, some small woody debris and organic material	0-12
5A (right bank)		1 - underwater	10% silt	4
5B (left bank)	NA	5	80% silt, 10% cobble	18
6	0	20	60% silt, 40% cobble, small and medium woody debris	12
7	0	underwater	50% silt behind fascine	0
8	0	5	80% silt, 20% large cobble	12
9	0	10	80% silt, 20% cobble	12
10	0	1	80% silt, 20% cobble grassy debris	8-10
11	0	0	10% silt downstream, upstream is underwater	0
12	0	1	50% silt, 50% cobble, small and medium woody debris	12
13	0	0	80% silt, small woody debris	0
14	0	1	30% silt, 70% cobble, small woody debris	4
15	0	1	70% silt, 30% cobble, small and medium woody debris	4-12
16	0	0	silt behind stake	0
17	0	20	40% silt	2-12
18	0	1	30% silt, 70% cobble, grassy debris	4-6
19	0	1	50% silt, 50% cobble, small woody debris	8
20	20	1	30% silt, 70% cobble	8
21	NA	0	50% silt, 50% cobble	0

Table A-5. Large woody debris structure Transect 1 effectiveness monitoring data collected in July 2009.

Distance (ft)	Species	Species (Common Name)	Percent Cover[1]	Water Depth (in)
0-10	*Elymus repens*	quackgrass**	8	0
	Phleum pratense	common timothy**	1	
	Bromus inermis	smooth brome**	1	
10-20	*Elymus repens*	quackgrass**	7	0
	Phleum pratense	common timothy**	2	
	Poa pratensis	Kentucky bluegrass**	1	
20-30	*Elymus repens*	quackgrass**	4	0
	Bromus inermis	smooth brome**	3	
	Phleum pratense	common timothy**	2	
	Poa pratensis	Kentucky bluegrass**	1	
30-40	*Elymus repens*	quackgrass**	6	slightly saturated
	Bromus inermis	smooth brome**	2	
	Poa pratensis	Kentucky bluegrass**	1	
	Phleum pratense	common timothy**	1	
	Polygonum spp.	smartweed	T	
40-50	*Elymus repens*	quackgrass**	7	slightly saturated
	Phleum pratense	common timothy**	P	
	Poa pratensis	Kentucky bluegrass**	P	
	Bromus inermis	smooth brome**	T	
	Polygonum spp.	smartweed	T	
50-60	*Elymus repens*	quackgrass**	3	slightly saturated
	Carex stipata	sawbeak sedge	2	
	Poa pratensis	Kentucky bluegrass**	2	
	Agrostis stolonifera	redtop**	1	
	Carex bebbii	Bebb's sedge	1	
	Carex spp.	sedge species	1	
60-70	*Poa pratensis*	Kentucky bluegrass**	5	slightly saturated
	Elymus repens	quackgrass**	2	
	Carex utriculata	beaked sedge	2	
	Carex bebbii	Bebb's sedge	1	
	Phleum pratense	common timothy**	P	
	Carex spp.	sedge species	P	

Distance (ft)	Species	Species (Common Name)	Percent Cover[1]	Water Depth (in)
	Elymus repens	quackgrass**	4	
	Poa pratensis	Kentucky bluegrass**	4	
	Agrostis stolonifera	redtop**	1	
	Cirsium arvense	Canada thistle*	1	
	Phleum pratense	common timothy**	P	
70-80	*Salexi bebbiana*	Bebb willow	T	0
80-90	Channel			NR[3]
	Agrostis stolonifera	redtop**	4	
	Elymus repens	quackgrass**	3	
	Bromus inermis	smooth brome**	2	
	Phleum pratense	common timothy**	1	
	Cirsium arvense	Canada thistle*	P	
90-100	*Epilobium* spp.	willow herb	T	0
	Elymus repens	quackgrass**	7	
	Agrostis stolonifera	redtop**	2	
	Carex stipata	sawbeak sedge	P	
	Nepeta cataria	catnip	P	
	Cirsium arvense	Canada thistle*	T	
100-110	*Rumex crispus*	curly doc	T	0
	Elymus repens	quackgrass**	8	
	Bromus inermis	smooth brome**	2	
	Poa pratensis	Kentucky bluegrass**	P	
	Cirsium arvense	Canada thistle*	P	
	Agrostis stolonifera	redtop**	P	
110-120	*Nepeta cataria*	catnip	T	0
	Elymus repens	quackgrass**	7	
	Cirsium arvense	Canada thistle*	1	
	Poa pratensis	Kentucky bluegrass**	1	
120-130	*Bromus inermis*	smooth brome**	1	0
	Elymus repens	quackgrass**	8	
	Cirsium arvense	Canada thistle*	1	
130-140	*Poa pratensis*	Kentucky bluegrass**	1	0

Distance (ft)	Species	Species (Common Name)	Percent Cover[1]	Water Depth (in)
	Elymus repens	quackgrass**	5	
	Cirsium arvense	Canada thistle*	3	
	Bromus inermis	smooth brome**	1	
	Poa pratensis	Kentucky bluegrass**	1	
140-150	*Brassica* spp.	mustard species*	T	0
	Elymus repens	quackgrass**	5	
	Cirsium arvense	Canada thistle*	4	
150-160	*Bromus inermis*	smooth brome**	1	0
	Elymus repens	quackgrass**	5	
	Cirsium arvense	Canada thistle*	3	
160-170	*Bromus inermis*	smooth brome**	2	0
	Elymus repens	quackgrass**	6	
	Cirsium arvense	Canada thistle*	4	
170-180	*Brassica spp.*	mustard species*	T	0
	Elymus repens	quackgrass**	6	
180-190	*Cirsium arvense*	Canada thistle*	4	0
	Elymus repens	quackgrass**	6	
190-200	*Cirsium arvense*	Canada thistle*	4	0

[1]Cover class codes are listed in Table A-8
[2]US = upstream; DS = downstream
[3]NR = not recorded
*Weedy or invasive species
**Non-native pasture grass

Table A-6. Large woody debris structure Transect 2 effectiveness monitoring data collected in July 2009.

Distance (ft)	Species	Species (Common Name)	Percent Cover*	Water Depth (in)
	Bromus inermis	smooth brome**	9	
	Elymus repens	quackgrass**	1	
	Cirsium arvense	Canada thistle*	T	
0-10	*Polygonum*	smartweed	T	0
	Elymus repens	quackgrass**	4	
	Bromus inermis	smooth brome**	3	
	Phleum pratense	common timothy**	2	
	Agrostis stolonifera	redtop**	1	
	Cirsium arvense	Canada thistle*	P	
10-18	*Polygonum*	smartweed	T	0
18-26	Channel			NR[2]
	Agrostis stolonifera	redtop**	5	
	Elymus repens	quackgrass**	3	
26-30	*Phleum pratense*	common timothy**	2	0
	Elymus repens	quackgrass**	6	
	Phleum pratense	common timothy**	2	
	Agrostis stolonifera	redtop**	2	
	Carex stipata	sawbeak sedge	P	
30-40	*Carex spp.*	Sedge species	T	0
	Elymus repens	quackgrass**	5	
	Agrostis stolonifera	redtop**	3	
	Carex bebbii	Bebb's sedge	1	
	Carex stipata	sawbeak sedge	1	
40-50	*Phleum pratense*	common timothy**	P	0
	Carex stipata	sawbeak sedge	4	
	Agrostis stolonifera	redtop**	3	
	Carex bebbii	Bebb's sedge	2	
	Carex utriculata	beaked sedge	1	
	Eleocharis palustris	common spikerush	P	
	Carex spp.	sedge species	P	slightly
50-60	*Juncus spp.*	rush species	P	saturated

Distance (ft)	Species	Species (Common Name)	Percent Cover*	Water Depth (in)
	Agrostis stolonifera	redtop**	4	
	Carex utriculata	beaked sedge	2	
	Carex stipata	sawbeak sedge	1	
	Carex bebbii	Bebb's sedge	1	
	Rumex crispus	curly doc	T	
	Eleocharis palustris	common spikerush	P	
	Carex spp.	sedge species	P	slightly
60-70	*Juncus spp.*	rush species	P	saturated
	Agrostis stolonifera	redtop**	4	
	Elymus repens	quackgrass**	3	
	Phleum pratense	common timothy**	1	
	Bromus inermis	smooth brome**	T	
70-80	*Carex utriculata*	beaked sedge	T	0
	Elymus repens	quackgrass**	9	
	Agrostis stolonifera	redtop**	1	
80-90	*Phleum pratense*	common timothy**	P	
	Bromus inermis	smooth brome**	T	
	Polygonum	smartweed	T	0
	Elymus repens	quackgrass**	4	
	Agrostis stolonifera	redtop**	2	
	Phleum pratense	common timothy**	2	
90-100	*Carex stipata*	sawbeak sedge	P	0
	Elymus repens	quackgrass**	6	
	Agrostis stolonifera	redtop**	2	
	Phleum pratense	common timothy**	2	
	Carex bebbii	Bebb's sedge	P	
	Carex spp.	sedge species	P	
	Juncus spp.	rush species	T	
100-110	*Polygonum*	smartweed	T	0
	Agrostis stolonifera	redtop**	4	
	Phleum pratense	common timothy**	2	
	Elymus repens	quackgrass**	2	
	Carex bebbii	Bebb's sedge	2	
	Polygonum	smartweed	P	0
110-120	*Juncus spp.*	rush species	P	

Distance (ft)	Species	Species (Common Name)	Percent Cover*	Water Depth (in)
	Agrostis stolonifera	redtop**	4	
	Elymus repens	quackgrass**	3	
	Phleum pratense	common timothy**	3	
120-130	*Polygonum*	smartweed	T	0
	Elymus repens	quackgrass**	5	
	Phleum pratense	common timothy**	3	0
	Agrostis stolonifera	redtop**	2	
130-140	*Taraxicum officinale*	common dandelion	T	
	Elymus repens	quackgrass**	7	
	Phleum pratense	common timothy**	2	
	Agrostis stolonifera	redtop**	1	
140-150	*Cirsium arvense*	Canada thistle*	T	0
	Elymus repens	quackgrass**	8	
	Phleum pratense	common timothy**	2	
150-160	*Agrostis stolonifera*	redtop**	P	0
	Elymus repens	quackgrass**	9	
	Phleum pratense	common timothy**	2	
	Bromus inermis	smooth brome**	P	
160-170	*Cirsium arvense*	Canada thistle*	T	0
	Elymus repens	quackgrass**	7	
	Phleum pratense	common timothy**	2	0
	Agrostis stolonifera	redtop**	1	
170-180	*Cirsium arvense*	Canada thistle*	T	
	Elymus repens	quackgrass**	6	
	Phleum pratense	common timothy**	3	0
180-190	*Agrostis stolonifera*	redtop**	P	
	Elymus repens	quackgrass**	9	
190-200	*Phleum pratense*	common timothy**	1	0

[1]Cover class codes are listed in Table A-8
[2]NR = not recorded
*Weedy or invasive species
**Non-native pasture grass

Table A-7. Large woody debris structure Transect 3 effectiveness monitoring data collected in July 2009.

Distance (ft)	Species	Species (Common Name)	Percent Cover[1]	Water Depth (in)
	Elymus repens	quackgrass**	8	
	Phleum pratense	common timothy**	2	
0-10	*Poa pratensis*	Kentucky bluegrass**	P	0
	Poa pratensis	Kentucky bluegrass**	4	
	Elymus repens	quackgrass**	3	
	Phleum pratense	common timothy**	2	
10-20	*Agrostis stolonifera*	redtop**	1	0
	Bromus inermis	smooth brome**	4	
	Phleum pratense	common timothy**	4	
	Poa pratensis	Kentucky bluegrass**	1	
	Elymus repens	quackgrass**	1	
20-26	*Cirsium arvense*	Canada thistle*	T	0
26-37	Channel			NR[2]
	Elymus repens	Quackgrass**	4	
	Bromus inermis	smooth brome**	3	
	Phleum pratense	common timothy**	1	
	Poa pratensis	Kentucky bluegrass**	1	
	Cirsium arvense	Canada thistle*	1	
37-50	*Polygonum*	smartweed	T	0
	Bromus inermis	smooth brome**	6	
	Elymus repens	quackgrass**	2	
50-60	*Cirsium arvense*	Canada thistle*	2	0
	Elymus repens	quackgrass**	6	
	Cirsium arvense	Canada thistle*	3	
	Bromus inermis	smooth brome**	1	
	Phleum pratense	common timothy**	P	
60-70	*Poa pratensis*	Kentucky bluegrass**	P	0
	Elymus repens	quackgrass**	9	
	Cirsium arvense	Canada thistle*	1	
70-80	*Rumex crispus*	curly dock*	T	0
	Agrostis stolonifera	redtop**	4	
	Elymus repens	quackgrass**	3	
	Poa pratensis	Kentucky bluegrass**	2	
	Phleum pratense	common timothy**	1	
80-90	*Rumex crispus*	curly dock*	P	0

Distance (ft)	Species	Species (Common Name)	Percent Cover[1]	Water Depth (in)
	Elymus repens	quackgrass**	3	
	Phleum pratense	common timothy**	2	
	Bromus inermis	smooth brome**	2	
	Polygonum	smartweed	T	
90-100	*Rumex crispus*	curly dock*	T	0

[1]Cover class codes are listed in Table A-8
[2]Not recorded
*Weedy or invasive species
**Non-native pasture grass

Table A-8. Cover class codes used during data collection along large woody debris structure transects.

Code	Percent Cover	Midpoint Percent
T	<1	0.5
P	1<5	3
1	5<15	10
2	15<25	20
3	25<35	30
4	35<45	40
5	45<50	50
6	55<65	60
7	65<75	70
8	75<85	80
9	85<95	90
F	95-100	97.5