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The Research, Process, and Design of the Trout Creek Revegetation Plan

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THE RESEARCH, PROCESS, AND DESIGN OF THE TROUT CREEK REVEGETATION PLAN

by

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Project Overview

The Bear River is the largest tributary to the Great Salt Lake, with water volumes reaching up to 1.4 million acre feet of water. The river begins in Utah's Uinta Mountains and flows into Wyoming and Idaho before finally flowing south and returning to Utah. The river flows nearly five hundred miles before emptying into Bear River Bay of the Great Salt Lake, ending only ninety miles from its origin (Utah History to Go, 2008).

Trout Creek near Thatcher, Idaho is a tributary to the Bear River. Trout Creek is a spring-fed stream of approximately six miles in length. Like many streams in the Bear River drainage, Trout Creek has been severely degraded by agricultural practices over the past century. Historically, riparian vegetation on Trout Creek consisted of Tufted hairgrass and Nebraska sedge as the dominant herbaceous plants, willows as the dominant woody vegetation, and a mixture of Common cattail and Hardstem bulrush as the dominant emergent wetland vegetation (NRCS, 2008). Today, the majority of Trout Creek, from its headwaters to the confluence of the Bear River is completely barren of woody riparian vegetation and much of the historic herbaceous vegetation community has shifted to non-native or dryer species not originally residing on the site. Much of the site contains invasive plants, which are harmful to the natural biodiversity of the site. Historically, Trout Creek contained Bonneville Cutthroat Trout (BCT) *Oncorhynchus clarki utah*, a designated "sensitive species" in the states of Idaho and Utah. Due to habitat degradation, increased stream temperatures, and non-native fish introduction, Trout Creek no longer supports BCT.

This report outlines the research and process implemented to create a riparian re-vegetative management plan for the restoration of approximately a 1/3 mile section of Trout Creek. This report discusses the participants in the project, and provides a relevant literature review, Trout Creek site description, applicable case studies, and the methodology conducted to produce the Trout Creek Revegetation plan.

Project Objectives

The restoration of Trout Creek is important to achieve the following objectives: 1) increase and improve existing habitat for Bonneville Cutthroat Trout, upland game birds and waterfowl species, 2) create a natural riparian buffer between the stream and adjacent farmland and roads, 3) improve the overall water quality of Trout Creek.

The Trout Creek restoration site is one piece of a larger watershed. In a watershed, upstream conditions continually affect areas downstream. Therefore, degradation on the Trout Creek restoration site is caused not only by on-site and adjacent land use practices, but all conditions that occur upstream in the watershed. The principles and management practices included in this restoration project can be applied to all areas of the watershed for overall system health. Ultimately, the long-term cooperation of all adjacent landowners to implement best management practices will be necessary for the greatest success of this project.

Project Participants

The restoration of Trout Creek is possible because of the participation of several key individuals and organizations. Nathan Hale and Kent Clegg, the land owner and land manager, respectively, acquired funding and expertise from a variety of sources. The USDA Natural Resource Conservation Service (NRCS) and the Environmental Coordination Committee of PacifiCorp are providing a portion of the funding for the design and construction of the project. Tyler Allred of Allred Restoration is contracted to provide the design of the new stream channel and guidelines of how it should be constructed. This thesis project provides the riparian re-vegetative management plan portion of the restoration of the new channel designed by Allred Restoration.

Some information contained within this report was obtained through input from Chris Hoag, a wetland plant ecologist for the NRCS Aberdeen Plant Materials Center and leading expert on aquatic and riparian restoration in Idaho; and also Eve Davies, a restoration biologist with PacifiCorp, who has completed several successful aquatic restoration projects in Utah and Idaho.

Literature Review

Healthy riparian areas provide many well understood and documented benefits. Riparian zones are commonly recognized as corridors for movement of animals within watersheds and corridors for the dispersal of plants (Gregory, Swanson, McKee and Cummins, 1994). The vegetative community in most riparian areas is typically more structurally varied than adjacent uplands and thereby provides a rich diversity of habitat niches. This diversity translates into the primary life requirements (food, cover, reproductive habitat) for a great variety of wildlife species such as BCT (Bentrup and Hoag, 1998).

Riparian areas are the links between forests and/or other uplands and streams. Riparian vegetation adjacent to a stream provides important food sources for macroinvertebrates, a necessary food source for other forms of aquatic life (Bentrup and Hoag, 1998). Riparian plant communities also contribute large wood debris to channels providing a major geomorphic feature in streams and rivers (Keller and Swanson, 1979). Solar radiation is selectively absorbed and reflected as it passes through the riparian canopy, altering the quality and quantity of light available for aquatic vegetation (Gregory, Swanson, McKee and Cummins, 1994). Increased amounts of shade also lower water temperatures in streams producing habitat more suitable for cold water fish species such as BCT. Temperature also influences factors such as the rate of nutrient cycling and dissolved oxygen content (Karr and Schlosser, 1978).

Riparian areas function to protect water quality. Riparian vegetation traps sediments and nutrients from surface runoff and prevents them from entering the water.

The matrix of roots created from vegetation also reduces sediment entering the stream by minimizing streambank erosion (Binford and Buchenau, 1993).

An estimated 50 percent of streams in the Great Basin are classified as impaired to one degree or another (Chambers and Miller, 2004). Irrigated cropland is estimated to be responsible for 89 percent of river miles with degraded water quality in the United States according to a 1992 US Environmental Protection Agency (USEPA) report (CFIFCD, 1996). Additionally, Alan Matheson of Trout Unlimited (2004) noted that 80% of wildlife in this region relies on the resources of riparian areas for survival during some period of their life cycle.

RIPARIAN RESTORATION

In 2002, the National Research Council stated that riparian areas constitute less than five percent of the land in the United States and estimate that up to 95 percent of native riparian vegetation has been lost. Considering the numerous ecological benefits of riparian areas, restoring riparian systems including native riparian vegetation is a critical part of habitat protection for fish and wildlife. Restoration is defined as the return of a degraded ecosystem to a close approximation of its natural potential (USEPA, 2000).

Riparian restoration is often the most cost-effective technique for restoring water quality in streams degraded by non-point source pollution (USEPA, 1996). Riparian restoration efforts have succeeded in establishing aquatic ecosystem function and structure in cases where riparian vegetation has been removed for decades and livestock grazing has compacted riparian soil and caused downcutting or widening of the stream channel (Platts, 1991).

Active restoration may be necessary due to erosion, exotic plants or numerous other factors (Kauffman, 1997). Bank stabilization and revegetation are active restoration techniques, often referred to as *bioengineering techniques,* which can effectively aide the natural recovery process of streamside vegetation.

Bioengineering is defined as integrating living woody or herbaceous materials with soil to increase the strength and structure of the soil (Bentrup and Hoag, 1998). A dense matrix of roots holds soil in place, while the above ground vegetation provides resistance to erosion caused by flow by dissipating energy and armoring the streambank. Bioengineering techniques are initially more expensive than traditional engineered techniques due to labor, repairs, monitoring and replanting; however their maintenance costs are much lower over time due to their ability to be self-sustaining. In contrast to traditional engineering approaches such as rip-rap and concrete structures that degrade water quality, bioengineering techniques improve water quality, provide habitat and add beauty to the landscape (Bentrup and Hoag, 1998).

RIPARIAN BUFFERS

An important part of any riparian restoration project is establishing riparian buffer widths (the width of the landscape from the bank full flow upslope). Riparian buffers are designated areas within which human-induced disturbances are limited based on their distance from the stream and their effects on water quality and wildlife habitat. Riparian buffer widths can be divided into three functional groups: zone 1, zone 2, and zone 3 buffers (Kleinschmidt Associates, 1999 in Johnson and Buffler, 2008).

Zone 1 of the buffer is considered a "no disturbance zone" where land uses that disturb soils or vegetation are prohibited. Zone 1 functions such as stream shading and streambank stabilization will not operate properly if vegetation removal or other land uses occur within the boundaries of the zone. Zone 1 encompasses land from the mean high watermark of the stream (bank full), landward to the boundary of the active floodplain of a stream where a break in the slope of the land occurs, plus 35 feet. Wetlands and springs should also include a zone 1 buffer of 50 feet (Johnson and Buffler, 2008).

Zone 2 of the buffer begins at the edge of zone 1 and extends landward variable distances depending on specific landscape attributes in the buffer including slope, soil and surface roughness. Zone 2 buffers function to provide sediment filtering and other water quality functions. Land use activities such as short duration grazing and low impact agriculture on slopes less than 5%, that do not impair these water quality functions are permitted in this zone (Kleinschmidt Associates, 1999 in Johnson and Buffler, 2008).

Zone 3 of the buffer includes the entire landscape on the landward edge of Zone 2. Row crop agriculture, grazing, and exurban development are often the primary uses. Use of NRCS best management practices such as stormwater management, grassed waterways, and field borders are recommended in this zone to protect long-term buffer functioning (Kleinschmidt Associates, 1999 in Johnson and Buffler, 2008).

BONNEVILLE CUTTHROAT TROUT

This project focuses on improving existing habitat for Bonneville Cutthroat Trout. The U.S. Fish and Wildlife service states that 291 populations of Bonneville Cutthroat Trout exist. These populations occupy approximately 850 miles of stream and 70,000 acres of lake habitat. This habitat area is somewhere between 5 and 17 percent of their historical range (The Western Native Trout Campaign, 2007).

Cutthroat trout have certain requirements for suitable habitat such as adequate flow and temperature regimes. Within the Bonneville Basin (the area historic Lake Bonneville once occupied), appropriate habitat for BCT exists in higher elevation, small mountain streams and lakes within coniferous and deciduous forests. This habitat type is most often found between 8,000 and 11,000 feet in elevation. BCT habitat can also be found in lower elevations ranging from meadow to alluvial desert river systems, generally occurring between 3,000 and 5,000 feet in elevation (US Fish and Wildlife Service, 2001). Trout Creek is a low-elevation meadow habitat type.

Although BCT can exist in several different stream habitat types, one universal requirement for BCT to survive is an intact, functioning riparian zone. Without a healthy, functioning riparian zone, BCT do not have the necessary cover, food, structure, shade and bank stability needed to survive. (Binford and Buchenau, 1993). BCT require special habitat conditions in order to spawn and for embryos to survive. Water temperatures must be within an optimal range (6.1-17.2 degrees Celsius), and streambed substrate must contain the appropriate depth and size of gravel. Cutthroat trout require at least 6 cm of gravel between .5 cm and 10 cm in size. Also, the survival of embryos depends largely on the absence of fine substrate less than .5 cm in size. The higher the percentage of fine substrate in the stream, the lower the survival rate is for embryos. The amount of fine sediment being transported by the stream is also relevant because much of this sediment can be deposited within spawning redds, reducing the success of the embryos by limiting the amount oxygen available. Thus water quality and preventing sedimentation are of utmost importance in managing for healthy spawning habitat (Bjornn and Reiser, 1991).

Conditions along Trout Creek are typical of streams with unsuitable temperature ranges for BCT. Streambank revegetation on the Trout Creek restoration site will lower water temperatures by increasing stream shading. However it is uncertain whether increased shading alone will provide enough temperature relief; therefore upstream revegetation may be necessary to accompany the work on this project.

Trout Creek presently contains a high percentage of fine substrate and little suitable spawning gravel. Upstream streambank conditions and land use practices are significant contributors to this problem. Adding suitable spawning gravel could provide a temporary solution; however until upstream problems are addressed, siltation of the streambed will continue and re-addition of gravel will be necessary. Reintroduction of BCT will produce a fishery that must be periodically re-stocked to maintain high population levels.

PHEASANTS

This restoration project also aims to improve the existing habitat for upland game birds, especially pheasants (*Phasianus colchicus*). Therefore, in addition to BCT habitat requirements, pheasant habitat requirements were used to determine the vegetation needs at the Trout Creek restoration site. Basic pheasant life requirements include protective cover, food, water and nesting space. Numerous field studies of pheasant movement habits have conclusively shown that they are normally non-migratory and that pheasants generally live and die within a 2 square mile or smaller area (Trautman, 1982). Therefore, all basic pheasant living needs must be accounted for within the project boundaries.

Pheasant populations have declined in southern Idaho due to the loss of winter cover. In a study of winter habitat use by hen pheasants in southern Idaho, David Leptich of the Idaho Fish and Game, found that Pheasants preferred sagebrush (Artemisia spp.), wetland, and herbaceous cover types and avoided grassland and agricultural cover types. Additionally, livestock grazing reduces pheasant use of the sagebrush cover type (Leptich, 1992). Leptich also found that wetlands were among the heaviest used cover type. Pheasants used wetlands for loafing and escape during the day, and roosting and thermal cover at night. Woody plants become important for winter cover when snow becomes deep and fills wetland cover types.

Nesting cover is of significant importance to the persistence of pheasants. Pheasants prefer to nest in herbaceous grasses and forbs including Intermediate wheatgrass (*Thinopyrum intermedium*) and Alfalfa (*Medicago sativa*). Much of the Trout Creek site is dominated by Intermediate wheatgrass and the adjacent farmland is primarily Alfalfa, thus the site is not currently lacking nesting cover (Trautman, 1982).

Pheasants feed on cultivated grains, weed and grass seeds, and insects. Pheasants also consume wild fruits such as chokecherry, wild rose, snowberry, hawthorn, serviceberry, and golden currant during the winter (Trautman, 1982). These types of flowering plant species are native to the project site and will be important to re-introduce to Trout Creek to provide habitat and food sources.

WATERFOWL

Waterfowl habitat is the final habitat criteria addressed by this restoration project. Waterfowl are a group of diverse birds with diverse habitat requirements. Waterfowl have exceptionally high-energy requirements due to their energetically expensive life cycle events including migration, molting, and reproduction. These requirements are satisfied by a variety of wetland habitats (Fredrickson and Reid, 1988). As a result of high mobility and a migratory life cycle, waterfowl can spread their resource consumption over wetlands separated by great distances.

Waterfowl have differing needs and tolerances for the density, height, and type of vegetation. For example, mallards prefer habitats with dense vegetation while northern pintails prefer sparse vegetation with shallow open water (Fredrickson and Reid, 1988). In general, monocultures of vegetation such as large expanses of cattail are less beneficial to waterfowl than wetlands with more diverse species compositions. For managing modified wetlands, manipulating the wetland to emulate natural wetland complexes and water regimes will provide diverse habitats for a variety of waterfowl (Fredrickson and Reid, 1988).

Nesting habitat is of high importance for the persistence of waterfowl on a site. Individual waterfowl species have varying nesting habitat needs. For example, the highest nesting densities for Northern pintails occur in open habitats where vegetation is sparse and often far from water. Common plants in these areas include meadow and prairie grasses as well as rushes. Pintails also nest in agricultural areas more frequently than other dabblers and commonly use pastures, roadsides and hayfields as nesting habitat (Fredrickson and Heitmeyer, 1991). Mallards typically nests within 100 yards of water, in depressions often lined with pasture grasses and herbaceous plants such as alfalfa (Fredrickson and Reid, 1988). The Trout Creek restoration site contains abundant nesting habitat suitable for a variety of waterfowl species.

Natural wetland sites in southeastern Idaho generally contain a mixture of Common cattail (*Typha latifolia*), various sedges (*Carex sp.*) and Hardstem bulrush (*Scirpus acutus*). According to information obtained in a telephone conversation with Chris Hoag (2008), a wetland plant ecologist with the Aberdeen Plant Materials Center of the NRCS, a 9:1 ratio of bulrush to cattail is the most optimal ratio for waterfowl species in this region. Due to the high density of cattail existing in the site, cattail removal and subsequent bulrush transplanting will be necessary to establish bulrush in numbers large enough to reach this goal.

Site Description

The Trout Creek restoration site is situated on the Whiskey Creek Ranch, located approximately midway between the headwaters of the creek and its confluence with the Bear River near Thatcher, Idaho (See Context Map pp. 46). This restoration site is approximately 1/3 mile in length, and the elevation is approximately 5,100 feet. Trout Creek is a spring driven system with relatively constant flows year-round. Spring snowmelt does not significantly impact the intensity of flow in the creek. The creek is located in a mid-elevation unconfined alluvial valley.

Historically, Trout Creek had a low gradient and high sinuosity. Approximately forty years ago the creek was diverted out of its original channel and re-routed into a canal that flows around the eastern and southern boundaries of the property and does not return to its original channel until the southwest boundary of the site (see Existing Drainage map pp. 47). Land use practices (primarily livestock grazing) and a lack of water in the channel due to the diversion resulted in an almost complete absence of woody riparian vegetation along the original channel. This lack of woody riparian vegetation provides very poor habitat for BCT, pheasant, and waterfowl species.

On the Southwest side of the site, several springs exist that provide a significant amount of standing water to the original stream channel. This water has resulted in a substantial wetland plant community currently dominated by Common cattail (*Typha latifolia)* and Nebraska sedge (*Carex nebrascensis)*, but also includes some Hardstem bulrush (*Scirpus acutus*). This *emergent wetland community* is one of three terrestrial plant communities that exist on the site (see Existing Vegetation map pp. 48). The other plant community types are a sedge/rush community and a mesic meadow community.

The *sedge/rush community* consists primarily of Nebraska Sedge and other sedges (*Carex sp.)*, Baltic rush (*Juncus balticus)*, Foxtail barley (*Hordeum jubatum)*, and Willow herb (*Epilobium sp.)*.

The *mesic meadow community* consists primarily of Kentucky bluegrass (*Poa pratensis)*, Intermediate wheatgrass (*Thinopyrum intermedium)*, Timothy (*Phleum pretense)*, Smooth brome (*Bromus inermis*), Redtop (*Agrostis capillaries)*, Wood's wild rose (*Rosa woodsii).* Other (secondary) species in the mesic meadow community include Orchard grass (*Dactylus glomerata*), Horsetail (*Equisetum sp.*), and Mint (*Mentha sp.*).

The location of these plant communities can be seen on the existing vegetation community map (pp. 48).

The survey of existing vegetation on the Trout Creek restoration site indicates that the site has been significantly disturbed. Ecological disturbance affects which plant communities can exist on specific soil types. For example, improper grazing management often facilitates the invasion of non-native species. Continued improper grazing management coupled with stream alterations often cause the water table to lower, resulting in altered soil moisture conditions, leading to changes in vegetation community composition (Platts, 1991).

According to the Natural Resource Conservation Services' Draft Ecological Site Description (2007) of Trout Creek and the surrounding area, three distinct terrestrial plant communities are possible depending on the level of disturbance the site has experienced. The first is State 1, Plant Community A: the historic climax plant community that would have historically existed if the site was undisturbed. The second is State 1, Plant Community B: the plant community that would exist under a moderate level of disturbance. Third is State 2: the plant community that would exist after significant disturbance and subsequent lowering of the water table. The possible plant communities for the three different levels of severity of ecological disturbance are as follows:

"State 1, Plant Community A. Historic climax plant community. The HCPC has Tufted hairgrass and Nebraska sedge as co-dominant in the herbaceous layer. There are a wide variety of grasses and grass-like species and forbs that may occur in minor amounts. Some of these species may be dominant in small areas due to soil and water variations. Willows and shrubby cinquefoil can occur in small amounts.

State 1, Plant Community B. This plant community is dominated by Nebraska sedge, other sedges and Baltic rush. Forbs have increased in the community and Kentucky bluegrass may have invaded. This phase has developed due to improper grazing management. The water table has not been lowered from that of Phase A.

State 2. This plant community is dominated by Nebraska sedge and other sedges and Baltic rush, but the overall production potential of the site is much lower than State 1. There is an increase in forbs and grasses that require less soil moisture. Kentucky bluegrass, Redtop bentgrass and Meadow foxtail may have invaded the community. This state developed due to continued improper grazing management and a permanent lowering of the water table from 20-40 inches to 40-60 inches below the surface. This state can be similar to Dry Meadow in early seral state. The site has crossed the threshold. This state cannot be returned to State 1 without raising the water table. This might be done using structures or bio-engineering over time, but the plant community may take many years to approach the plant community in State 1." (NRCS, 2008).

Using the NRCS descriptions above, the site was rated as having a State 2 plant community. The high level of disturbance associated with the State 2 plant community types such as Kentucky bluegrass and Redtop bentgrass is assumed to be the major factor in site degradation. The considerable presence of State 2 species suggests the water table has dropped significantly and restoration to the State 1 plant community is only possible with extensive restoration efforts.

A goal of this project is to provide the necessary vegetative conditions for the site to be self-sustaining and over time, raise the water table enough for a return to State 1 plant communities which support various wildlife and cold-water fish species such as

BCT. Establishing riparian plants that prevent erosion and stream downcutting will be critical for returning the stream to a more functional hydrologic condition.

It is important to understand the soil types existing on the site and what type of vegetation they can support. Differing soil characteristics such as texture, depth, and drainage characteristics affect what types of vegetation can grow at any given place. The soils on the site have not yet been included in an NRCS Soil Survey; however they are classified by the NRCS as a "Nuffer-Blackotter Complex" agricultural soil. "The Nuffer series consists of very deep, somewhat poorly drained soils formed in mixed alluvium. They are on low terraces and slightly elevated areas on flood plains. Slopes range from 0 to 2 percent. Permeability is moderately rapid in the upper part and very rapid in the lower part." (National Cooperative Soil Survey, 2008).

Case Studies

Two case studies of riparian revegetation projects were used as precedents for the Trout Creek revegetation process. It is important to use successful revegetation projects as precedents for the Trout Creek revegetation to ensure an appropriate process is taken in developing the plan. The use of precedents helps to avoid mistakes and offers insights into the opportunities and constraints of different restoration projects. The first case study is the Provo River Restoration Project just downstream of Jordanelle Dam in Utah. The second is the Lower Red River Meadow Restoration Project in north-central Idaho. These two sites were selected because they contained similar objectives and levels of degradation as Trout Creek. Additionally, the Lower Red River project was of a similar scale and stream type as Trout Creek.

PRECEDENT 1: PROVO RIVER RESTORATION

Historically the middle Provo River meandered through the Heber Valley, offering outstanding fish and wildlife habitat. In the 1940s the middle Provo River was channelized and confined between dikes. As a result of this channel alteration, the complex middle Provo River ecosystem was lost. In the early 1990s the Jordanelle Dam was constructed just upstream of the Heber Valley, further impacting the flow and hydrologic regime of the Provo River (Wild Fish Habitat Initiative, 2008).

In 1999, the Utah Reclamation Mitigation and Conservation Commission began the Provo River Restoration Project (PRRP) downstream of Jordanelle Dam. The project was funded to offset the impacts to the river from water management activities associated with the dam by restoring the middle Provo River's pattern and ecological function to a more natural condition. In addition to channel modifications and flood plain reconnection, the PRRP included both passive and active riparian revegetation measures as a means to restore riparian areas for improved fish and wildlife habitat.

Although the PRPP is much larger in scale than the Trout Creek Revegetation plan, many of the restoration principles directly apply to the Trout Creek restoration. Determining the historic riparian vegetation composition, as well as prescribing what plant communities should be reestablished are two main components of the PRPP applied to the Trout Creek plan. A summary of the riparian vegetation section of the PRPP is included in the appendix of this report (see Appendix Item 1).

PRECEDENT 2: LOWER RED RIVER MEADOW RESTORATION

Since the early 1900s, human activities have impacted the hydrology and ecology of the Lower Red River Meadow. The river channel was straightened and native riparian vegetation eliminated due to dredge mining, or in an attempt to reduce flooding and maximize grazing area throughout the meadow. The river/wet meadow ecosystem responded with:

- decreased channel length and sinuosity
- channel downcutting
- disconnection of the river from the meadow floodplain
- lowered water table
- elevated water temperatures in the river
- reduced quantity and quality of fish and wildlife habitat (Wild Fish Habitat Initiative, 2008)

Historically, the Red River supported abundant numbers and diverse populations of fish species. Although some native species still persist, they are generally found in low numbers. The low population levels are due in part to the habitat and water quality degradation that has taken place (Wild Fish Habitat Initiative, 2008).

The Lower Red River (LRR) Meadow Restoration is more similar in scale to the Trout Creek project than the Provo River Restoration. The causes of degradation are also very similar. Improper grazing management and other human-induced factors such as straightening of the stream, have caused a loss of riparian vegetation and a lowering of the water table in both streams. Restoration activities on the LRR included reconnecting historic meanders, constructing new meanders, reshaping channel cross sections, installing a variety of bioengineered bank treatments, and planting native riparian vegetation (Wild Fish Habitat Initiative, 2008). The Trout Creek restoration also includes the construction of a new channel and reshaping old meanders, bioengineering techniques, and native plant re-vegetation.

A review of the LRR case study aided the Trout Creek project in several ways. The determination of historic native vegetation composition and the selection of revegetation species are modeled in part after the LRR plan. Additionally, broad concepts from the LRR plan on vegetation placement for the success of young plants and wildlife benefit was applied to the Trout Creek plan. A full summary of the revegetation plan of the Lower Red River can be found in the appendix of this report (see Appendix Item 2).

Methodology

Planning the Trout Creek Revegetation Plan was an in-depth process involving several steps, beginning with a site inventory, analysis and research of the site's natural potential and characteristics. Specific management goals and site conditions dictated what vegetation treatments and future management prescriptions need to occur on the site. The process was derived from a combination of a literature review including two relevant case studies and the coordination and input from local restoration experts Chris Hoag and Eve Davies.

Portions of the development of the Trout Creek Revegetation Plan were based on case studies of the Provo River Revegetation Plan in Utah and the Lower Red River Meadow Revegetation Plan in Idaho. The following tables illustrate process similarities and differences in the 3 projects. Table 1 lists steps in the process of determining historic vegetation communities and the measured conditions of the on-site survey of each plan.

Table 2 compares the plant selection criteria for each project along with the widths of the riparian zone and buffer widths. Table 3 illustrates the benefits of each design for fish and wildlife with the previously mentioned emphasis on BCT, pheasants, and waterfowl in the Trout Creek Revegetation Plan.

TABLE 1

PROJECT	Determining Historic Vegetation	On-site Survey
Precedent 1: **Provo River, UT**	The PRRP determined historic vegetation communities using these factors: • no pristine reference sites were found • several impacted reference sites were used • historical aerial photos • surveys of nearby sites that hadn't been diked, dredged, recently grazed, damned, or dewatered.	The on-site surveys of the Provo River collected data the following variables: • woody and herbaceous species composition • tree basal area • woody plant stem density • % overstory cover • herbaceous plant cover • tree population age • soil survey • fish and wildlife species distribution and abundance
Precedent 2: **Lower Red River Meadow, ID**	LRRM Restoration determined historic vegetation communities using these factors: • adjacent land surveys • historical data and photographs • local accounts of historical conditions.	The LRRM on site surveys included data collection and mapping of the following variables: • woody and herbaceous species composition • soil survey • mapping existing vegetation communities
Current Project Site: **Trout Creek, ID**	Historic vegetation was determined from the following factors: • no suitable reference sites were found • survey of adjacent Whiskey Creek (highly impacted) • historical accounts from experts in the field and of the geographic area • literature review of historic ecological conditions	The on-site survey of Trout Creek included data collection mapping of the following variables: • woody and herbaceous species composition • existing vegetation communities • new channel alignment • literature review for soil characteristics

Table 1- Comparison of historic vegetation determination and components of on-site surveys.

TABLE 2

PROJECT	Plant Selection	Riparian Zone Width
Precedent 1: **Provo River, UT**	The PRRP selected plants based on the following criteria: • native plants found along Provo River +/- 300 ft. from revegetation site • species found along designated reference reaches • native species that have a high value (e.g. wildlife food).	The PRRP's riparian zone width varies greatly. • the river is connected to a functioning floodplain between 800 and 2,200 ft. wide and in many locations the floodplain is buffered
Precedent 2: **Lower Red River Meadow, ID**	The LRRM selected plants based on the following criteria: • native plants only • seed collected on-site • willows collected from nearby and similar sites • seed and plant selection subject to availability	The LRRM's riparian width follows this guideline: • riparian zone extends a minimum of 20 ft. from streambank edge
Current Project Site: **Trout Creek, ID**	The Trout Creek Revegetation Plan selected plants based on the following criteria: • native or non-invasive plants only, focusing on wildlife value. • willows collected from nearby and similar sites includes: • streamside riparian vegetation • emergent wetland vegetation • woody upland vegetation	Trout Creek's riparian zone width follows the following guidelines: • riparian zone width varies along the length of the site • a minimum of 20 ft. of riparian vegetation will be maintained from the streambank edge • a 35 ft. "no disturbance zone" free from all agricultural and other activities will extend from the edge of the active floodplain • "no disturbance zone" will extend 50 ft. from all wetlands and springs

Table 2 – Comparison of plant selection and riparian zone width components of the PRRP, LRR, and Trout Creek Revegetation Plans.

TABLE 3

PROJECT	Fish Habitat	Wildlife Habitat
Precedent 1: **Provo River, UT**	An increase in aquatic habitat diversity is obtained by creating: • Side channels • Undercut banks • Increased cover from streambank vegetation • Improved water quality	The vegetation has a natural design with features that provide: • Historical habitat variability and structure • 800- to 2,200-foot of protected floodplain. • Wildlife habitat has increased dramatically.
Precedent 2: **Lower Red River Meadow, ID**	Riparian plantings will create and enhance fish habitat conditions by increasing: • Bank stability • Undercut banks • Woody debris input • Water quality • Stream shading While decreasing: • Stream temperatures • Suspended sediment	The revegetation plan is beneficial to a variety of wildlife species by providing: • Diverse and dense plantings in riparian corridor • Expanded wetland and open water areas Both provide: • Nesting • Foraging • Cover
Current project site: **Trout Creek, ID**	Riparian plantings and restored channel will create and enhance fish habitat (especially for BCT) by increasing: • Bank stability • Undercut banks • Woody debris input • Water quality • Stream shading While decreasing: • Stream temperatures • Suspended sediment	The revegetation plan is designed for use by a variety of bird and mammal species, focusing particularly on upland game birds and waterfowl, by providing: • Diverse and dense plantings in riparian corridor • Expanded wetland and open water areas • Fruit-producing upland vegetation • Upland nesting, foraging and cover habitat

Table 3 – Comparison of fish and wildlife habitat components of the PRRP, LRR, and Trout Creek Revegetation Plans.

Using the PRRP and the LRR case studies as precedents, the methodology of the Trout Creek Revegetation Plan was broken down into 8 steps: 1) understanding current plant communities existing on the site, 2) identifying historic native plant communities, 3) determining the most appropriate species for revegetation, 4) design and reconstruction of the historic channel and reconstruction of a new channel, 5) the construction of a newly designed stream channel, 6) the determination and design of a plan for the implementation of three distinct revegetation needs (streambank, wetland, and upland revegetation treatments), 7) development of an herbivory monitoring and prevention plan, and 8) the determination of an optimal riparian buffer width.

Step 1: The first goal of the Trout Creek Revegetation plan was to understand what plant communities existed on the site. To accomplish this, a detailed vegetation inventory of the site was conducted as the first step in the process. This was conducted in both of the precedent case studies. At the Trout Creek site technicians identified individual plant species, their location, and relationships to other plants and the landscape as well as their proximity to the stream and distance from the water table. This vegetation survey established a relationship between growing conditions and plant species presence. Plant species were identified using plant identification keys, with assistance from Eve Davies, a PacifiCorp biologist. Plants that were unable to be identified were taken to the Intermountain Herbarium at Utah State University for proper identification.

Once all dominant species were identified, three distinct vegetation communities were classified on the site: 1) a mesic meadow community 2) a sedge/rush community, and 3) an emergent wetland/marsh community. Mesic meadow vegetation occupied sites that were dryer and generally at higher elevation than adjacent sedge/rush or emergent wetland communities. Sedge/rush vegetation occupied wetter sites than the Mesic Meadow community and was often found in depressions closer to the water table. Any area with at least fifty percent sedge/rush cover was considered to have a sedge/rush community type. Emergent wetland vegetation occupied the wettest sites, usually directly adjacent to the original stream channel. Positional data of the boundaries of each vegetation community was collected using handheld GPS units. This data was then uploaded into ArcMap GIS to create a map of the existing vegetation communities (see Existing Vegetation Communities Map, pp. 48).

Step 2: The second step in the process was to identify native plant communities which existed on the site prior to human disturbance and to identify the extent of the disturbance's ecological impact. Ideally this step is accomplished by analyzing and comparing a nearby, undisturbed reference site of the same stream or a nearby stream. High-quality reference sites serve two main functions in restoration efforts: they provide a comparison of sites that allows an assessment of the extent of ecological impacts and also serve as a template for describing desired future conditions (Brinson and Rheinhardt, 1996). Unfortunately no undisturbed or nearly undisturbed reference sites exist anywhere in the surrounding area. The LRR and PRRP case studies experienced similar problems in identifying ideal reference sites. In both cases, literature analysis and historical accounts of the area provided useful information to identify historic vegetation (see Table 1 and Appendix Items 1 & 2). For Trout Creek this information was obtained conversations with Chris Hoag of the NRCS and Eve Davies of PacifiCorp. Their expert knowledge of the historic conditions of the area, as well as a review of the NRCS'

Ecological Site Description of the area, determined that the streamside woody vegetation within the *mesic meadow community* was historically dominated by Coyote willow (*Salix exigua*) and Yellow willow (*Salix lutea*) (Hoag 2008, Davies 2008, and NRCS Ecological Site Description, 2007).

Impacted wetlands on the Trout Creek site, although dominated by Common cattail (*Typha latifolia*), contain Hardstem bulrush (*Scirpus acutus*) and a variety of sedges (*Carex sp.*) (See Figure 1). The PRRP and LRR case studies used surveys of nearby areas to help determine historic vegetation composition (see Table 1 and Appendix Items 1 & 2). Healthier wetlands on the adjacent Whiskey Creek to the northwest contained a more balanced ratio of cattail, bulrush, and sedges (Figure 2). Although Whiskey Creek is not a pristine reference site, it is an adjacent site with a healthier composition of vegetation than Trout Creek and gives hints as to what historic vegetation may have existed. Conversations with experts, Chris Hoag and Eve Davies, confirmed these species were the historic dominant *emergent wetland community* species.

Figure 1- Emergent wetland community dominated by a monoculture of Common cattail on Trout Creek

Figure 2- Mixture of Common cattail and Hardstem bulrush found in an emergent wetland community on Whiskey Creek.

The Whiskey Creek site also provided indications of the types of historic woody upland vegetation existed in the *mesic meadow community*. On Whiskey Creek, Wood's wild rose (*Rosa woodsii*), Western black hawthorne (*Crataegus rivularis*) (Figure 3), and Golden currant (*Ribes aureum*) were found in small amounts. All three of these species are native to the region. Chris Hoag and Eve Davies confirmed that it is probable these species also occurred on the Trout Creek restoration site.

Figure 3- Western black hawthorn found on Whiskey Creek

Historic information on grass and sedge species within the *mesic meadow community* was obtained through literature review. The NRCS Ecological Site Description of the area states that the historic climax plant community in this area would typically consist of tufted hairgrass (*Deschampsia caespitosa*) and Nebraska sedge (*Carex* nebraskensis) as dominant species and a variety of other grass species would exist in smaller amounts. The Trout Creek vegetation survey information indicated that Kentucky bluegrass (*Poa pratensis)*, Intermediate wheatgrass (*Thinopyrum intermedium*), and Redtop bentgrass (*Agrostis capillaries*) invaded the site and have become the dominant species.

Step 3: The next step was to determine which species would be the most appropriate for revegetating the site in accordance with the management goals and site conditions. For streamside vegetation in the *mesic meadow community*, Coyote willow (*Salix exigua*) and Yellow willow (*Salix lutea*) were the obvious choices of willow species for several reasons (Figure 4). First, they are the historic willow community that existed on-site. Secondly, they are extremely successful species for streambank stabilization. Thirdly, these species are readily available to harvest from several local PacifiCorp owned sites near Soda Springs, ID.

Figure 4- Example of Coyote willow (*Salix exigua*) on a streambank of the Owyhee River.

The *sedge/rush community* contained a mixture of plants that closely resembles the historic plant community composition. Introducing additional sedge/rush species is therefore, not necessary. This is also the case for the emergent wetland community which contains a mixture of Nebraska sedge (*Carex nebraskensis*), Hardstem bulrush (*Scirpus acutus*), and Common cattail (*Typha latifolia*).

Currently, no significant amount of woody upland vegetation exists on the Trout Creek site. Restoring diverse woody upland vegetation to the *mesic meadow vegetation communities* is critical to provide forage, nesting, and wintering habitat for upland bird, waterfowl and other game species. The primary upland revegetation species will consist of Wood's wild rose (*Rosa woodsii*) and Golden currant (*Ribes aureum*). These native species will provide an excellent food source for wildlife. Additionally these species reproduce not only by seed, but also rhyzomatically, resulting in rapid colonization.

Wood's wild rose and Golden currant are also available from local nurseries. Due to the management goal of maximizing wildlife habitat, two species not native to the site, but non-invasive were considered. The LRR case study used several species that were historically absent from the LRR, but did occur in limited numbers on nearby sites (see Appendix Item 2). Using this successful precedent, Common chokecherry (*Prunus virginiana*) and Western mockorange (*Philadelphus occidentalis*) are optional species specified to provide additional forage for wildlife. Although Chokecherry is native to the region, it is unlikely to have occurred naturally on the site. Additionally, Western mockorange, a native to the western United States is also specified for introduction to Trout Creek at the land manager's discretion if adequate supplies of Wood's wild rose or Golden currant are unavailable. Western mockorange will survive well under the site's soil and moisture conditions and provides a valuable food source for wildlife. If Chokecherry is used, it is specified to be planted on the driest areas of the site.

Step 4: A consultation with Tyler Allred of Allred Restoration, the professional hydrologist contracted by the landowner, was conducted at the Trout Creek restoration site to discuss the design and reconstruction of the historic channel and construction of a new section of stream channel. At this meeting, Tyler Allred physically laid out the alignment of the new channel. The new channel will follow the historic Trout Creek channel for about ¼ of the distance of the channel at which point a new channel will be dug to the east of the historic one (see Reconstructed Channel map pp. 49). This new channel layout will provide additional length of flowing stream for fish habitat and also keep the existing wetlands in an inundated condition. As the hydrologist, Tyler Allred was responsible for the design of the stream meanders, location, and bank angles (steepness). Streambanks will be at least forty five degrees, resulting in a bank slope of 1:1 or greater. This will provide opportunities for the hydraulic forces of the stream to create undercut banks, a critical habitat component for BCT.

Step 5: Construction of the new stream channel was completed soon after the channel design was finalized. The new channel was mapped using a handheld GPS unit. Next the data was inputted into ArcMap GIS to produce a visual map of the new channel (see Reconstructed Channel map pp. 49). By overlaying the new channel data over the data for the existing vegetation communities it was possible to determine which vegetation communities existed at specific points along the new channel. Existing vegetation communities indicate a site's soil moisture conditions and its ability to support specific types of plant species. In combination with the topographic survey map of the area (see Appendix Item 4), the existing vegetation map was valuable in determining which re-introduced vegetation types would be likely to survive at any given point on the new channel.

Figure 5- Section of newly constructed channel within a *mesic meadow vegetation community* at the Trout Creek site.

Figure 6- Inside bend of newly constructed channel within a *sedge/rush community* at the Trout Creek site.

Step 6: Three distinct types of revegetation needs existed on the site: 1) streambank treatments, 2) wetland treatments, and 3) upland vegetation treatments. Streambank treatments were divided into two categories 1a) mesic meadow treatments and 1b) sedge/rush treatments, based on the dominant vegetation community that existed at the location of treatment.

1a) Mesic meadow streambank treatments will re-vegetate the streambanks with Yellow willow (*Salix lutea*) and Coyote willow (*Salix exigua*). It is the nature of streambank erosion that outside bends receive more erosive forces from stream flow than inside bends and runs. Taking this into consideration, willow planting treatments are further separated into two types: outside bend treatments and inside bend/run treatments.

The relatively constant flow, low erosion potential, and steep bank angle of Trout Creek, and the desire to use Coyote and Yellow willows made horizontal willow fascines a particularly good bioengineering choice for this revegetation project. Other bioengineering techniques considered included brush mattresses, vertical willow bundles, post, and pole plantings. The PRRP and LRR case studies used a variety of techniques for willow revegetation depending largely on their specific site characteristics. The conditions on Trout Creek vary greatly from those in the PRRP and LRR restorations, thus horizontal willow fascines are prescribed for the specific site conditions on Trout Creek.

Horizontal fascines are sausage-shaped bundles of live willow cuttings fastened together and inserted into a trench dug into the streambank. The willow fascines sprout and take root, stabilizing the streambank with a dense matrix of roots. Coyote and

Yellow willows are particularly good species for this method because of their dense root systems (Bentrup and Hoag, 1998).

Instructions for building and installing horizontal willow fascines were taken from The Practical Streambank Bioengineering Guide written by Gary Bentrup and Chris Hoag of the Interagency Riparian/Wetland Plant Development Project. Some modifications to the installation instructions contained in that publication were suggested by Chris Hoag during personal telephone conversations.

On inside bends and runs, one horizontal fascine, eight inches in diameter will be installed at the low water line with one half of the fascine submerged and the other half out of the water. To provide additional erosion protection, on outside bends, two fascines will be installed. The first is to be completely submerged and the second stacked directly on top of the first, will remain above the low water line. Detailed instructions and diagrams for this treatment can be found in the Trout Creek Revegetation Plan section of this report.

1b) The second set of streambank treatments focus on the areas of the stream that are dominated by a sedge/rush community. Any area with at least fifty percent sedge/rush cover was considered to have a sedge/rush community type. Sedge/rush species have extremely fibrous root systems and are excellent species for stabilizing streambanks. Several methods of vegetating streambanks with sedge/rush vegetation were considered including sod mattresses and plug plantings. However, due to the cost and labor associated with these methods, an alternative was formulated utilizing the existing vegetation on top of the streambanks. By excavating soil horizontally on the streambank underneath sedge/rush vegetation, an undercut will be created. The layer of soil and vegetation above the undercut will be laid down to the streambank, leaving a mat of sedges and rushes that will armor the streambank and provide significant erosion protection. This treatment is prescribed for all streambanks where sedge/rush vegetation comprises at least fifty percent of the vegetative cover adjacent to the stream. More detailed information and diagrams about this treatment can be found in the Trout Creek Revegetation Plan section of this report.

2) Wetland treatments are necessary on Trout Creek due to the monocultures of cattail that dominate the wetlands on the site. A goal of reestablishing Hardstem bulrush (*Scirpus acutus*) and Common cattail (*Typha latifolia*) at a 9:1 ratio and creating 50% open water was established. Through conversations with Chris Hoag and Eve Davies, a mechanical removal of cattails with an excavator and subsequent planting of bulrush was determined to be the easiest way to achieve this goal. Several methods of planting bulrush were investigated including transplanting, planting by seed, and planting young bulrush plugs. Due to the inability to control water depth fluctuations on the site, it is doubtful that planting by seed and young plugs would be successful. Transplanting mature bulrush from another site offers the best chance for success. Not enough bulrush is locally available to replace all cattails. Therefore, an increase in the amount of open-water areas must be achieved by controlling the depth of the ponds. Open water areas are to be dug at least 3 feet deep to keep cattails from reestablishing as quickly. This maintenance operation will need to be performed every 2-3 years to maintain the open-water habitat. Detailed information about these treatments can be found in the Trout Creek Revegetation Plan section of this report.

3) Upland vegetation treatments are designed to maximize wildlife food and cover. The habitat needs to support a high number of diverse upland game birds. Flowering plants that produce edible fruits are therefore of high importance. Of the plants that are native to the site, Golden currant (*Ribes aureum*) and Wood's wild rose (*Rosa woodsii*) were selected as the primary upland vegetation for reestablishment. Western black hawthorne (*Crataegus rivularis*) although native to the site, was not chosen due to its slow growth and difficulty of establishment. As an alternative, Common chokecherry (*Prunus virginiana*) was prescribed for the dryer areas of the site. Western mockorange, although not native to the area was selected as an optional plant to be used at the land manager's discretion (depending on the availability of other prescribed species) to provide additional forage due to its non-invasive nature and ability to grow in the mesic meadow upland areas. Grasses serve as important protective cover for pheasants and ducks. The Trout Creek site contains an abundant and diverse collection of tall grasses suitable for pheasant and waterfowl nesting and protective cover, thus no new grass seeding was prescribed.

Plant spacing was an important part of the planting design. Wood's wild rose is to be planted at 3 feet on-center while Golden currant, Chokecherry, and Mockorange are to be planted at 5 feet on-center. According to Chris Hoag, these are the most favorable spacing intervals to provide dense vegetation masses for optimal wildlife cover.

Proper site preparation is critical to the success of young woody plantings to provide proper establishment conditions and to reduce competition from adjacent herbaceous vegetation cover. Herbicide application and subsequent tillage, is to be conducted to provide a weed-free and uncompacted soil environment for healthy root establishment. Installation of landscape fabric around new plantings to inhibit competition from new weed growth is also prescribed. Detailed instructions for these treatments can be found in the upland vegetation section of the Trout Creek Revegetation Plan included in this report.

Young woody vegetation is very sensitive to drought, and thus needs to be irrigated during the year's hottest months. Through conversations with Tony Selley of Tony's Grove Nursery in Logan, Utah, it was determined that sprinkler irrigation of ¾ inch of water, once per week from mid June through late July will be necessary for the first two growing seasons (Selley, 2008). This is similar to the LRR case study (see Appendix Item 2).

Step 7: Developing an herbivory monitoring plan and implementing prevention measures are essential to protecting young riparian, wetland, and upland vegetation from predation by beaver, mule deer and other herbivores. Several methods of reducing herbivory exist including trapping, fencing, repellants and tree shelters. Tree shelters provide an effective physical barrier around the stems of young plantings. Constructed from plastic, cloth or wire mesh, tree shelters are a cost effective method of reducing predation on young plants and seedlings. The LRR case study prescribed using large wildlife exclosures. Due to the cost and labor associated with wildlife exclosures, they are prescribed only if wildlife damage is found to be occurring on the Trout Creek site after other methods (tree shelters, trapping, etc) are implemented. Monitoring the health of young woody plants is also vital for the first three years. If significant predation is observed, protective exclosures must be constructed to keep deer and beaver away from young plants.

Step 8: Establishing a designated riparian buffer is critical to protecting the integrity of riparian plantings and wetlands. Ideally, three riparian buffer zones allowing increased activity as distance from the stream increases would be established (see riparian buffer zone guidelines pp. 9). Land adjacent to the Trout Creek restoration site is already heavily impacted and owned by various individuals, effectively negating the possibility of controlling land uses along the entire corridor. Therefore only land within the project boundaries will be considered for management guidelines. However, to create long term stability in the watershed, it will be essential to implement buffers upstream and downstream of the project site. Perhaps this project will illustrate the benefits of riparian buffers and entice other landowners to implement the same best management practices. The characteristics of the restoration site dictate a zone 1, "no disturbance zone" will be the only designated riparian buffer. These restricting site characteristics include close proximity to roads and exurban development, agricultural production, and uncontrolled adjacent land uses such as cattle grazing. The riparian buffer will be established from the high water mark of the stream, landward to the outer edge of the active floodplain plus a minimum of 35 feet. Additionally, this no disturbance zone will extend a minimum of 50 feet from any wetland or spring.

Formulating the Trout Creek Revegetation Plan was a comprehensive effort requiring on-site surveys, a literature review and coordination with many professionals. The following section of this report is the completed revegetation plan developed for PacifiCorp, the USDA Natural Resource Conservation Service, and the land manager of the property, Kent Klegg. A revegetation plan is a comprehensive set of planting prescriptions designed to re-establish vegetation on a restoration project for the purpose of: 1) preventing erosion 2) creating and enhancing fish and wildlife habitat, and 3) improving water quality. This revegetation plan was a required part of the process for obtaining a stream alteration permit from the Idaho Department of Water Resources and is a suitable format to be integrated into future riparian revegetation plans.

Trout Creek Revegetation Plan

Prepared by: Dan Bolin – LAEP Department, Utah State University

1.1 Introduction

This plan provides specific planting guidelines for the revegetation of Trout Creek. The objectives of this plan are to provide optimal habitat for upland game birds such as pheasant, as well as waterfowl and Bonneville Cutthroat Trout, and to improve the overall water quality of Trout Creek. In addition to habitat and water quality objectives, this plan takes into consideration the aesthetic qualities of the site. Many of the species recommended by this plan are native to the local area.

Several decades ago Trout Creek was diverted out of its original channel and placed into a canal that flows around the eastern and southern borders of the project area. As part of a comprehensive restoration of this site, the creek will be rerouted back into its original channel and into a newly constructed section of channel. Trout Creek has been farmed and grazed for several decades and currently no woody riparian or upland vegetation exists on the site. Fish and wildlife habitat on the site is currently marginal at best. This plan will focus on the revegetation of a significant portion of Trout Creek. Revegetation treatments will drastically improve habitat for fish and wildlife species on the site.

Revegetation treatments for Trout Creek fall into 3 categories: 1) streambank treatments, 2) emergent wetland treatments, and 3) upland vegetation treatments. Revegetation treatments for streambanks on the site occur on both the existing mesic meadow and sedge/rush community types. Emergent wetland treatments occur only where existing emergent wetland vegetation communities are located. Upland vegetation treatments (plantings) occur in the existing mesic meadow vegetation community.

1.2 Existing Vegetation Communities

All existing vegetation on the site was mapped using a portable, handheld GPS unit. Three dominant vegetation communities were found on the site: a mesic meadow community, a wetter sedge/rush community, and an emergent wetland community. These vegetation communities are shown on the *Existing Vegetation Map*.

The dominant species for each vegetation community are as follows:

Mesic Meadow Community

Dominant Species:
Phleum pratense – Timothy
Thinopyrum intermedium – Intermediate wheatgrass
Poa pratensis – Kentucky bluegrass
Agrostis capillaris – Redtop bentgrass
Bromus inermis – Smooth brome
Rosa woodsii – Wood's wild rose
Dipsacus fullonum – Teasel

Other Species:
Dactylis glomerata – Orchard grass
Equisetum sp. – Horsetail
Carduus nutans – Musk thistle
Mentha sp. – Mint
Medicago Sativa – Alfalfa

Sedge/Rush Community

Dominant Species:
Carex spp. – Sedge
Carex nebraskensis – Nebraska sedge
Juncus balticus – Baltic rush (wire grass)
Hordeum jubatum. – Foxtail barley
Epilobium spp. – Willow herb (forb)

Other Species:
Rumex sp. – Dock

Emergent Wetland Community

Dominant Species:
Typha latifolia – Common cattail
Scirpus acutus – Hardstem bulrush
Carex nebrascensis – Nebraska sedge

1.3

Mesic Meadow
Streambank Treatments

The majority of the Trout Creek site is dominated by a mesic meadow vegetation community. Vegetation in this community consists primarily of pasture grasses. This vegetation community is indicative of soil moisture conditions that are appropriate for willow growth along streambanks.

Mesic meadow streambank treatments will occur on streambanks within the existing mesic meadow vegetation community (see proposed master plan map). The treatments for outside bends differ from inside bends and runs.

Horizontal Willow Fascines

Live willow fascines are linear bundles of live willow cuttings fastened together and inserted and secured into a shallow, horizontal trench excavated into the streambank. The fascines will sprout and take root along the length of the bundle, forming a dense root system for revegetating and stabilizing the streambanks.

Coyote willow (*Salix exigua*) and Yellow willow (*Salix lutea*), species especially appropriate for bank stabilization and revegetation are available locally and are particularly appropriate to the conditions on Trout Creek. PacifiCorp has indicated they have a few nearby sites (e.g., Soda Reservoir) where both of these species can be harvested from.

Preparation Instructions

» Harvest willow cuttings from a local (ideally) stand of similar elevation that is in a healthy condition. Ideally up to 1/4 of each stand will be harvested, taking no more than 2/3 of any given stand.

» Harvest cuttings that are at least a ½ inch in diameter. Take care to harvest a mixture of sizes and species (if possible). Cuttings should be harvested when the willows are dormant in the fall to ensure the greatest success.

» Tie cuttings into bundles for transportation to the site. Remove terminal buds to send energy to lateral buds.

» Soak the bundles for 5 to 7 days. Remove bundles before new roots emerge.

» The cuttings should be constructed into one linear compressed fascine with the cut ends placed in alternating directions.

» The fascines should be approximately 8 inches in diameter. The bundles should be tied every 18 inches with wire or heavy-duty twine.

Figure 1- An example of a typical willow fascine - (illustration taken from The Practical Streambank Bioengineering Guide, USDA NRCS Plant Materials Center, Aberdeen, ID.)

TREATMENT FOR INSIDE BENDS AND RUNS (RIFFLES)

see Proposed Master Plan Map:

» Excavate a trench roughly ½ the diameter of the fascine (4-5 inches) along the streambank just above the low flow line. The lower 1/3 of the fascine should be in the water and the upper 2/3 should be outside of the water.

» Place the willow fascine into the trench and stake every 3 feet. The stakes should ideally be wooden, wedge shaped stakes approximately 3 feet in length (or live willow stakes). Pound the stakes through the center of the fascine into the bank until the fascine is held tightly in place with no movement.

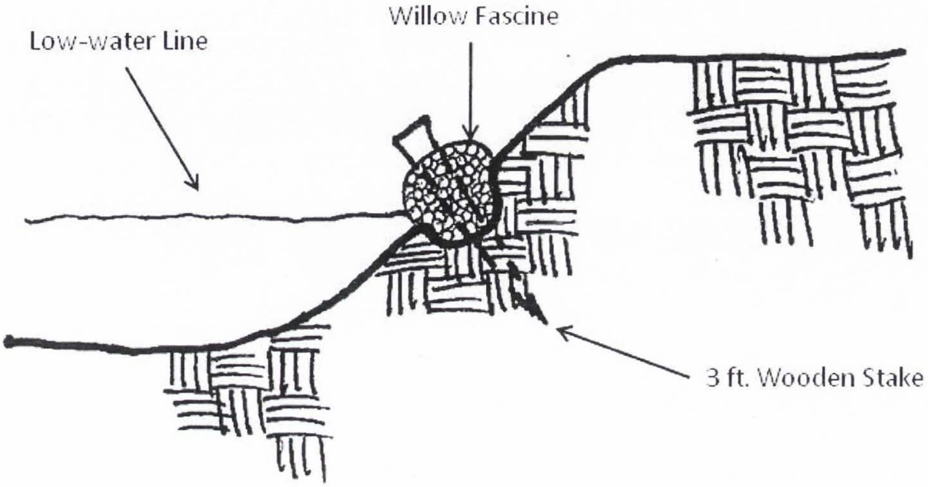

Figure 2 - Inside Bend and Run (riffle) Treatment

» To construct the wooden stakes: Cut 10 foot sections of 2x4 into 3 pieces and then cut diagonally to make 6 wedge shaped stakes.

» Backfill around the fascine by placing soil from the top of the bank onto the fascine, taking care to ensure that the soil fills the gaps in the cuttings. The soil should not completely cover the fascine, but some soil should fill into the gaps in the branches.

TREATMENT FOR OUTSIDE BENDS
see Proposed Master Plan Map:

» Stack two 8-inch fascines on top of one another to provide increased erosion protection.

» Excavate a trench along the streambank that is roughly 4 inches deep and tall enough to fit 2 fascines stacked on top of one another (approximately 12-14 inches). About 1/3 of the fascines should fit into the trench while 2/3 remain exposed. The trench should be excavated at the low flow line. When installed, the lower fascine should be submerged in the water, and the upper fascine should be out of the water.

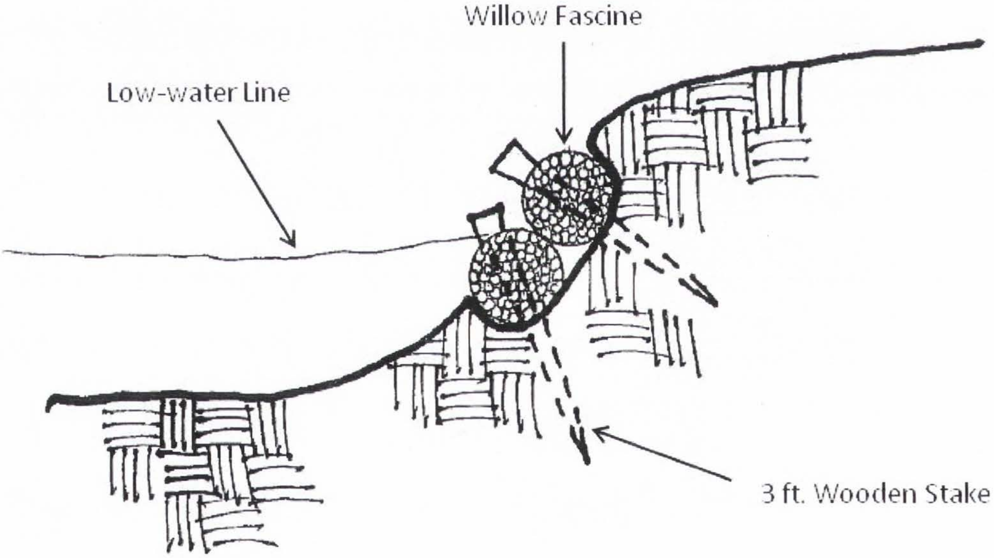

Figure 3 - Outside Bend Treatment

» Place the willow fascine into the trench and stake every 3 feet. The stakes should ideally be wooden, wedge shaped stakes approximately 3 feet in length. Alternatively, a live willow stake may be used in place of a wooden stake as a pole planting that may establish itself as a willow bush on its own. The stakes should be pounded through the center of the fascine into the bank until the fascine is held tightly in place with no movement.

» Backfill around the fascines by placing soil from the top of the bank onto the fascines, taking care to ensure that the soil fills the gaps in the cuttings. The soil should not completely cover the fascine, but some soil should fill into the gaps in the branches.

Recreational Considerations for Mesic Meadow Streambank Treatments

Generally willow fascines will fill in most available streambank habitat where growing conditions are favorable. Considering that fishing will be a desired activity on Trout Creek after the restoration, some areas may be more desirable left unvegetated for access to the creek and to allow casting without the impedance of vegetation. **These areas do not need to be extensive for adequate access.** Casting lanes and an area to stand on the streambank should be sufficient.

» Adding riprap or boulders (in place of willow fascines) to the streambank in areas where vegetation is not desirable will be adequate to keep willows from establishing.

» This treatment is the most appropriate where rock has already been introduced in the riffle areas, and on inside bends where pools with good fish habitat exist.

»It is possible that willows may not actually fill in all areas where fishing access is desired. Alternatively, cutting willows that have established may be a less expensive and labor intensive effort than riprap installation.

Maintenance Considerations

» Periodically (once every two weeks) for the first year, all fascines should be inspected to ensure that they remain secured to the streambank and that some soil cover remains on the bundles.

» Any weed control is to be accomplished by mechanical and not chemical treatments. Newly sprouted willows are very sensitive to chemical weed control treatments.

1.4

Emergent Wetland Vegetation Treatments

(see Proposed Master Plan Map)

Areas classified as having emergent wetland vegetation are currently dominated by cattails (*Typha latifolia*). Typically cattail monocultures do not allow for the highest level of species diversity. A more diverse wetland with emergent vegetation, shrubs and open water will accommodate the largest number of plant and animal species.

The native species composition on Trout Creek would likely be a mixture of hardstem bulrush (*Scirpus acutus*) and common cattail (*Typha latifolia*) for the deep-water emergent vegetation areas. The most optimal ratio of these vegetation types is a 9:1 bulrush to cattail ratio along with 50% open water (as per phone conversation with Chris Hoag). Due to the current monoculture of cattails, a mechanical treatment removing cattails from the wetlands and hauling them off-site will be necessary to successfully reach this ratio.

Figure 4 – An example of mechanical cattail removal

ESTABLISHING HARDSTEM BULRUSH AND OPEN WATER IN PLACE OF CATTAILS

» Using a backhoe with an 18-24 inch bucket, excavate a plug of cattails to be removed. When removing cattails, be sure to dig at least 6-8 inches deep to ensure collection of cattail root system.

» Replace cattails with the same sized plug of hardstem bulrush harvested from a nearby source of bulrush. The wetlands on Whiskey Creek may be a good source.

» Alternatively, hardstem bulrush can be acquired commercially in 10 inch plugs for planting, however this is an expensive and labor intensive option.

» A sufficient source of bulrush may not be available to replace all cattails. Considering the goal of 50% open water, areas where cattails currently exist and not enough bulrush is available to replace them, can serve as open water habitat. Dig these areas out at least 3 feet deep to prevent cattails from reestablishing quickly.

» A "no disturbance zone" will be established, extending 50' from all wetlands and springs.

Maintenance Considerations

» Every few years it will be necessary to dig out cattails to maintain open water habitat. .

1.5

Sedge/Rush Community Streambank Treatment

The Trout Creek site has an abundant Nebraska sedge/Baltic rush community on the site. Sedges provide significant protection to streambanks from erosion. Areas that support healthy sedge/rush communities are generally too saturated to support woody vegetation such as willows (as opposed to dryer zones with flowing water). Several areas on the newly constructed channel on Trout Creek have sedge/rush communities extending to the edges of the channel.

Figure 5 - Inside bend with sedge/rush community type.

Instructions for Runs and Inside and Outside Bends in Sedge/Rush Communities

» All streambanks that consist of 50% or greater sedge/rush cover are to be considered sedge/rush community types.

» Bank stabilization is to be accomplished by removing soil under vegetation to create an "undercut" that lays the mat of sedge/rush vegetation down to the low water line for bank protection (see figure 6). The amount of soil removed will vary depending on the condition of the vegetation and the bank. This should be done on all streambanks with at least 50% sedge/rush cover.

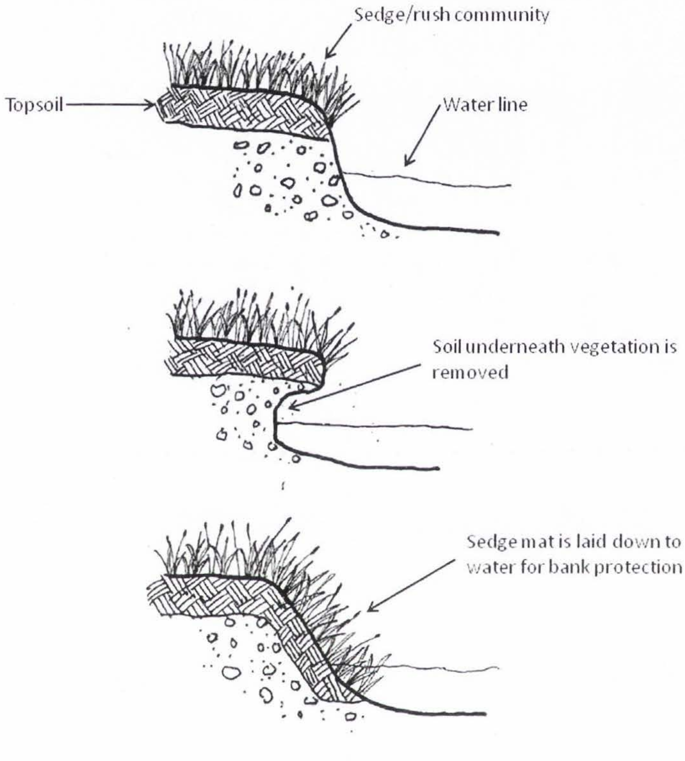

Figure 6 - Sedge/Rush Community Treatment

1.6

Woody (Upland) Vegetation Treatments

Upland vegetation is an important component to the Trout Creek revegetation plan. Woody upland vegetation provides habitat cover and forage for a variety of bird and game species. The species that are proposed to be planted are Golden currant (*Ribes aureum*), Wood's wild rose (*Rosa woodsii*), and (optionally) Common chokecherry (*Prunus virginiana),* and Lewis mockorange (*Philadelphus lewisii*). Each of these species provide forage and cover for wildlife and flower at various times, maximizing available forage time.

Instructions for Planting and Maintaining Upland Vegetation (see Proposed Master Plan Map)

» Upland vegetation is to be planted in the areas identified by the shaded red areas on the Trout Creek Revegetation Master Plan.

» All upland vegetation is to be planted once the vegetation goes dormant in late October through early November.

» Site preparation is critical for the success of new plantings. The planting area must be free of living sod and perennial weeds before planting. This may be accomplished through a combination of chemical and mechanical treatments; however herbicides should not be used within one year of planting.

» Sufficient tillage of upland planting sites is to be conducted to kill the sod and maintain the entire site in a weed free condition prior to shrub planting.

» Weed control fabric is to be installed on planting sites to reduce competition between herbaceous vegetation and new upland plantings.

» Weed control fabric should be woven material treated with carbon black, guaranteed to last at least 5 years.

» Soil, rocks, or staples are to be installed to hold down fabric edges to protect the fabric from wind forces. Staples or rocks can be spaced in the center of the fabric close to where the shrubs will be planted. If soil is not used to anchor the fabric edges, staples, pins, or rocks must be placed every 3- 5 feet along the edge.

» Do not use soil to hold down the fabric centers, as weeds will quickly establish on the soil spots, reducing the effectiveness of the fabric. Weed control fabric should be reasonably level, well anchored and taut.

» Upland vegetation is to be irrigated with approximately ¾ of an inch of water, once a week during the hottest month of the year (mid-June through mid-July or early August).

» Vegetation is to be planted in clumps of the same species. More than one species can be used in each shaded area on the Master Plan, however they need to be grouped separately to provide masses of a single species.

» To achieve a more aesthetically appealing landscape quickly; for each 5 or 6 plants, consider planting a "specimen" shrub in the center (see Figure 7). A specimen shrub is a larger, more mature individual. For example, if the bulk of the plants are 8-12 inch bare-root stock, a specimen may be a 24-36' shrub. If 1-gallon containerized plants are being used, a specimen would be a 2-gallon containerized shrub. However, this is a more expensive option and the distinction will disappear within 1-2 years.

» Nursery stock grown from local seed is the most desirable because it is adapted to the local climate regime.

» Plant Golden currant at 5 feet on-center (o.c) intervals.

» Plant Wood's wild rose at 3 feet o.c..

» Plant Mockorange and Chokecherry (if used) at 5 feet o.c..

» Take care to plant Chokecherry only on the driest areas of the site.

» As a general rule, plant Wood's wild rose and golden currant in approximately equal numbers.

Maintenance Considerations

» The condition of the newly planted shrubs is to be monitored regularly throughout the first 3 years.

» If significant predation by deer is observed, a protective enclosure will be constructed to keep deer away from the young shrubs. Fencing may be constructed from a variety of materials, however a temporary electric wire fence may be the most cost effective.

» Weed control is to be conducted carefully around young plants. Young shrubs are very susceptible to herbicide. Mechanical weed removal is to be used.

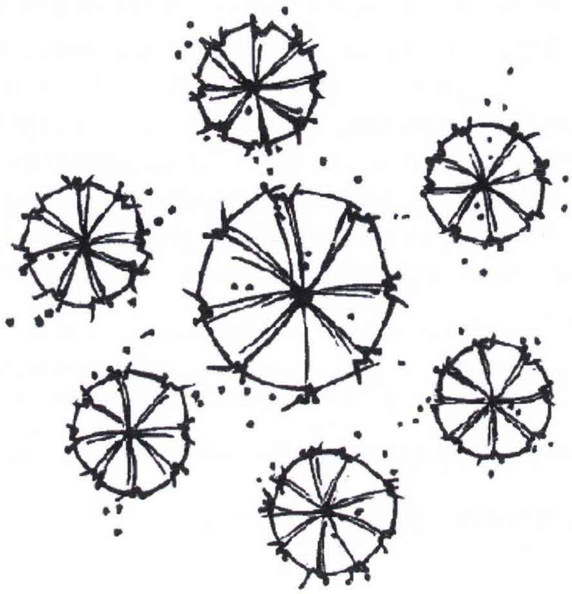

Figure 7 - Shrub massing with "specimen" shrub in the center.

1.7
Buffer Width Guidelines

» No farming or other land disturbing activities are to occur within 35 feet landward of the active floodplain on the site.

» Additionally, no land disturbing activities are to occur within 50 feet of any wetland or spring on the site.

1.8
Conclusion

The instructions contained in this plan provide guidelines for the successful revegetation of the historic and newly constructed Trout Creek channel, associated wetlands, and upland vegetation. The plant species recommended in this plan are primarily native to the area and provide excellent cover, forage, and wintering habitat for desired upland bird and waterfowl species. After the installation of new vegetation, careful monitoring of the site will be necessary to ensure the success of the new plantings. Along with regular monitoring of the site, irrigation, predation control, and invasive weed control will also be necessary depending on the future condition of the site. Refer to the existing Trout Creek Monitoring Plan for this information.

1.9
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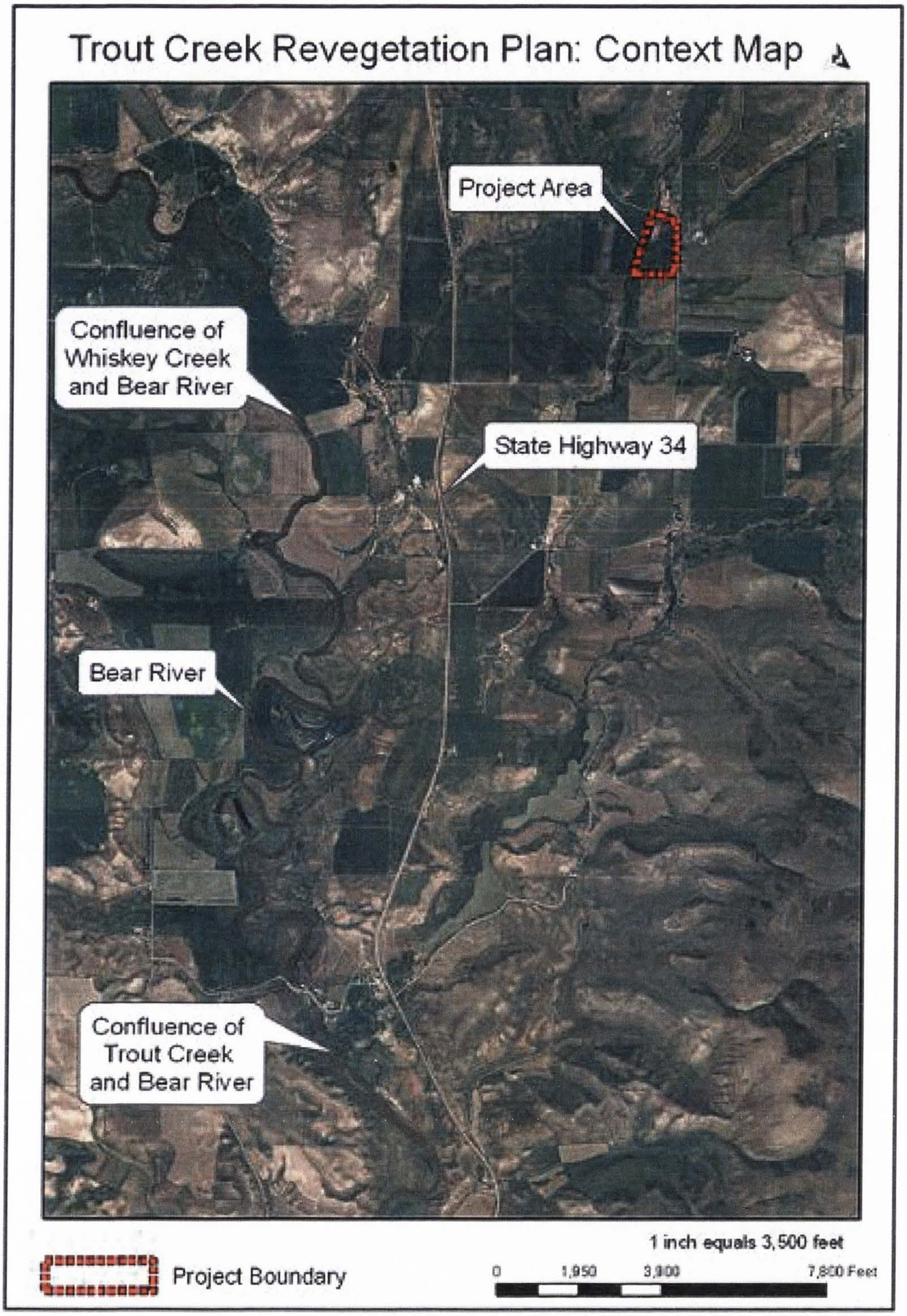
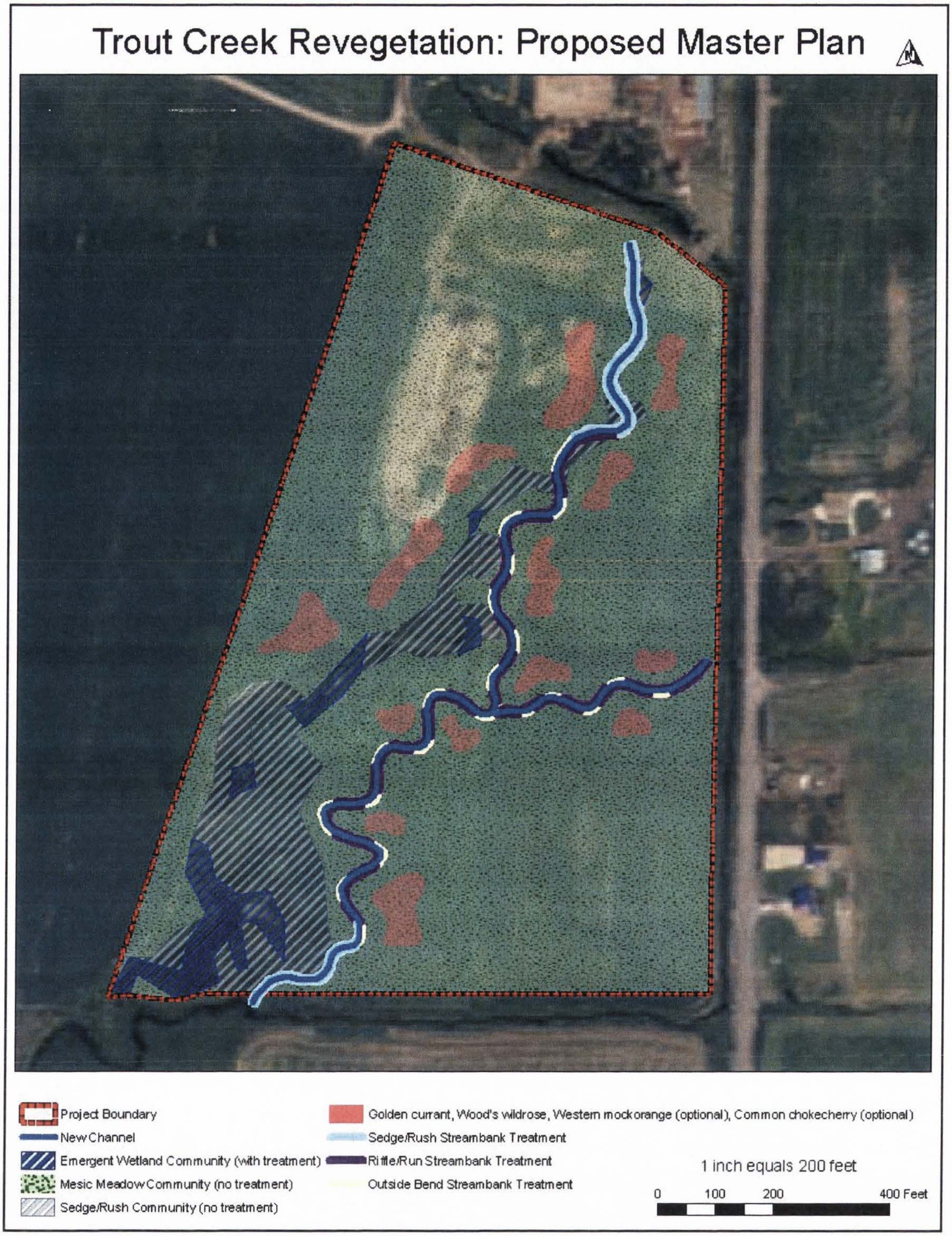
Site Maps


Trout Creek Revegetation Plan: Context Map
Project Area
Confluence of Whiskey Creek and Bear River
State Highway 34
Bear River
Confluence of Trout Creek and Bear River
Project Boundary
1 inch equals 3,500 feet
0
1,950
3,900
7,800 Feet

Trout Creek Revegetation Plan: Existing Drainage


Trout Creek Revegetation Plan: Existing Vegetation
Project Boundary
Emergent Wetland Community
Sedge/Rush Community
Mesic Meadow Community
1 inch equals 200 feet
0
100
200
400 Feet


Trout Creek Revegetation Plan:
Reclaimed/Reconstructed Trout Creek Channel
Project Boundary
New Channel
Emergent Wetland Community
Sedge/Rush Community
Mesic Meadow Community
1 inch equals 200 feet
0
100
200
400 Feet


Trout Creek Revegetation: Proposed Master Plan
Project Boundary
New Channel
Emergent Wetland Community (with treatment)
Mesic Meadow Community (no treatment)
Sedge/Rush Community (no treatment)
Golden currant, Wood's wildrose, Western mockorange (optional), Common chokecherry (optional)
Sedge/Rush Streambank Treatment
Riffle/Run Streambank Treatment
Outside Bend Streambank Treatment
1 inch equals 200 feet
0 100 200 400 Feet

Conclusion

Functioning ecosystems are the foundation for conserving biodiversity. The goal of restoration is to reestablish the structure, species composition, and natural processes of the ecosystem's biological and physical components. Properly conducted restoration projects return a system to a resilient and self sustaining condition that is able to accommodate stress and change. The Trout Creek Restoration was designed to return the stream and surrounding vegetation to a more natural structure and function within the current context and limitations of its watershed.

Ideally an aquatic restoration project takes a watershed approach to solving the problem. A watershed approach addresses the root causes for degradation, both on site and throughout the watershed. In the case of Trout Creek, a true watershed approach was not possible due to the inability to control upstream land use practices. However some adjacent and on-site land use practices such as excluding cattle and limiting farming disturbance were addressed. Additionally, the majority of Trout Creek's degradation originated within the limits of the restoration site. Channelization of the stream, improper grazing management, and agricultural practices were the primary causes of degradation. This restoration addresses these problems by eliminating active farming within the riparian buffer area and restores a more natural channel type.

Developing the revegetation plan for Trout Creek was an in-depth and comprehensive process based on an extensive literature review, survey of on-site conditions, and an understanding of the existing natural potential of the watershed. The revegetation plan takes into account the costs, labor, and other limitations of implementing the project. Specific goals of maximizing fish and wildlife habitat and improving water quality were in place before the restoration started and the design accomplishes those goals to the degree the climate, geology, hydrology, and biological characteristics of the site will support.

The Trout Creek Revegetation Plan used two similar successful projects as precedents: the Provo River Restoration Project and the Lower Red River Meadow restoration. It was important to use successful revegetation projects as precedents for the Trout Creek revegetation to ensure the appropriate process was taken in developing the plan. Using these precedents helped to avoid mistakes and offered insights into the opportunities and constraints of the Trout Creek revegetation.

Based on the site inventory and analysis conducted at the Trout Creek restoration site, three different habitat areas were identified for revegetation efforts: 1) a mesic meadow vegetation community consisting of both streamside and upland vegetation, 2) a sedge/rush community, and 3) an emergent wetland community. Each of the three vegetation community types provide habitat to fulfill different needs for a variety of species. Bonneville Cutthroat trout, upland game birds (such as pheasants), and waterfowl were the target species for habitat improvements. Each of the prescribed vegetation treatments were designed to maximize habitat for these animals and improve the overall water quality of the stream.

Monitoring the project will be essential to ascertain whether goals are achieved. If they are not, modifications to the project must be considered. Monitoring efforts include the inspection of all streambank, upland, and emergent wetland treatments. Monitoring the presence of invasive weeds is also necessary to determine if weed control measures are necessary. Monitoring will also be helpful for future restoration efforts by identifying the problems or successes that occur from the manner or timing of vegetation installations. If specific techniques prove to be extremely successful, they may be implemented on similar projects in the future. Whiskey Creek to the northwest and adjacent to Trout Creek is scheduled to be restored in 2009 and 2010. Any information about the success or failure of specific Trout Creek treatments must be applied to the revegetation of Whiskey Creek.

This project provides unique opportunities for experimental research. Future projects could experiment with different treatments on Whiskey Creek to compare and contrast data in a paired watershed study with Trout Creek. This type of comparative study would help determine which revegetation or channel design techniques are most effective in restoring native habitat in the tributaries of the Bear River.

As designed, the Trout Creek Revegetation plan takes into account the structure, species composition and natural processes of the ecosystem as well as the opportunities and constraints of the watershed. This project will ultimately return Trout Creek to a self-sustaining system that is resistant to natural disturbances such as flooding and environmental change, accomplishing the goal of maximizing quality Bonneville Cutthroat Trout, pheasant, and waterfowl habitat on the site.

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Provo River Restoration Project: Riparian Vegetation

Final Report Summary

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Report prepared for the
Utah Reclamation Mitigation and Conservation Commission
Salt Lake City, Utah

SUMMARY

Summary of Chapter I - Introduction and Objectives

The riparian vegetation community along the Provo River, Utah between Jordanelle Dam and Deer Creek Reservoir (Fig. S-1) has been severely impacted due to channelization, dewatering and dredging of the channel, and the clearing of flood plain vegetation for agriculture fields. The Provo River Restoration Project aims to modify the geomorphology and hydrology within the project area. Our general objectives were to (1) determine the baseline patterns and composition of the riparian vegetation along the Provo River where the restoration project will occur, and (2) characterize abiotic factors in the flood plain that influence riparian vegetation, as a guide to restoration needs. Thus, our specific objectives for this project were:

1. Contrast the vegetation, soils, and hydrologic conditions in reference and degraded reaches along the Provo River and nearby areas.

2. Determine the physical processes that are maintaining the riparian community in the Provo River reference reaches.

3. Suggest restoration approaches that focus on the establishment and maintenance of desired vegetation communities and physical processes. Restoration recommendations include vegetative, hydrologic, and geomorphic considerations.

4. Develop a monitoring plan to assess short- and long-term restoration success and suggest a set of possible variables that can be used to assess and monitor the biotic integrity of the vegetation communities in the Provo River Restoration project area.

Summary of Chapter II - Study Sites

The Utah Reclamation Mitigation and Conservation Commission arbitrarily divided the segment of the Provo River between Jordanelle Dam and Deer Creek Reservoir into nine reaches for the purposes of organization and evaluation. These reaches differ in extent of river corridor modification and reduction in riparian vegetation. Based on site reconnaissance and aerial photo review, Reaches 4, 6, 7, 8, and 9 of the Provo River project area were selected to be studied in this project (Fig. S-2). These five reaches are representative of the different types of historic river corridor modification, geomorphic surfaces, and different vegetation communities. Reaches 6, 8, and portions of Reach 7 were analyzed as degraded reaches while Reaches 4, 9, and portions of Reach 7 were analyzed as references reaches. We also studied two sites outside of the project area, Little Dell Recreation Area and Rock Cliff State Park, as additional reference sites.

High-quality reference sites serve two main purposes in restoration efforts: they provide a comparison of sites that allow one to assess the extent of ecological impacts and they serve as a template for describing desired conditions (Brinson and Rheinhardt 1996). There is not one single ideal reference site for the Provo River. However, clues from several imperfect reference sites can be compiled, which together provide a starting point for impact assessment and restoration goals. We used 3 sources as partial reference sites: (1) historical photos of the Provo River taken prior to dam construction and river diking; (2) nearby river reaches that have not been diked, dredged, recently grazed, dammed or dewatered including Little Dell and Rock Cliff State Park; and (3) three reaches (4,7, and 9) within the Provo Restoration Area. Analyses of the vegetation and abiotic conditions in the Provo River reference sites are the basis for the restoration plans proposed in this report.

Summary of Chapter III - Methods

This chapter outlines the field data collection and statistical analysis methods. We collected data on vegetation, soil, and hydrologic/geomorphic habitat (Table S-1). The vegetation data consist of the following: woody and herbaceous species composition, woody plant stem density, tree basal area, height of tallest tree per study plot, percent overstory cover, herbaceous plant cover, and population age for dominant woody species. The soil variables are soil texture, soil moisture holding capacity, soil organic matter, soil pH, available soil nitrogen, soil phosphorus, and soil electrical conductivity. The hydrologic/geomorphic habitat variables are plot slope, plot elevation (absolute), plot elevation above base flow and thalweg, distance to closest active channel (primary or secondary), and plot inundation frequency. The statistical analyses for this study focused on determining the vegetation patterns and the gradients influencing these patterns, along the Provo River. The data were analyzed using three types of statistical analyses, an ordination analysis (Detrended Correspondence Analysis, or DCA [Hill 1979]), a classification analysis (Two Way Indicator Species Analysis, or TWINSPAN [Hill 1979a]), and a correlation analysis. The result of these combined analysis was a set of patch types developed for the Provo River reference areas.

Table S-1. List of variables.

Vegetation	*Soil*	*Hydrologic/Geomorphic*
Tree basal diameter (m), by species	Texture (% sand, silt, clay)	Slope (%)
Shrub canopy area (m^2), by species	Moisture holding capacity (%)	Absolute elevation (m)
Height of tallest tree (m)	Organic matter (%)	Elevation above base flow (m)
Canopy cover (%)	pH	Elevation above channel thalweg (m)
Herbaceous plant cover (% total and % by species)	Available nitrogen (%)	Distance to primary channel (m)
Number and species of woody seedlings <1 meter tall	Phosphorus (mg/kg)	Distance to active secondary channel (m)
Tree population age (years)	Electrical conductivity (ds/m)	Inundation frequency (per 100 years)
Weighted average Wetland Indicator Score		

Summary of Chapter IV - Baseline Conditions: Comparisons Between Reference and Degraded Areas

The baseline vegetation and abiotic conditions in the degraded reaches establish a starting point for the restoration project. The conditions in the reference reaches may be considered as ending or target points. Throughout the project, variables should be monitored and compared with the degraded and reference baseline conditions to evaluate the progress of the restoration project.

Vegetation composition

Reference reaches

The vegetation community in Provo River Reaches 4 and 9 have the highest numbers of species. The standardized values of woody and herbaceous species richness declines from the Provo River reference reaches to the degraded reaches, but is lowest for the Little Dell and Rock Cliff reference areas (Table S-2). Species that are present in Little Dell and Rock Cliff but not on the Provo River include *Berberis repens*, *Betula occidentalis*, and *Equisetum hyemale*. It is possible that these species have been locally extirpated due to the levels of degradation present along the Provo River.

In the study plots of Reaches 4 and 9 on the Provo River, *Populus angustifolia* was the dominant tree species and the three *Salix* species (*Salix exigua*, *Salix lasiandra*, and *Salix lutea*) were the dominant shrub species (Table S-3). In Reach 4, the herbaceous understory was dominated by *Agrostis stolonifera*, *Cirsium arvense*, *Phalaris arundinacea*, and *Poa pratensis*. Dominant herbs in Reach 9 included *Dactylis glomerata*, *Poa pratensis*, and *Trifolium pratensis*.

In the Little Dell study plots, *Acer negundo and Populus angustifolia* were the dominant tree species and *Cornus sericea*, *Rosa woodsii*, and *Symphoricarpos oreophilus* were the dominant shrub species (Tables S-4, S-5). The herbaceous understory in Little Dell was dominated by *Agrostis stolonifera*, *Dactylis glomerata, Equisetum hyemale, Poa pratensis,* and *Solidago canadensis* (Tables S-4, S-6).

In the Rock Cliff study plots, the dominant shrub species are *Salix exigua*, *Salix lutea*, and *Cornus sericea* (Table S-5). *Agrostis stolonifera*, *Bromus inermis*, *Phalaris arundinacea*, and *Poa pratensis* were the dominant herb species (Table S-6).

Woody exotics were not abundant within Provo River reaches 4 and 9, Little Dell, and Rock Cliff. While an occasional *Elaeagnus angustifolia* and *Tamarix chinensis* are present, none fell within the study plots and the overstory was dominated by native species in all areas. However, exotic herbs were abundant in both Provo River reference reaches 4 and 9, as well as in the Little Dell and Rock Cliff study areas (Table S-2). Percent exotic cover was high in Reach 4 (84%) as was relative exotic species richness (58%).

Degraded reaches

There were a total of sixty-four species within the Reach 8 Provo River study plots, thirty-nine of which are native to the United States (Tables S-3, S-7, S-8). Three native tree species and ten native shrub species were present. Fifty-one herbaceous species, twenty-six of which are native, were present.

There were a total of sixty-four species within the Reach 6 Provo River study plots, twenty-seven of which are native to the United States (Tables S-3, S-7, S-8). Three native tree species and six native shrub species were present. Fifty-five herbaceous species, eighteen of which are native, were present.

In the study plots of Reaches 6 and 8 on the Provo River, *Populus angustifolia* was the dominant tree species and the three *Salix* species (*Salix exigua*, *Salix lasiandra*, and *Salix lutea*) were the dominant shrub species (Table S-3). In Reach 6, *Agrostis stolonifera*, *Cirsium arvense*, *Equisetum arvense*, and *Poa pratensis* were the dominant herb species. Dominant herbs in Reach 8 included *Phalaris arundinacea*, *Phleum pratense*, and *Poa pratensis*.

As in the Provo River reference reaches, woody exotics were not abundant within Provo River reaches 6 and 8. Native species dominated the overstory. However percent exotic herb cover was high in Reach 6 (80%), as was relative exotic species richness (66%).

Vertical and horizontal structure

Reference reaches

The diversity of patch types in the Provo River reference reaches show a well-structured vegetation community. Vertical structural diversity is evident in the range of canopy layers (herbs, shrubs, short trees, tall trees) within the patch types (Table S-9). Patch types range from areas with multiple canopy layers (e.g. Young Riparian Forest and *Populus angustifolia* Forest) to areas with single canopy layers (i.e. Emergent Marsh and Wet Meadow).

Reach 4, Little Dell, and Rock Cliff have the tallest flood plain trees. Reaches 4 and 9 have the maximum canopy cover for most fluvial surfaces, indicating the dense canopy of a thick multi-layered overstory (Table S-2). However, the mean percent canopy cover for the Reach 4 island is the lowest, possibly indicating a newer surface with younger plants.

As expected, since Reach 4 has not been channelized or cleared, it has the widest flood plain riparian forest as well as the widest island and point bar forests. The width of the flood plain forest is narrow in Reach 9 due to clearing for wetland mitigation ponds.

The arrangement of the patch types across the flood plain shows horizontal structural diversity in both reaches.

Table S-9. Vertical structure for patch types.

Canopy Layer	*Herbaceous*	*Shrub**	*Short Tree***	*Tall Tree****
Patch Type				
Young Riparian Forest	X	X	X	X
Secondary Channel Edge Vegetation	X	X	X	X
Maturing Riparian Forest	X	X	X	X
Populus angustifolia Forest	X	X	X	X
Salix lutea Shrub Land	X	X	X	
Mixed Shrub/Scrub Land	X	X	X	
Mature *Crataegus douglasii* Shrub Land	X	X	X	
Acer negundo Woodland	X	X	X	
Emergent Marsh	X			
Wet Meadow	X			
Perennial Pond	X			

*Shrub = Species listed as shrubs in Table S-3.
**Short tree = All juvenile and adult tree species listed as trees in Table S-3, except for mature *Populus angustifolia*.
***Tall tree = Mature *Populus angustifolia*.

Degraded reaches

The average percent canopy cover for the Reach 8 flood plain (20%) is lowest for all reaches, indicative of the large open areas for agricultural fields and herbaceous wetlands. In addition, the percent canopy cover on Reach 8 point bars is the lowest for all the reaches (16%). The percent canopy cover in Reach 6 is not as low as would be expected because while much of the reach has been cleared for agriculture and cattle pasture, many large trees were left standing to provide shade for the livestock.

Reach 8 has a narrow flood plain forest due to the berms and clearing for agriculture and mitigation wetlands. While Reach 6 does have an average width island forest, its point bar forest is the most narrow. The lack of developed point bar forests is probably due to the constraints of the berms.

Population age structure

Reference reaches

Provo River Reaches 4 and 9 are the only areas with post-dam *Populus angustifolia* establishment pulses and these reaches have the strongest relationships between *Populus angustifolia* age and distance from the river. Reach 4 has the most pulses of *Populus angustifolia* establishment, due to the active flood plain and side channels. The active side channels in Reach 4 keep areas of the flood plain in a relatively highly disturbed and early seral stage, as compared to the Reach 9 terrace that has no active side channels and is not inundated by main-channel overflow. For 2 transects in Reaches 4 and 9, there is a significant positive relationship between *Populus angustifolia* age and distance from the channel edge. This suggests that processes of channel meandering are important for sustaining and developing the riparian forest.

Several age classes of *Acer negundo* and *Alnus incana* are present across the terraces and flood plain of the two reference reaches (Table S-2). In addition, juveniles and adults of other woody species (*Salix exigua*, *Salix lasiandra*, *Salix lutea*, *Crataegus douglasii*, and *Cornus sericea*) are present in reference reaches, giving these reaches high age structure diversity (Table S-3).

Degraded reaches

It is likely that many of the older stands of trees on the terraces in the degraded reaches have been cleared for agricultural field development and wetland pond construction, skewing the population towards younger ages. The age patterns of *Populus angustifolia* suggest that this species is regenerating through asexual means on the flood plain and terraces and sexual means on the point bars, islands, and channel margins.

As in the reference reaches, many *Acer negundo* and *Alnus incana* age classes are present across the terraces of the two degraded reaches (Table S-2). Juvenile and adult plants of other woody species such as *Salix exigua*, *Salix lasiandra*, *Salix lutea*, *Crataegus douglasii*, and *Cornus sericea* are also present in the degraded, giving these reaches high age structure diversity (Table S-3).

Successional processes (soil characteristics)

Reference reaches

Age structure analysis shows that *Populus angustifolia* are recruiting on the point bars and islands in the Provo River reference reaches. A range of seral stage plants and abiotic conditions are present in the Provo River reference reaches, as is evidenced by the patch types that range from the early successional Young Riparian Forest to the later successional *Acer negundo* Woodland. Increasing levels of clay, organic matter, and nutrients in the soil are some of the variables that indicate later successional stages. On average, Rock Cliff and the Reach 4 flood plain soils have the lowest levels of clay, organic matter, nitrogen, and phosphorus (Table S-2). With its many side channels and main channel that is not constrained, Reach 4 is subject to dynamic fluvial processes that are not present in the other reaches. Similarly, the Rock Cliff study area also has many active side channels. It is possible that occasional overbank flooding is creating enough regular disturbance to keep these areas in relatively early seral-stages. The oldest tree in Reach 4 is 67 years. In contrast, the oldest tree in Reach 9 is 131 years. The flood plain is not dynamic in Reach 9, eliminating disturbance by fluvial processes. On average, the flood plain soils in Reach 9 have relatively high levels of organic matter and nutrients. While it is possible that Reach 9 constitutes a more stable area than Reach 4, these organic matters, nutrients, and sediments could also be washing in from the wetland mitigation ponds bordering the riparian vegetation to the east. The Little Dell flood plain soils are moderately high in levels of clay, organic matter, and nitrogen, and have the highest levels of phosphorus (Table S-2). This could possibly indicate a more stable, later seral stage area.

The Reach 9 island soils are the least developed in terms of clay, organic matter, and nitrogen levels. The Reach 4 point bar soils are the most well developed in terms of high percentages of clay, organic matter, and available nitrogen, indicative of stable point bars due to the unbermed channel. The point bars in the Little Dell and Rock Cliff reference areas have high percentages of clay and phosphorous, although these values are based on only 1 and 2 samples, respectively. Values for organic matter and nitrogen on the Little Dell and Rock Cliff point bars are similar to those on the Provo River (Table S-2).

Degraded reaches

As in the Provo River reference reaches, age structure analysis shows that *Populus angustifolia* are recruiting on the point bars and islands in the degraded reaches as well. While the Reach 6 flood plain soils have high levels of phosphorus and nitrogen, this is probably due more to fertilization than natural successional processes. The Reach 6 island soils are the most developed in terms of levels of clay, organic matter, and nitrogen. Possibly the dense *Salix* communities in these areas are trapping sediments during flood flows, allowing for soil development.

The point bar soils sampled in Reach 8 have the coarsest sediments and lowest nutrient levels. This point bar is composed mainly of cobbles, with a sparse, thin layer of fine sediments. The area is very active at high flows, with several traversing backwater channels and an inundated leading edge.

Hydrologic and geomorphic conditions

Reference reaches

Reach 4 is the only unbermed section and is the only area where the river is connected to the flood plain. The current geomorphology of Reach 4 is that of a multi-channel system with areas associated with the secondary channels inundated during periods of high flow (at least 52 m^3s^{-1}). Even at high discharges, much of the Reach 4 flood plain will not be inundated under the present dam operation regime (Figs. S-3, S-4).

Degraded reaches

Inundation frequencies for areas outside of the berms in reaches 6,8, and 9 were not calculated, but the flood plain could be inundated only at discharges greater than 84 m^3s^{-1} (Figs. S-5, S-6, and S-7). Since the maximum potential release from Jordanelle Dam is 70 m^3s^{-1}, the vegetation communities outside the berms presumably have not been inundated by main channel overflow since the construction of the berms in the 1940's and 1950's. The flood plain is now disconnected from the river channel, making it a terrace. The early successional *Populus-Salix* communities between the berms are inundated on average 96 and 87 years every 100 years, using the Hailstone and Charleston gage data respectively. The deposition of island and point bar sediments in these reaches suggests that although the river is constrained by berms, it is returning to a natural pattern of sediment deposition along inner meander curves.

Summary of Chapter V - Relationships Between Vegetation and Abiotic Variables in the Provo River Reference Reaches

To visualize community patterns in the Provo River reference areas, the herbaceous and woody data were analyzed independently. For Reach 8, only the herbaceous data were used to determine patch types because of the degraded condition of the woody vegetation. This chapter discuses the plant distributions resulting from each ordination, and the abiotic variables that were significantly correlated with the ordination axes. DCA determined how the species were distributed across the abiotic gradients. TWINSPAN separated the species into groups according to their ecological preferences.

Sediment texture and moisture availability factors are most strongly related to the vegetation community distributions. The woody species DCA axis 1 scores for Reach 4 were highly positively correlated with % clay, showing a strong relationship between the distributions of these species and differences in sediment textures across the fluvial surfaces. The woody species DCA axis 1 scores for Reach 9 were highly positively correlated with distance to primary channel and meters above base flow. Gradients of water availability (as reflected in distance from an active channel, meters above base flow, and inundation frequency) across the fluvial surfaces are also related to woody and herbaceous species distributions in all reaches. Distance from an active channel and meters above base flow had high positive correlations with either axis 1 or 2 scores for all DCA ordinations. Since inundation frequency decreases with increasing distance from the channel, inundation frequency was negatively correlated with Reach 4 axis 1 scores for the woody species and the woody and herbaceous species combined.

TWINSPAN divided the vegetation data set into groups of species that have similar ecological requirements. This allowed for the development of patch types, with each patch type consisting of a group of species specific to a set of abiotic ranges and/or a particular location. In both Reaches 4 and 9, there is a general successional trend with species such as *Salix exigua*, *Salix lasiandra*, and *Salix lutea* growing on relatively coarse-grained, nutrient-poor soils in areas that are frequently inundated. Species such as *Rosa woodsii, Acer negundo*, and *Crataegus douglasii* grow on relatively fine-grained, nutrient-rich soils in areas that have low frequencies of inundation.

In Reach 4, TWINSPAN divided the woody species into five basic groups that are the basis of the patch types. A group dominated by all the *Salix* species, except for mature *Salix lutea*, formed a group at the wet end of axis 1. This group was the basis for the Young Riparian Vegetation patch type. All of these species are obligate wetland and tend to occur on channel edges, where water is highly available and sediments are coarse. The second group, consisting of mature *Populus angustifolia* and juvenile *Alnus incana*, formed the basis for the *Populus angustifolia* Forest patch type. A third group of *Salix lutea* and *Rubus idaeus* defined the *Salix lutea* Shrub Land patch type. The Mixed Shrub/Scrub Land patch type was based on a fourth group of *Cornus sericea*, juvenile *Crataegus douglasii*, and *Rosa woodsii*. These species are either facultative wetland or facultative and occur on relatively fine grained soils. Finally, the fifth group consisting of *Crataegus douglasii*, *Alnus incana*, and *Ribes aureum* defined the Mature *Crataegus douglasii* Shrub Land patch type. A facultative species, *Crataegus douglasii* dominates this group, and occurs on very fine textured sediments.

The TWINSPAN groupings and their ecological interpretations for Reach 9 were similar to those in Reach 4, with some variations. Five main groups are present. As in Reach 4, the first group defined the Young Riparian Vegetation patch type and consisted of all mature and juvenile *Salix* species, except mature *Salix lutea*. The second group consisted of mature *Salix lutea* and a few other species that occur in minimal numbers; this group defined the *Salix lutea* Shrub Land patch type. The third group consisted of only *Cornus sericea* and (along with a group from the combined woody and herb analysis) was the basis for the Mixed Shrub/Scrub Land patch type. *Populus angustifolia* dominated the fourth group and defined the *Populus angustifolia* Forest patch type. The *Acer negundo* Woodland patch type is defined by the fifth group that is dominated by the presence of *Acer negundo* and *Rosa woodsii*. *Acer negundo* and *Rosa woodsii* occur in areas with relatively fine sediments and high moisture holding capacity.

In Reach 8, three main groups are evident in the TWINSPAN groupings, one of which roughly defines the Emergent Marsh patch type by the presence of *Typha latifolia*. The Wet Meadow patch type is not well represented. The dominant species in this community are *Festuca arundinacea* and *Agrostis stolonifera*. Both of these species occurred towards the middle of the axis 1 scale, suggesting that they are widespread and not particular to one side of the dichotomy or another, and thus difficult to place in a cluster. The assignment of a Wet Meadow patch type was based on the field identification of wet meadow areas.

Summary of Chapter VI - Patch Types

The ordination and classification results from Reaches 4, 8, and 9 led to the formation of seven patch types, each acting as a 'functional group' within the larger community. Four groups were added to the patch types defined by the TWINSPAN groupings, for a total of eleven.

The patch types are divided into three main categories: early successional woody vegetation, mid-late successional woody vegetation, and herbaceous wetlands:

* Early Successional Woody Vegetation
    - Young Riparian Forest
    - Secondary Channel Edge Vegetation
    - Maturing Riparian Forest
* Mid-Late Successional Woody Vegetation
    - *Populus angustifolia* Forest
    - *Salix Lutea* Shrub Land
    - Mixed Shrub/Scrub Land
    - Mature *Crataegus douglasii* Shrub Land
    - *Acer negundo* Woodland
* Herbaceous Wetlands
    - Emergent Marsh
    - Wet Meadow
    - Perennial Ponds

These patch types sort out along a rough successional gradient with levels of organic matter, clay, and phosphorus increasing with the later seral-stage areas (Fig. S-8). Inundation frequency also decreases towards the later end of the successional gradient. Each patch type occurs within a range of soil, hydrologic, and geomorphic characteristics that explain their distributions across the fluvial surfaces. *Populus angustifolia* and *Salix* spp. dominate the early successional woody vegetation areas that are frequently inundated and have coarse soils with low nutrient and organic matter levels. As forest age increases and a mature *Populus angustifolia* forest develops, along with areas of later successional species such as *Crataegus douglasii* and *Acer negundo*, soil development processes increase. This results in higher levels of clay, organic matter, and nutrients present in the soils of these patch types.

The term herbaceous wetland describes areas with no woody vegetation, and either saturated soils or standing water. Herbaceous wetland patch types are placed in their own category, rather than within the successional gradient because while these areas do occur naturally in the Heber Valley, wetland mitigation pond run-off strongly influences the sampled herbaceous wetlands. It is therefore difficult to determine where they would fall along a 'natural' successional gradient. In general, the soils in these areas also have high levels of clay, organic matter, and nutrients.

Summary of Chapter VII - Riparian Vegetation Restoration

General considerations

Active vs. passive restoration

The proposed restoration recommendations involve a combination of active and passive techniques, based on the specific hydrologic, fluvial geomorphic, and biologic processes needed to maintain the patch types (Table S-10). Active restoration consists of direct human intervention while passive restoration allows natural processes to maintain the ecosystem. Initial active restoration will "jump start" the project through plantings of the dominant native species and construction of fluvial surfaces with heterogenous topography. The goal is for a self-sustaining system where natural processes create and maintain the variety of fluvial surfaces and their associated vegetation communities, and allow for successional processes to proceed at natural rates.

** We suggest that the Commission initially undertake a combination of active restoration techniques (direct human intervention) and passive restoration measures (allowing natural processes to do the work). The exact combination of active and passive approaches should vary between sites and patch types, as we specify in later sections.*

** Over time, we suggest that the combination approach give way to an approach that emphasizes passive restoration techniques.*

** The active and passive measures should focus on restoration of the physical habitat (hydrology, geomorphology) and on the biotic components (e.g. riparian vegetation and soils).*

Experimentation vs. proven methods

** We advocate incorporating experimental components into the Provo River Restoration project.*

** For example, we suggest including treatments that compare passive approaches to active approaches, and that compare various types of active approaches. One such experiment should be undertaken in the early successional sites, where channel margins or point bars will be exposed or constructed as part of the restoration effort. Other experiments should be undertaken in the late- successional sites.*

Table S-10. Examples of active and passive restoration.

Hydrologic Restoration

- Passive
  - Release flows from Jordanelle Dam of appropriate timing, magnitude, and duration.

Geomorphic Restoration

- Active
  - Use machinery to sculpt a diversity of fluvial surfaces such as point bars, secondary channels, flood plains of varying elevation and slope, and ponds.
  - Modify soil factors through mulching.
- Passive
  - Allow natural fluvial processes, as influenced by river flows and vegetation, to create fluvial surfaces and erode/deposit sediments.
  - Allow natural vegetation processes to increase organic matter and nutrient content of soils.

Biotic Restoration

- Active
  - Plant cuttings or container plantings of tree and shrub species, and seed for some herb species.
  - Remove problem exotics in specified areas.
- Semi-active
  - Apply donor soils - salvage top 15 cm of soils from bulldozed riparian sites that are relatively free of exotics. Transplant to restoration site to increases biodiversity of herbaceous plants. Enables 'self-assembly' by allowing plants to sort themselves out naturally along environmental gradients.
- Passive
  - Restore the geomorphic habitat (e.g., point bar, mid-elevation flood plain, secondary channels) and hydrology (e.g., large and small flood flows) to enable natural recruitment of early and late-successional species with readily available seed sources.
  - Restore the natural processes (e.g., channel meandering, flood plain aggradation) that drive successional processes and allow for long-term establishment of plant species.

Restoration of plants and soil biota

<u>*Planting of native species*</u>

** Be judicious in opting for active planting; utilize a variety of techniques including passive process restoration (a wait-and-see approach) as well as plantings, in an experimental framework, taking into consideration the issues listed below.*

** Select the revegetation species from a data base that includes (1) native plant species presently found along the Provo River; (2) native plant species growing along the designated reference reaches; and/or (3) native species that have high value (e.g., as wildlife food) AND which may have occurred naturally on the Provo River based on literature review of the geographic and ecological range of the species.*

** When introducing plants, use locally adapted ecotypes and strive for a high level of diversity within the population of planting stock.*

Assembly rules and successional sequences

**Where possible, work within a successional framework and plant species in temporal sequences that conform to successional patterns*

Biotic interactions, mutualisms, and reproductive biology

** Pay attention to biotic interactions when planting. For example, initially plant species that are generalists with regard to pollinators or seed dispersers and allow more specialized species to establish after more specif habitat conditions have developed.*

** Pay attention to reproductive strategies. For example, plant out-crossing species in sufficient densities and spatial patterns to allow for pollinator-mediated seed set.*

** For quickest revegetation of ground surfaces, plant species that are capable of vegetative reproduction*

Directed planting vs. self-assembly

** Tailor plant species to appropriate abiotic conditions.*

**Work with the ecosystem and accommodate or take advantage of existing site conditions, where possible. In many cases, the inundation frequencies and soil characteristics of the restoration sites (e.g., agricultural fields) may fall naturally within the range of woody species. If so, it is probably most cost-effective to simply plant species that are favored by such sites. In other cases, one may wish to alter the site conditions through soil amendment or physical sculpting of the habitat, to achieve a greater degree of habitat diversity within the flood plain.*

How to restore understory biodiversity?

** Salvage the top layers of soil (upper 15 cm) from construction activity, in places, to be used as donor soils. Soils should NOT be salvaged from the stream edge of Reach 8 where there are lots of weedy seed banking species. Eventually, soils should be salvaged from Reach 9, in particular the southern end where the relative cover of exotic species is the lowest for all the reaches.*

** Donor soils can be placed in a variety of places. Donor soils from flood plain sites tend to contain a wide variety of species reflecting the entire successional history. This diversity of species allows for self-sorting along the existing environmental gradients.*

** Sites augmented with the donor soils should be monitored for plant establishment and compared with un-augmented sites.*

** Obtain a sowed seed mixture that contains a diverse mixture of candidate species occurring in the target patch type. The seed mix should be applied at different times during the year, and in multiple years to allow for vagaries of rainfall, temperature, seed-predation and other factors that influence germination success.*

<u>Removal of exotics</u>

** We propose a patient wait-and-see strategy to see if the native species recover in the absence of grazing, trampling, and nearby agricultural activity. If the natives are not showing trends of recovering, we then propose active weed control measures coupled with native species seeding measures.*

** Need for direct weed control may arise throughout the restoration project; target sites and species should be identified through monitoring. For example, there may be a need to weed-out <u>Phalaris arundinacea</u>, <u>Agrostis stolonifera</u>, or other vegetatively-spreading exotics on newly constructed point bars and islands.*

<u>Problem habitats</u>

** Donor soils can help to restore populations of mycorrhizae and other important soil biota to abandoned fields.*

Geomorphic restoration

** To allow for the establishment and maintenance of the different vegetation communities, it is necessary to create a diversity of fluvial surfaces such as point bars, secondary channels, flood plains of varying elevation and slope, and ponds (abandoned ox-bows). Initially sculpt flood plain geometry to create a heterogeneous topography,* *including the presence of secondary channels, on which early, mid and late successional riparian communities can be planted or can naturally establish following planned floods of different magnitudes.*

** A good approach is to take advantage of what exists while creating additional diversity if necessary. If the targeted area is a level agricultural field, sculpting will be necessary to encompass the range of inundation frequencies for the various patch types. After the initial sculpting, we recommend allowing natural fluvial processes, as influenced by river flows and vegetation, to create fluvial surfaces through the erosion and deposition of sediments.*

**It may be necessary to initially modify soil factors such as organic matter level, through mulching. Eventually, natural vegetation processes will increase the organic matter and nutrient content in the soils*

** If monitoring reveals that sediment augmentation will be needed, methods need to be developed to determine (1) the amount of sediment augmentation needed, (2) location of sediment augmentation, and (3) the textural composition of the augmented sediment. Sediment needed for recruitment sites and deposition on the mid to late successional flood plain area should range in texture from sand to silty-clay. Deposition of fine soils on the upper flood plain will only occur during high peak flows. This should dictate the timing of sediment augmentation.*

Hydrologic restoration

A hydrological regime should be established to (1) help maintain the restored Provo River riparian community and (2) encourage natural recruitment and establishment of native riparian species. The regime should be based, in part, on historical hydrological patterns for the river. Five components of flow regimes- namely the magnitude, frequency, duration, timing and rate of change of hydrologic conditions- strongly influence the structure and function of riparian ecosystems (Poff et al. 1997). All should be considered in the design of the flow regime.

** We recommend that frequencies of flood flows of different magnitudes be based on historical annual peak flow frequencies from gages upstream of the present Jordanelle Reservoir (Table S-11).*

Table S-11. Annual peak flows and frequencies from upstream (Hailstone gage) and from downstream (Charleston gage - calculated) for the period 1950-1996, and recommended peak frequencies of several magnitudes of high flow releases from

Jordanelle Dam. Recommendations for use of the "cottonwood-willow recruitment box" (Mahoney and Rood 1993, 1998) for shaping the flood hydrograph are made for each peak flow.

Annual Peak Flows	*Frequency of Historical Upstream Peak Flows*	*Frequency of Historical Downstream Peak Flows*	*Recommended High Flow Levels*	*Frequency of Recommended High Flows*	*Use of Recruitment Box*
> 112 m^3s^{-1}	3/47 years				
> 98 m^3s^{-1}	4/47 years				
> 84 m^3s^{-1}	10/47 years	1/47 years			
> 77 m^3s^{-1}	15/47 years	1/47 years			
> 70 m^3s^{-1}	25/47 years	1/47 years	ca. 70 m^3s^{-1}	1/6 years	Yes
> 56 m^3s^{-1}	35/47 years	4/47 years	ca. 56 m^3s^{-1}	1/ 4 years	Yes, if possible
> 42 m^3s^{-1}	42/47 years	26/47 years	ca. 42 m^3s^{-1}	1/ 2 years	Not necessary
> 28 m^3s^{-1}	45/47 years	44/47 years			
> 14 m^3s^{-1}	47/47 years	47/47 years			

Regeneration floods

**We recommend that hydrographs of planned floods follow natural flood hydrograph patterns to assure timely formation of seed-bed locations for riparian species, and that the "recruitment box" concept be used to determine the timing of peak flows and the recession rate of the receding limb of the flood needed for Populus-Salix establishment.*

** To create a flood of 70 m^3s^{-1} for the total length of river from Jordanelle Dam to Deer Creek Reservoir, the full release from Jordanelle Dam must be left in the river during the flooding period. Irrigation take out channels can greatly reduce flood flows and may reduce the affects of flooding. For example, comparing peak flows in 1993 at the Hailstone and Charleston gages, Hailstone reached a peak over 98 m^3s^{-1}, while Charleston, located in the Heber Valley below irrigation take-out channels reached only 63 m^3s^{-1}. This level of reduction of flood magnitude will need to be addressed in future planning of floods designed to return natural fluvial processes to the riverine ecosystem.*

** It will be necessary to monitor several representative cross-sections to determine levels of inundation of these flood flows on the riparian gradient from stream to upland, and their effect on recruitment of riparian species.*

Maintenance floods

It is important to release over-bank flood flows with a range of magnitudes, so as to inundate the various successional stages of the riparian community with specific frequencies. This will maintain productivity of the existing vegetation and allow for periodic regeneration of some late-successional species. Using calculated values for historical inundation frequencies for early, mid and late successional woody vegetation communities along the Provo, we can make recommendations on frequency of different magnitude releases from Jordanelle Dam.

* *We recommend that flood flows of varying magnitudes be released with appropriate frequency so as to inundate the various naturally-occurring and planted-patch types within their historically-determined ranges of inundation frequency.*

* *It will be necessary to monitor several representative cross-sections to determine levels of inundation of these flood flows on the riparian gradient from stream to upland and their effect on recruitment of riparian species.*

Recommendations by patch type

Young Riparian Forest and Maturing Riparian Forest

* *Initially sculpt the slope angle of channel margins and point bars of main and secondary channels with heavy equipment so that wetted soil for growing riparian seedling roots (about 3 +/- mm per day) will be maintained by a gradually receding flood.*

* *Release small floods sufficient to moisten the establishment zones.*

* *Plant some of the newly exposed channel establishment zones with Salix exigua, Salix lasiandra, Salix lutea, and Populus angustifolia stem cuttings or poles, and leave other areas unplanted, in an experimental fashion, as described below.*

* *Over the long-term, periodically release the large flood flows that will create and moisten germination sites for Populus and Salix.*

Secondary Channel Edge Vegetation

**During initial flood plain construction with heavy machinery, create secondary channels (one per 100 m of flood plain length) of which some are active channels during* *base flows of 14 m^3s^{-1} and others are active only when stream flows exceed 28 m^3s^{-1}. The number and location will depend on width and sinuosity of the main channel.*

** Release flows to maintain desired channel dimensions.*

** In an experimental fashion, release flows that may stimulate Alnus regeneration by providing some sediment reworking and inundating channel margins*

** Treat some of the created side channels areas as experimental no-plant areas and some as plant areas*

** In some planted areas: overplant with Populus first, than add Alnus later; and in some areas, plant Alnus alone*

** Apply donor soils in some sites and set aside others as control sites, in experimental fashion*

Mid to late successional woody vegetation patch types

** Test soils for texture and nutrients and survey sites for elevation above the thalweg. Plant species according to their tolerance ranges for soil texture and nutrient content, and for depth to groundwater and inundation frequency, taking advantage of existing site conditions. For example, in areas with low inundation frequency and soils with high levels of clay, silt, nitrogen, organic matter, and phosphorus plant Acer negundo and/or Crataegus douglasii.*

** In areas with little topographic diversity (e.g., level agricultural fields), create a diversity of fluvial surfaces, to allow for heterogeneity of habitats, and then plant within physical tolerance ranges.*

** We recommend that restoration construction of channel and flood plain geometry recognize the need to be able to wet much of the flood plain with a 70 m^3s^{-1} peak flow, the maximum attainable from Jordanelle Dam*

** If some patch types are still under-represented in the restoration site in terms of site soil potential, consider soil modifications (e.g., mulching, donor soil applications).*

** Plant the dominant woody species for each patch type including Salix lutea, Cornus sericea, Crataegus douglasii, Rosa woodsii, Alnus incana, Ribes aureum, Populus angustifolia, and Acer negundo.*

** When planting, take into account reproductive biology. For example, plant obligate out-crossing species such as dogwood in sufficiently dense patches to allow for cross-pollination; monitor to insure that adequate pollinators are present.*

** When planting, take into account successional patterns and shade tolerance. For example, plant some areas with large Populus poles and then underplant with young, small Acer negundo; leave other areas not underplanted to monitor for natural seedling recruitment of the later-successional Acer negundo. Other later-successional species such as woods rose, serviceberry, and wild raspberry should do fine in open-sun conditions.*

** Aim for a mix of structure types, including mixed-canopy sites that have a tall tree canopy later and a shrub understory; shrublands, and woodlands. For example, in addition to a mixed canopy Populus/Acer type (mature Populus Forest patch type), strive to create Mixed Shrub/Scrub Land patch type, a Salix lutea shrubland type, and Crataegus douglasii Shrub Land type that contain various combinations of Salix lutea, Cornus sericea, Rubus idaeus, Ribes aureum, Crataegus douglasii, Rosa. woodsii, and Lonicera involucrata. Plant areas of Acer negundo to form woodlands.*

** Apply donor soils in some areas to restore soil organisms and herbaceous biodiversity. Donor soils may be particularly important in agricultural fields.*

** Hand broadcast mixtures of native plant seeds (using mixtures of species targeted for each patch type), for several years in succession. Apply the seeds in some areas but not others, to determine whether this is a necessary and effective restoration approach.*

** Control for exotic invasive species, if necessary.*

** Release flows that will produce the desired patch-type-specific inundation frequencies*

** Over the long-term, allow natural processes to develop and maintain flood plain gradients and successional seres*

**Supplement the sediment budget of the river with fine sediments if the new sediments being deposited on the flood plains are coarser than expected for that patch type, recognizing that deposition is influenced partly by vegetation structure and density.*

Emergent Marsh, Wet Meadow, Perennial Ponds

** Establish these types in areas with nutrient-rich, fine textured soil. For Wet Meadows, create areas with saturated soils, fed either by ground water or small secondary channels. For Emergent Marsh, create areas with perennial standing water, fed either by ground water or small secondary channels. Create ponds with fluctuating water levels, but perennial standing water.*

**Plant Salix lutea at low density at a few sites to establish some woody structure in the Wet Meadow patch type.*

** Plant a few of the dominant herbaceous plants, including Carex rostrata, Carex lanuginosa, Carex nebrascensis, Juncus ensifolius, and Juncus longistylis. Focus on species with ability to propagate asexually, if the goal is to rapidly revegetate the ground surface.*

** If possible, apply donor soils or mulch sites with litter, detritus, seed, and root materials from native wetlands to provide organic matter and restore soil organisms.*

** Control for invasive exotic species as needed, as indicated by monitoring*

** Establish flows from secondary channels and/or groundwater into the herbaceous wetland areas but prevent excessive flooding.*

** Allow natural processes, including beaver activity, to create physical habitat.*

Summary of Chapter VIII - Riparian Vegetation Recruitment Experiment

A restoration experiment should consider all of the following approaches, integrate them, and build them into both short-term and long-term management schemes that initially will be considered an experiment:

1. Controlling the hydrology of the riparian zone through management of releases from Jordanelle Dam.
2. Actively contouring the channel margins to allow wetting of several elevation zones.
3. Passively allowing natural recruitment to take place in all newly graded areas.
4. Actively planting appropriate species in elevation zones that will be inundated and not inundated by controlled floods.
5. Encouraging recruitment through use of donor soils in appropriate areas.

Site selection

Sites selected for experimental studies of riparian recruitment and recovery along the mainstem of the Provo River should initially all have similar gross topography. Three control sites and three experimental sites each of point bars and channel margins should be selected for the experimental project.

Channel edge topography and surface materials

Microtopography of the meander lobes and channel margins should be designed to allow a gradual decline of the wetted surface as an experimental flood gradually decreases in magnitude. Meander lobes and channel margins should be constructed with materials that mimic old gravel beds or base material in the surrounding valley.

Meander lobes (point bars) and channel margins

Each of the three experimental meander lobes should be divided into 4 quadrants, alternating a planted quadrant with a non-planted quadrant (Fig. S-9). Three constructed meander lobes should be left barren but be marked into 4 quadrants as controls. Each of the three 100 m experimental channel-margin sub-reaches should be constructed in a fashion similar to the meander lobes (Fig S-10). They should be divided into several alternating planted and non-planted segments, again alternating as on the meander lobes.

Passive vs. active restoration

Designate a subset of the exposed point bars and channel margins as '*passive restoration treatment areas*'. Water managers should provide the necessary short-term inundation in spring and appropriate draw-down rate in summer to allow for *Salix/Populus* seedling establishment. This no-plant treatment will tell us whether the local seed sources are adequate to supply propagules for natural seedling establishment and will also provide a test of our understanding of the flow regime needs of the seedlings. We anticipate that seed abundance will not be a limiting factor. Ideally, the construction activity should be carried out in spring/early summer months during the *Salix/Populus* seed release period. Meander lobe and channel margin areas designated for planting should be planted with young (1-2 years) saplings of early successional woody plants in a density equivalent to that found in natural surfaces after a few years.

Designate another subset of the point bars and channel margins as *'planting areas'*. These areas should be planted with young early successional woody plants such as Populus angustifolia, Salix exigua, Salix lutea, Salix lasiandra, Alnus incana, and Cornus sericea. Woody plants should be planted on the channel margin equivalent to the zone between the stages for 42 m^3s^{-1} and 56 m^3s^{-1}. *Salix* spp. should be placed on the outer edges, with *Populus* toward the inside. Make sure to include a mix of genders and appropriate genetic stock.

Donor soils

Donor soils may be used to reestablish riparian vegetation, especially herbaceous groundcover. Donor soils should be spread (ca. 2 cm thick) on barren surfaces of constructed meander lobes and channel margins above the stage corresponding to
70 m^3s^{-1}. Donor soils should be placed on the upper portion of the "planted" quadrants or segments of the meander lobe and channel margin respectively.

Hydrology

The primary controlling parameter in this experiment is hydrology. A three year flood pattern is suggested that mimics the natural regime required for *Populus* and *Salix* seedling establishment and survival. In the first year, there should be a flood (70 m^3s^{-1}) that creates scoured and sediment deposition conditions. A smaller (56 m^3s^{-1}) flood during the second year would allow for adequate water levels for seedling survival. This flood should be repeated in year three if there was good recruitment following year two.

Monitoring

Monitoring transects should be placed perpendicular to the axis of the river through each quadrant (planted and unplanted) on the meander lobes, and across each experimental segment of each sub-reach along the channel margin. Transects should extend across areas used for donor soil experiments, if these were developed. Quadrats (0.5 x 0.5 m) should be placed each meter along these transect lines and sampled for (1) establishment of new plants whether riparian species of interest or not, and (2) survival of plants planted within the planted areas. After year two, larger quadrats (1 x 1 m) should be placed at alternate quadrat points along the transect and sampled for saplings. The small quadrats should be retained and used to sample herbaceous plants and woody riparian seedlings. Measurements taken within each quadrat should include: (1) density of each species, (2) aerial cover of each species. Within the larger quadrats, height of the largest individual of each woody species should be measured.

Summary of Chapter IX - Monitoring and Indicators of Restoration Success

Monitoring efforts should be integrative, including monitoring of all ecosystem components of concern within the same riverine flood plain unit. Transects established for vegetation (habitat) monitoring should be the sample entity for other attributes. Where there are unique ecosystem types (e.g., herbaceous wetlands) in which listed species might occur (e.g., spotted frog), vegetation transects should be established in these areas. Aside from these special locations, several cross-sectional transects should be established in each restoration reach. At least two transects within each restoration reach should represent different fluvial geomorphic forms, that is, straight channels, meander curves (usually with cut banks and point bars), multiple channel reach (often with primary and secondary channels), or a combination of these.

Sampling along monitoring transects should be designed to determine (1) amount of sediment scour or deposition, (2) recruitment of woody riparian species, (3) herbaceous cover, and (4) growth, maintenance, and vigor of established riparian plants. Hydrological phenomena along the flood plain gradient should also be determined in association with the vegetation transects. Frequency of inundation and depth to water table using monitoring wells at points (plots) along the transect are two parameters critical to establishment and survival of riparian vegetation.

In the short term, restoration success can be gauged by doing a functional equivalency comparison in which key variables are compared between restored and reference sites (Table S-12). Functional, in addition to structural, attributes must be addressed when evaluating restoration success. *In particular, the restored ecosystem must be self-sustainable in order for the restoration project to be a success. Plant populations must be self-maintaining after the initial* *plantings; the community must be able to recover from natural and human disturbances; and the community must be resistant to invasive plant and animal species.*

Restoration success can be gauged in the long term through an index of riparian ecosystem integrity. Operational definitions of ecosystem health and ecosystem integrity tend to include the following components (Costanza 1992; Karr 1991):

1. **Homeostasis function**: the ability to continue to self-organize in a changing environment, without the need for external human support.

2. **Resistance or resilience function**: capacity for self-repair after perturbation or stress. The ability of an ecosystem to maintain its structure and function over time in the face of external stress, or ability to rapidly recover after stress, either to the pre-stress state or to a related 'trajectory'.

3. **Levels of diversity** and complexity similar to a pre-stress, reference condition.

4. **Levels of vigor/productivity** similar to a pre-stress, reference condition.

5. **Functions and processes** similar to a pre-stress, reference condition.

Table S-12. Variables to be sampled in monitoring phase to gauge short-term restoration success.

Vegetation	*Soil*	*Hydrologic/Geomorphic*
Species diversity	Texture (% sand, silt, clay)	Distance to channel (m)
Patch type diversity	Moisture holding capacity (%)	Elevation above thalweg (m)
Growth form diversity	Organic matter (%)	Elevation above base flow (m)
Native species diversity	pH	Sediment scour or deposition (m)
Vertical structure	Available nitrogen (%)	Inundation frequency (per 100 years)
Population age structure	Phosphorus (mg/kg)	
Canopy cover (%)	Electrical conductivity (ds/m)	
Species densities		
Canopy height (m)		
Number of dead stems		

No clear standards exist to measure these components. There is currently no accepted 'list' of indicators of health for riparian ecosystems. Development of easily measurable and meaningful indicators is an ongoing process (Karr 1991). In selecting indicators of integrity, a good place to start is to identify essential environmental factors or processes that maintain and control the community type and select indicators that are sensitive to these factors (Keddy et al. 1993). Indicators also should be multimetric, with variables measured at a variety of hierarchical scales within the ecosystem (Karr and Chu 1999).

The ecosystem integrity approach is related to the functional equivalency approach and thus the variables are similar. Analysis of the following variables (Table S-13) will help develop an index of riparian ecosystem integrity.

1) Diversity and composition components

a) Species diversity or species richness. What is the total number of plant species and mean number of plant species per unit area?

b) Functional group diversity or guild diversity. How many of the determined patch types are present within a reach?

c) Growth form diversity. Are plants present in a variety of growth forms, including herbs, shrubs, and trees?

d) Native species diversity. What is the relative abundance of native to exotic plant species?

2) Vertical and horizontal structure.

a) Vertical structure. Is there a continuum of patches from open areas to areas with a multi-layered canopy?

b) Landscape structure. Is there a mosaic of patches ranging from open meadows, shrublands, open forests with a shrub understory, and dense forests?

3) Population age structure. Are there multiple age classes of dominant woody species?

4) Successional processes. Are processes of point bar colonization, flood plain aggradation, soil productivity increases, occurring at natural rates?

Table S-13. Variables to be sampled in monitoring phase to gauge long-term restoration success.

Vegetation	*Soil*	*Hydrologic/Geomorphic*
Tree basal diameter (m)	Texture (% sand, silt, clay)	Slope (%)
Shrub canopy area (m^2)	Moisture holding capacity (%)	Absolute elevation (m)
Height of tallest tree (m)	Organic matter (%)	Elevation above base flow (m)
Canopy cover (%)	pH	Elevation above channel thalweg (m)
Herbaceous plant cover (% total and % by species)	Available nitrogen (%)	Distance to primary channel (m)
Number and species of seedlings <1 meter tall	Phosphorus (mg/kg)	Distance to active secondary channel (m)
	Electrical conductivity (ds/m)	Inundation frequency (per 100 years)

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REVEGETATION

Planting willows in reconstructed channel (left). Willow growth on same bank, one year later (right).

The engineering and revegetation components of the project have a synergistic effect. Lengthening the stream and installing grade control structures result in increased surface water elevations as well as floodplain inundation frequency and duration. In turn, these improved hydrologic conditions provide soil moisture necessary for the establishment and sustainability of the native riparian plant communities. Overhanging vegetation, deep and fibrous root systems, and dense and diverse plant communities within the riparian zone provide bank stabilization, cover and shade for fish, nutrients for aquatic insects, instream woody debris, and habitat for wildlife.

Species comprising the once prevalent native plant communities were hypothesized using on-site and adjacent land surveys, current published literature, historical data and photographs, and local accounts of historical conditions. Active replanting is necessary since elimination of the original woody riparian corridor, both on the project site and upstream as well, reduced seed sources to numbers incapable of supporting natural recruitment. As plantings become established and soil moisture conditions are restored, natural recruitment and regeneration are expected.

5.1 Revegetation Design Criteria

The revegetation design criteria for the Lower Red River Restoration Project were developed to meet project goals, philosophy, and objectives. A number of factors were considered including plant selection, fish and wildlife habitat features, riparian zone width, hydrology, planting density and plant size, streamflow velocity, sinuosity ratio, bank slope, soil stratigraphy, construction travel corridors, disturbed construction areas, and browsing/grazing control (Table 5.1).

Sustainable riparian communities are dependent on the evolution of natural physical properties restored by the engineering features (Chapter 4). Therefore, several revegetation criteria are associated with restored channel and floodplain function. For example, elevating the low flow water level to within 36 inches (91 cm) of top of bank and reconnecting the floodplain to the stream channel increases frequency and duration of the meadow hydroperiod, providing suitable soil moisture conditions for the native plant communities. Planting locations based on soil moisture requirements for particular species are based on this expected rise in low flow water surface elevations and enhanced hydroperiod.

Table 5.1. Revegetation design criteria used for Phases I and II of the Lower Red River Meadow Restoration Project. Criteria are based on Carlson et al. (1991) and recommendations of the Red River TAC and Wildlife Habitat Institute (WHI).

Restoration Factor	Revegetation Design Criteria
Plant Selection	All plant species will be native to site. Herbaceous wetland/riparian plant seed will be collected on site, grown in a commercial greenhouse, then out-planted on site. Dormant willow pole cuttings will be collected on nearby sites having similar elevation, temperature, and precipitation conditions. Plantings should be as diverse in composition as the major components of the target plant community. Seed and cutting selection will be subject to availability.
Fish Habitat	Established riparian plantings will create and enhance fish habitat conditions. As the height and density of streambank vegetation increases, overhanging vegetation will provide shade and cover. Deep and dense root systems will stabilize banks and allow the development of undercut banks. Woody riparian vegetation will supply a source of instream woody debris. Increased stream shading and stabilized streambanks will result in reduced summer water temperature, turbidity, and suspended sediment levels, thereby improving overall water quality.
Wildlife Habitat	Diverse and dense plantings in the riparian corridor and expanded wetland and open water areas will provide nesting, foraging, and cover habitat for a variety of waterfowl, upland birds, and terrestrial mammals.
Riparian Zone Width	Riparian zone will extend a minimum of 20 feet (6.1 m) from streambank edge of mean low water level on straight reaches and inside bends or from top of bank on vertical cut banks.
Hydrology	Engineering features will raise surface water elevations to within 36 inches (91 cm) of top of bank at low flows, enhancing soil moisture conditions for riparian community establishment. Streamside plantings will be situated to anticipate this change in low flow water surface level. Planting design will accommodate the preferred hydrologic conditions for each species.
Planting Density/Plant Size	High density, mass plantings provide greater erosion control and plant survival and are more likely to withstand browsing, trampling, or other physical damage. Design and specifications will incorporate the largest stock size available and the greatest quantities possible within budgetary constraints.
Streamflow Velocity	Newly vegetated banks need protection from high-water/high velocity events. In general, fully revegetated streambanks can tolerate flows up to 8 feet per second (2.4 m/s) for short periods and up to 5 feet per second (1.5 m/s) for extended periods. Revegetation design will assume that post-reconstruction streamflow velocities will not exceed these parameters. This assumption is based on the restoration of the channel gradient to 1936 conditions, ranging from 0.17 percent to 0.23 percent. Success of streambank revegetation increases when channel gradients are below 1 percent. Greatest success is achieved as gradients approach or fall below 0.1 percent.

Table 5.1 cont. Revegetation design criteria used for Phases I and II of the Lower Red River Meadow Restoration Project. Criteria are based on Carlson et al. (1991) and recommendations of the Red River TAC and WHI.

Restoration Factor	Revegetation Design Criteria
SINUOSITY RATIO	Streambank revegetation success is greatest when stream curve radius to stream width ratio exceeds 10. Planned channel reconstruction design will conform to this guideline.
BANK SLOPE	In general, revegetation is most successful on streambanks with slopes of 3:1 or flatter. Steeper slopes are subject to greater water velocities and stronger erosive forces and will undermine revegetation efforts. Revegetation design, specifications, and planting time periods will consider reconstructed bank slope within the various channel reaches to optimize revegetation success.
SOIL STRATIGRAPHY	Fluvial materials are characteristically deposited in non-uniform layers of varying soil textures. Fine-textured streambank soils are more resistant to erosive forces than coarse-textured soils. A subsurface gravel layer subject to erosive forces can be scoured out causing the collapse of the upper bank. Plant species selection and planting densities will be determined by the soil stratigraphy and erosive potential of various stream reaches; faster-growing plants and higher planting densities will target the reaches with the highest erosion potentials. Whenever feasible topsoil removed during excavation will be stockpiled and replaced prior to planting.
CONSTRUCTION TRAVEL CORRIDORS	Fragile, moist riparian soils are susceptible soil compaction from heavy equipment and vehicle traffic. Soil compaction negatively affects riparian plant establishment and may encourage the recruitment of invasive and aggressive exotic communities. Travel corridors will be planned to minimize compaction and soil damage in the riparian corridor. Whenever feasible, heavy equipment with tracks, rather than rubber tires, and 4- or 6-wheeled all-terrain vehicles (ATVs) will be used. After construction is complete, travel corridors will be ripped to a depth of 2 feet (61 cm), graded, and seeded with a native grass mix. A policy will be established for construction shut down during rain events and for future access and maintenance.
DISTURBED CONSTRUCTION AREAS	All areas of exposed soil, as a result of construction activities, will be sown with an erosion control seed mix and planted with native herbaceous and woody vegetation according to the approved planting design and specifications. Prior to planting, coconut fiber erosion control matting will be positioned on sites having the greatest erosion potential (e.g. reinforced banks).
BROWSING/GRAZING CONTROL	The property perimeter fence will be maintained to protect new plantings from cattle trespass. Revegetative success monitoring and construction of temporary wildlife exclosures will be used to evaluate browsing impacts to riparian plantings. Deer/elk repellent may be used as necessary. Temporary wildlife exclosures are designed to establish islands of dense, woody vegetation that will spread and serve as a seed source facilitating future natural recruitment.

5.2 PLANTING DESIGN AND METHODOLOGY

Planting Design

EXPECTED TARGET COMMUNITY. A riparian classification system has yet to be developed for the north-central region of Idaho. Therefore, the expected target communities for the Lower Red River Meadow were hypothesized using the following sources:

- Community descriptions in similar ecosystems of nearby regions (Padget et al., 1989; Brunsfeld and Johnson, 1995; Hansen et al., 1995),
- On-site surveys of native vegetation in an established exclosure at the downstream end of the meadow and existing plant communities within the riparian/meadow areas of the RRWMA (Brunsfeld, 1994), and
- Historical photographs and local accounts.

Brunsfeld (1994) hypothesized that willows comprised the major component of the original woody riparian community, primarily Drummond willow *(Salix drummondiana)*, Geyer willow *(S. geyeriana)*, and Booth willow *(S. boothii)*. Other woody species included Pacific willow *(S. lasiandra)*, sandbar willow *(S. exigua)*, red-osier dogwood *(Cornus stolonifera)*, thinleaf alder (*Alnus incana*), and bearberry honeysuckle *(Lonicera involucrata)* (Appendix A).

Many of the native herbaceous species existing today comprised the original associated understory including a variety of sedges *(Carex spp.)*, rushes *(Juncus spp.)*, bulrushes *(Scirpus spp.)*, and grasses that thrive in moist to wet soils. However, coverage and diversity of these species have been reduced by grazing, haying, and channel alterations that have resulted in decreased soil moisture conditions and invasion of exotic pasture grasses (Brunsfeld, 1994).

On wetter sites near the stream channel and in off-channel topographic depressions, communities of Drummond willow/beaked sedge *(S. drummondiana/Carex rostrata*) or Geyer willow/beaked sedge *(S. geyeriana/C. rostrata)* are expected to develop. On drier sites at the outside edges of the riparian zone and slightly drier meadow areas, communities of willows/bluejoint reedgrass *(Salix spp./Calamagrostis canadensis)* or willows/tufted hairgrass *(Salix spp./Deschampsia cespitosa)* are expected to develop.

PLANTING SCHEMES. An overview of the planting scheme for Phases I and II is provided in Figure 5.1. Riparian communities vary according to the three general stream reach types – straight, outside bend, or inside bend (Figure 5.2). The planting plan specifies Drummond willow, Geyer willow, Pacific willow, and sandbar willow. Subsequent field surveys determined that Booth willow was not part of the original dominant willow community in this geographic location and therefore was eliminated from the planting scheme. Other native woody species used in the design include red-osier dogwood, thinleaf alder, serviceberry (*Amelanchier alnifolia*), Douglas hawthorn *(Crataegus douglasii)*, quaking aspen *(Populus tremuloides)*, and bearberry honeysuckle. Although serviceberry, hawthorn, and quaking aspen are absent from the list of hypothesized original woody vegetation, these native species exist in limited numbers on or very near the project site, and therefore, were included in the planting design. Native herbaceous species include dagger-leaf rush (*Juncus ensifolius*), Coville's rush (*J. covillei)*, Colorado rush (*J. confusus),* small-fruited bulrush (*Scirpus microcarpus*), small-winged sedge (*C. microptera*), lens sedge (*C. lenticularis*), and beaked sedge (*C. rostrata*).

Planting Methodology

WOODY PLANT SPECIES. Willow species are planted as dormant pole cuttings during the late spring and summer. Other woody shrubs are planted as seedling plugs. Since native sources are unavailable on site, the willow pole cuttings are collected as close to the project site as possible. Geyer willow are collected in Elk City, Idaho; Drummond willow near Elk River, Idaho; and Pacific and sandbar willow are collected from the St. Joe or upper Clearwater rivers. Seed sources for alder, dogwood, aspen, honeysuckle, serviceberry, and hawthorn are found on the project site and up- or downstream.

Willow pole cuttings are collected, prepared, and cooler-stored during February and March prior to each field season. Pole cuttings are removed from the cooler and soaked in water for three days at ambient outside temperatures to initiate bud and root growth just prior to spring/summer planting. Project personnel experimented with a few red-osier dogwood pole cuttings (as opposed to seedlings grown in the greenhouse) in 1997. The red-osier dogwood pole cuttings received similar treatment as the willow plus horizontal scoring of the bark and soaking in a root-promoting acid solution (idolebutyric acid).

Seeds of thinleaf alder, red-osier dogwood, serviceberry, and other native woody species are collected in the summer/fall, cleaned and prepared for storage during the winter, and then planted in a commercial greenhouse in late winter and early spring (February through May). Seedlings can be planted in the fall or the following spring. Seedlings held over until the following spring are moved into a cooler during peak dormancy (January) and stored until ready to plant.

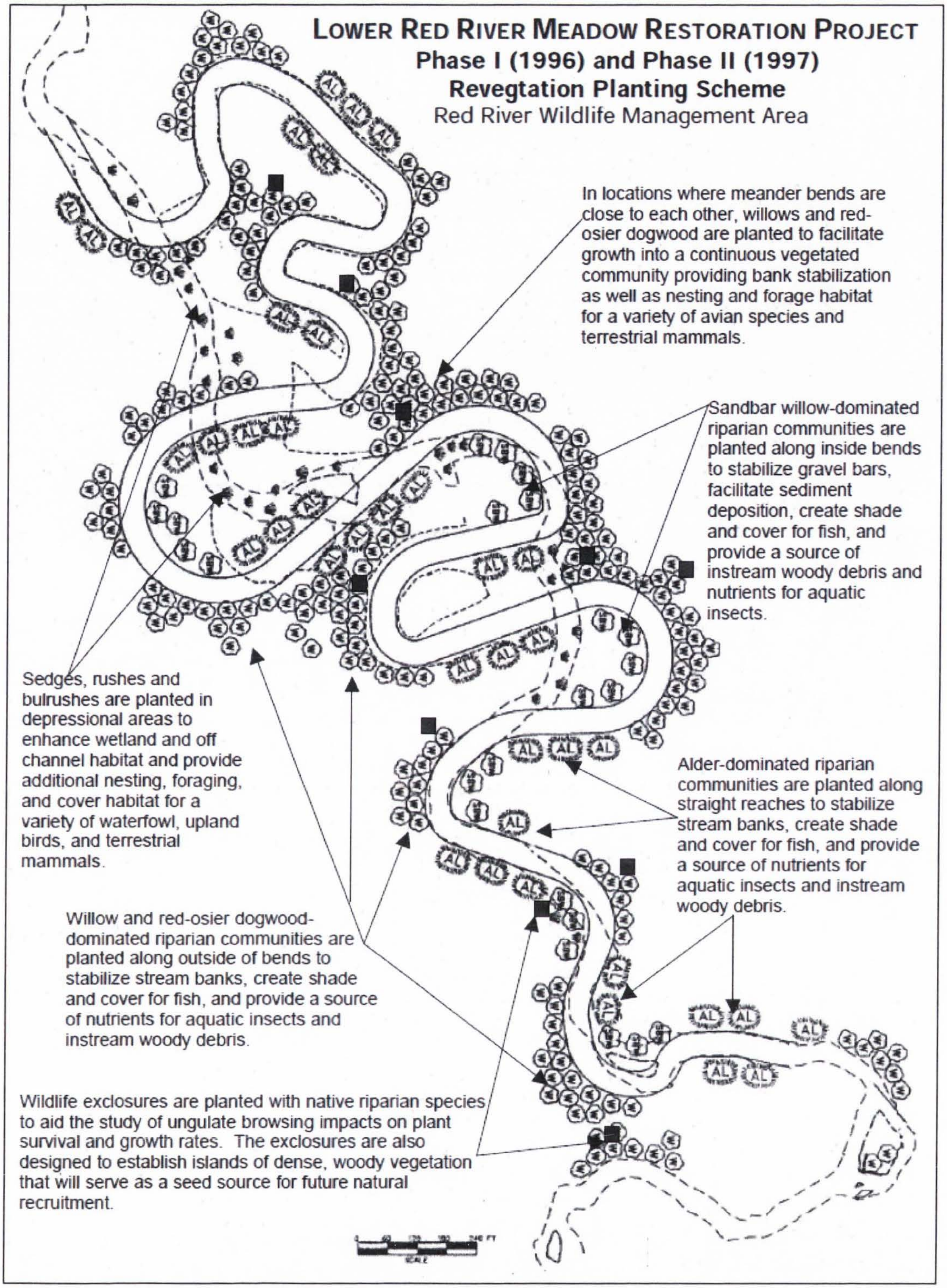


Figure 5.1. Locations and expected functions of native riparian plant communities in Phases I and II of the Lower Red River Meadow Restoration Project (adapted from RME, 1997).

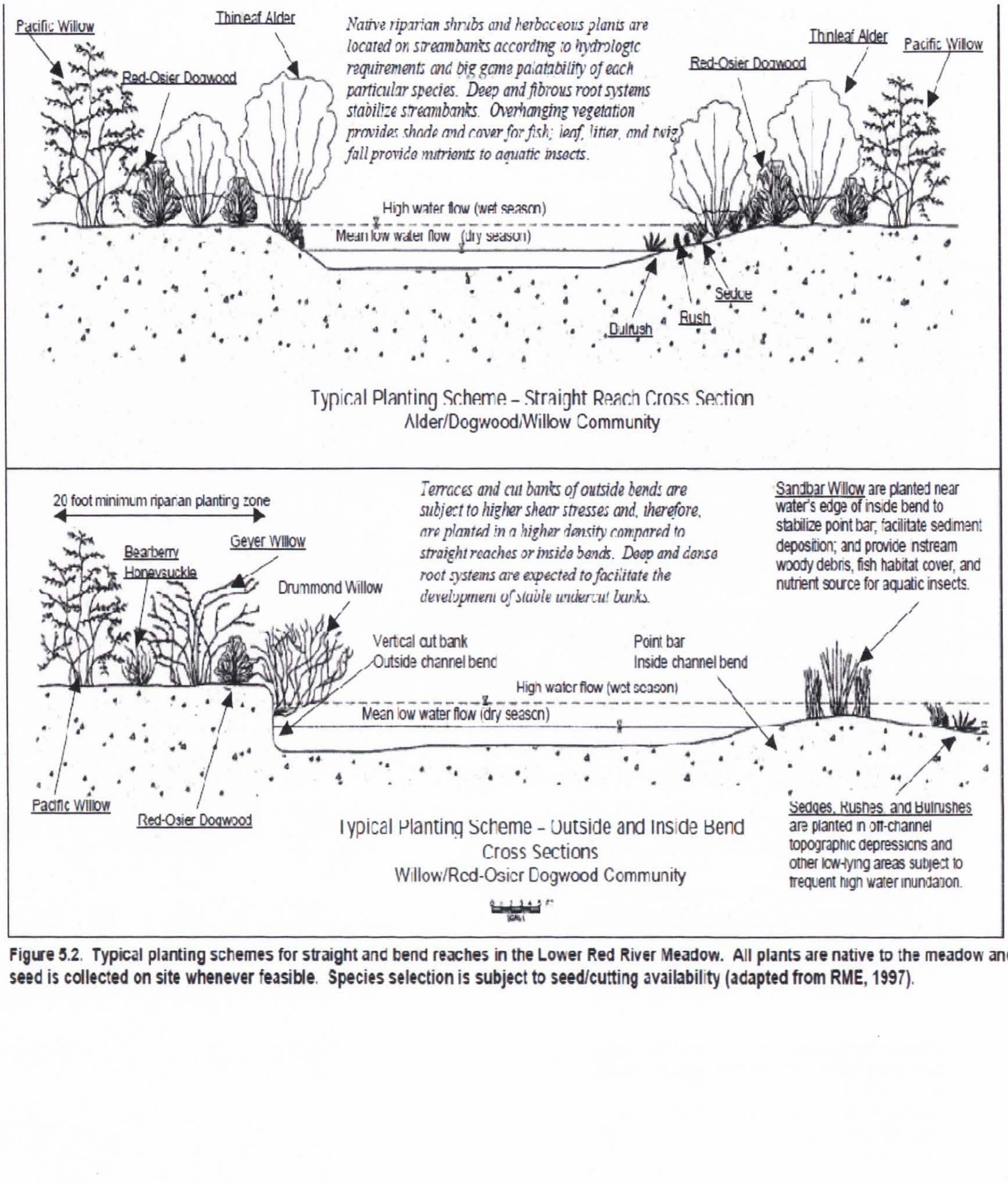


Figure 5.2. Typical planting schemes for straight and bend reaches in the Lower Red River Meadow. All plants are native to the meadow and seed is collected on site whenever feasible. Species selection is subject to seed/cutting availability (adapted from RME, 1997).

In general, planting locations are selected according to the hydrologic requirements and big game palatability of a particular species. For example, species requiring the highest amount of soil moisture, such as Drummond willow and sandbar willow, are placed closest to the water's edge. Drummond willow and red-osier dogwood, highly palatable to big game animals, are planted into the outside cut banks where access is difficult. Less palatable species, such as thinleaf alder, are used in the more game-accessible straight reaches.

Pacific and Geyer willow poles, ranging 5 to 10 feet (1.5 to 3 meters) in length, are placed within 20 feet (6.1 meters) of the water's edge on top of the bank or terraces. The terraces of outside bends are planted with a higher density planting [approximately 6 to 10 feet (1.8 to 3 meters) on center] compared to straight reaches or inside bends. A tree planting auger is used to drill 4 inch (10 cm) diameter holes as deep as possible to ensure the cuttings reach the mid-summer water table. An auger-resistant layer of river rock/gravel occurs at varying depths throughout the meadow. Holes drilled less than 32 inches (81 cm) deep, due to this impenetrable gravel layer, are abandoned and refilled. A single pole is placed in each hole and, if possible, pressed further into the ground. The holes are then backfilled with existing soil to achieve good soil to stem contact.

Drummond and sandbar willow poles, ranging from 4 to 8 feet (1.2 to 2.4 meters) in length, are placed at or near the water's edge. Depending on soil conditions, both Drummond and sandbar willow can either be inserted by hand or placed in a drilled hole. Drummond willow poles are pushed into the soil to reach the mid-summer water table, usually at a 45-degree angle to the vertical bank along outside bends (Figure 5.3). Drummond willow poles are planted in high densities, often exceeding 1 foot (30 cm) on center, to accelerate the development of stable streambanks, shade and cover, and reduced water temperatures.

Sandbar willow poles are pushed into the soil at or below the waterline on the inside bend point bars. In areas where soil conditions preclude hand placement, a hole is drilled to a 2-foot (61-cm) depth, the pole cutting is placed, and the hole is then backfilled to achieve good soil-to-stem contact. Sandbar willow poles are planted in point bar areas to facilitate long-term sediment deposition and subsequent decrease in channel width.

Thinleaf alder seedlings are planted along straight reaches and red-osier dogwood are interspersed amongst the Drummond willow along the outside bend cut banks. Serviceberry seedlings are planted on the top of banks or terraces. Woody seedlings are planted using an auger with a 1.5-inch (3.8-cm) diameter earth bit or hand dibble. The seedling is placed into the hole and then backfilled, using care not to create airspace along the seedling plug and soil interface.

HERBACEOUS PLANT SPECIES. Seeds from dagger-leaf rush, Coville's rush, Colorado rush, small-fruited bulrush, small-winged sedge, lens sedge, and beaked sedge are collected on the project site in August and September. Seedlings are grown in a commercial greenhouse in 10 cubic inch (164 cubic cm) containers the following spring and early summer and delivered to the meadow for planting in August and September.

Herbaceous plants are also placed according to their specific hydrologic and other known habitat requirements. Dagger-leaf rush, Coville's rush, and small-fruited bulrush are planted at or near the water's edge (Figure 5.4). Colorado rush and small-winged sedge are planted in dryer sites on top of the banks or terraces. Lens and beaked sedge are planted into the slumped areas of cut banks (Figure 5.3) and in off-channel water-holding depressions.

The majority of seedlings are planted with a 1.5-inch (3.8-cm) diameter, gas-powered auger/drill; a small percentage is planted with a hand dibble. The herbaceous seedlings are planted in varying densities. The design specifications set the spacing of herbaceous seedlings on approximately 4-foot (1.2-meter) centers, interspersed amongst the woody shrub species. In areas disturbed by construction and more susceptible to erosional forces, such as exposed vertical banks, herbaceous plant densities are increased.

GRASS SEEDING. An erosion control seed mix is sown in newly exposed soil disturbed by construction activities such as reinforced

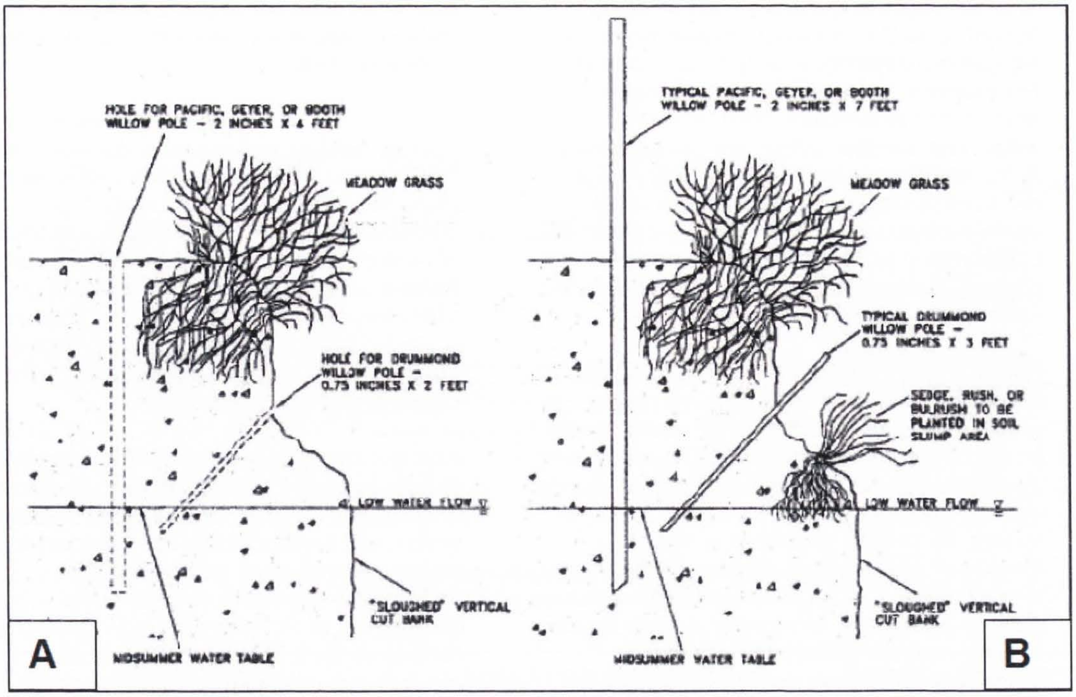


Figure 5.3 Typical planting details for placing dormant willow pole cuttings. Holes are drilled vertically or at a 45-degree angle into the streambank to a depth below the midsummer water table (A). Geyer and Pacific willow poles are planted on top of bank; Drummond willow poles are planted at an angle into the vertical outside bank, and herbaceous wetland plants are placed into soil slump areas (B) (adapted from RME, 1997).

Figure 5.4. Native, water-loving small-fruited bulrush are planted into exposed soil of an outside bend in Phase I, RRWMA, Lower Red River Meadow Restoration Project.

banks, former channel areas, and access roads. Prior to seeding, a finish-sized D4 bulldozer performs the final grading in construction areas and obliteration of temporary access roads. A four or six-wheeled ATV with harrow attachment follows the final grading to prepare a smooth seed bed. Using a spreader mounted on the ATV, the erosion control seed mix is broadcast over the disturbed areas. The seed mixture is comprised of the following six species and percentages:

- Sheep fescue 30% *(Festuca ovina)*
- Bromar mountain brome 30% *(Bromus carinatus)*
- Sherman big bluegrass 15% *(Poa sandbergii)*
- Canada Bluegrass 15% *(Poa compressa)*
- White dutch clover 10% *(Trifolium repens)*
- The above 5 species are mixed with ReGreen™*

**ReGreen™ is a sterile wheatgrass/wheat hybrid that establishes quickly, providing first year erosion control, and then dies out, allowing the native species to establish.*

The planted seed is subjected to a second harrowing to ensure good contact with the soil surface. A coconut fiber (coir) erosion control fabric is placed and stapled to the leading 50-foot (15-meter) edge of the reinforced bank areas (upstream ends of former channel). These areas are then re-seeded with the erosion control seed mixture. A general-purpose fertilizer (16-16-16) is applied with a hand spreader over all planted areas.

IRRIGATION. Due to low rainfall, typical during the summer months in the lower meadow, irrigation is supplied with overhead sprinklers until grass and forb seedlings are well established [> 2 inches (5 cm) tall]. Irrigation usually continues through the first week of October, thereafter, fall rains and cooler temperatures prevail. Irrigation is necessary only during the first growing season, immediately after planting, to ensure sufficient growth prior to fall dormancy and adequate erosion control for the following spring runoff. Plants utilize the natural supply of soil moisture during subsequent growing seasons.

WILDLIFE EXCLOSURES. Deer *(Odocoileus spp.)* and elk *(Cervus elaphus)* inhabit the Lower Red River Meadow and adjacent forested lands and can cause significant damage to fresh woody and herbaceous plantings. In an effort to limit and monitor ungulate browsing and to quickly establish on-site seed sources, the revegetation plan includes the construction of 20 wildlife exclosures in Phases I – IV on the RRWMA (Figure 5.5). Each 16' x 16' x 8' (4.9 m x 4.9 m x 2.5 m) exclosure consists of eight 6" x 6" x 12' (15 cm x 15 cm x 3.7 m) treated timbers placed 3 feet (0.91 meter) in the ground and eight stock panels stapled to the timbers. Cross cables and 2" x 6" x 16' (5 cm x 15 cm x 4.9 m) top boards are used to strengthen each structure. Exclosures are set with each side

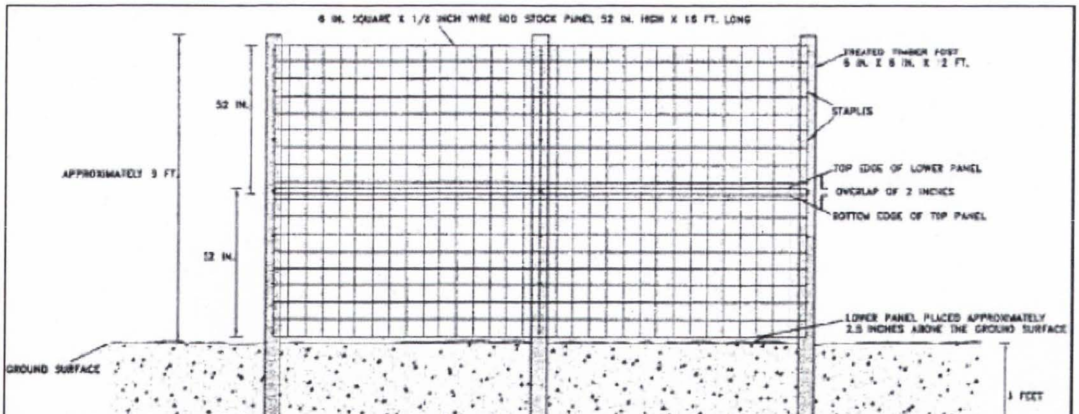


Figure 5.5 Wildlife exclosure details, cross-section view, for construction in Phases I – IV on the RRWMA, Lower Red River Meadow Restoration Project (adapted from RME, 1997).

facing one compass bearing of cardinal direction and the bottom panel on the south-facing side is fixed to drop down for access. Each exclosure is planted with a representative sample of woody seedlings and/or pole cuttings being planted in the project area (Figure 5.6).

5.3 Revegetation Accomplishments and Challenges

During 1996 and 1997 field seasons, 31,500 woody and herbaceous riparian plants were planted in a 20-foot (6 meter) riparian buffer along the stream reaches of Phases I and II on the RRWMA (Table 5.2). An erosion control seed mix consisting of 1,400 pounds (635 kilograms) of five native grass and one naturalized forb species and 600 pounds (272 kilograms) of ReGreen™ was sown. Planted areas were supplied with a total of 2,570 pounds (1,166 kilograms) of fertilizer. Coir fiber erosion control matting was installed on the four reinforced banks and eight wildlife exclosures were constructed.

Although a majority of the plants outside the exclosures appeared to be thriving well shortly after planting, elk damaged approximately 50 of the Pacific and Geyer willow poles by stripping the bark. The damage occurred primarily to willows planted on the top of the banks of outside bends on the west side of the river. However, nearly all of the damaged plants showed new shoots growing at or near

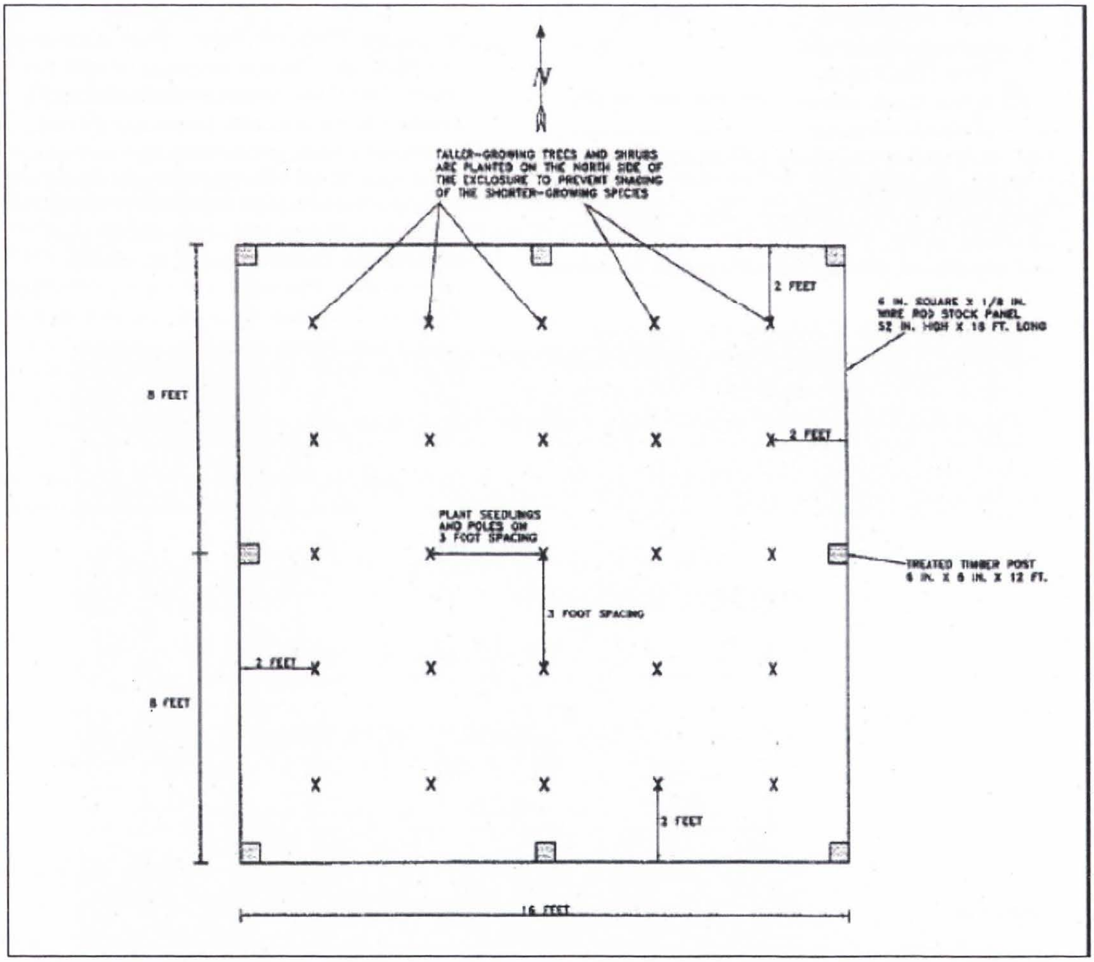


Figure 5.6 Wildlife exclosure layout. Twenty exclosures are planned for Phases I-IV on the RRWMA to document browsing impacts on newly planted vegetation and to establish islands of dense, woody vegetation that will serve as seed sources for future natural recruitment (adapted from RME, 1997).

ground level later in the growing season. A small number (< 25) of Drummond willow were damaged by beaver after initial planting.

During the 1997 field season, weather conditions changed dramatically after July 4th from cool and wet to hot [90°F (32°C)] and dry. Within a week, the majority of the thinleaf alder, dagger-leaf rush, and small-winged sedge that had been planted prior to July 4th displayed leaf browning. With irrigation, however, nearly all alder seedlings had grown new leaves within two weeks and the herbaceous plants had acquired extensive new growth prior to the first frost.

5.4 Expected Outcomes

In the long-term, streambank vegetation will become the natural stabilizing force, reducing erosion rates and providing shade, cover, and nutrient sources for aquatic organisms and fish. A dense and diverse riparian community will enhance wildlife habitat by providing food, cover, and nesting habitat for waterfowl, birds, and terrestrial mammals and will help lower stream temperatures as overhanging vegetation and stable undercut banks develop.

The project's long-term monitoring program will document the evolution of the expected target plant communities and the enhanced fish and wildlife habitat. First year planting success of woody and herbaceous vegetation in Phase I, evaluated from 1997 monitoring data, is discussed in Chapter 6.

Table 5.2. Numbers and species of seedlings and cuttings planted in Phases I and II on the RRWMA, Lower Red River Meadow Restoration Project, October 1997.

Common *(Scientific)* Name	1996 Phase I	1997 Phase II	TOTAL
Pole Cuttings			
Sandbar willow *(Salix exigua)*	545	-	545
Drummond's willow *(Salix drummondiana)*	3,000	355	3,355
Geyer willow *(Salix geyeriana)*	750	395	1,145
Pacific willow *(Salix lasiandra)*	525	-	525
Red-osier dogwood (*Cornus stolonifera)*	144	-	144
Subtotal	4,964	750	5,714
Herbaceous Seedlings			
Dagger-leaf rush (*Juncus ensifolius*)	1,601	1,627	3,228
Coville's rush (*Juncus covillei*)	1,600	1,087	2,687
Colorado rush (*Juncus confusus*)	300	791	1,091
Small-fruited bulrush (*Scirpus microcarpus*)	920	1,325	2,245
Small-winged sedge (*Carex microptera*)	3,286	2,510	5,796
Lens sedge (*Carex lenticularis*)	1,743	1,797	3,540
Beaked sedge (*Carex rostrata*)	1,200	1,550	2,750
Subtotal	10,650	10,687	21,337
Woody Seedlings			
Thinleaf alder (*Alnus incana*)	1,950	1,294	3,244
Red-osier dogwood (*Cornus stolonifera*)	1,000	-	1000
Serviceberry (*Amelanchier alnifolia*)	200	-	200
Subtotal	3,150	1,294	4,444
		TOTAL	**31,495**

United States Department of Agriculture
Natural Resources Conservation Service

Ecological Site Description

Jlg..
Species/comp. Data Needed
Formatted 2/3/05
Updated. 2/20/06

Site Type: Rangeland

Site Name: Meadow DECA18/CANE2

Site ID: R012XY038ID

Major Land Resource Area: B13X

Physiographic Features

This site generally occurs on gently sloping to nearly level stream valleys, high mountain valleys on flood plains with slopes of 0 to 4 percent. It also occurs around localized seeps and springs. This site is frequently crossed by old stream courses, oxbows and potholes. The surface is generally not flat, but slightly undulating with small depressions and high spots. Elevation ranges between 4000-8000 feet (4480-8960 meters).

Landform:

Flood plain: **Aspect:** All

	Minimum	Maximum
Elevation (feet):	4000	8000
Slope (percent):	0	4
Water Table Depth (Inches):	0	20-40
Flooding:		
Frequency:	occasional	
Duration:	very brief	brief
Ponding:		
Depth (inches):	2	6**
Frequency:	occasional	
Duration:	very brief	brief
Runoff Class:		

** Ponding occurs in small depressional areas within the site.

Climatic Features

Average annual precipitation varies greatly depending on the elevation and other factors. Soil moisture is influenced more by run-on, seepage and water table than from precipitation. Seasonal fluctuations in soil moisture or depth to water table seldom become critical to plant growth.

Plant growth usually begins as soon as ice, snow and floodwaters recede. This may occur any time after mid-April. Heavy frosts may occur until June and at higher elevations may come throughout the summer. Summer temperatures are usually cool and winters cold with heavy snowfall. Plant growth continues, in most years, until September 1 to October 1, depending on killing frosts. Optimum growth is from May 15 to August 15.

Minimum **Maximum**
Frost-free period (days):
Freeze-free period (days):
Mean Annual Precipitation (inches):

Average Monthly Precipitation (inches) and Temperature (°F):

	Precip. Max.	Precip. Min.	Temp. Max.	Temp. Min.
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

Climate Stations		**Period**	
Station ID	**Location or Name**	**From**	**To**

For local climate stations that may be more representative, refer to http://www.wcc.nrcs.usda.gov.

Influencing Water Features

Meadow site is influenced by additional water from either adjacent streams through seasonal flooding, water table, seeps or springs or from run-on from adjacent sites. The site may include the following wetlands and stream types.

Wetland Description:	**System**	**Subsystem**	**Class**	**Sub-class**
	Palustrine	**NA**	**Aquatic?**	
	Palustrine	**NA**	**Scrub-Shrub**	**Brd.-leav.**
Deci.				
	Riverine	**intermittent**	**Streambed**	**vegetated**

Stream Type: ??

Representative Soil Features

Soils on this site are mainly clays, clay loams, or silty clay loams over 20 inches (50 cm.), moderately deep to deep, alluvial in origin and may be somewhat stony or gravelly. The soils range from slightly alkaline to slightly acid in pH. Available water capacity is moderate to high and is supplemented by upward capillary movement from the shallow water table. The effective rooting depth is limited by the water table.

Erosion hazard is slight, however, the peaty and high organic soils tend to hummock severely from trampling. These soils are susceptible to gully formation which intercepts normal overflow patterns and results in site degradation. The soils are somewhat poorly drained and have a water table at or near the surface at the beginning of the growing season and down to 20-40 inches at the end of the growing season. Flooding occurs occasionally during snowmelt and just after snowmelt. Ponding can occur in small depressional areas during this time period. The plant community is dependent on near saturated soils during a major portion of the growing season. The water table is influenced by seasonal flooding, stream flows, seeps or springs or from run-on from adjacent sites. Soil characteristics, flooding and water table can vary across the complex of meadow sites.

Soil Series Correlated to this Ecological Site -

No data

Parent Material Kind:
Parent Material Origin:
Surface Texture:
Surface Texture Modifier:
Subsurface Texture Group: Surface Fragments ≤ 3" (% Cover):
Surface Fragments > 3" (%Cover):
Subsurface Fragments ≤ 3" (% Volume):
Subsurface Fragments > 3" (% Volume):

	Minimum	Maximum
Drainage Class:		
Permeability Class:		
Depth (inches):		
Electrical Conductivity (mmhos/cm)*:		
Sodium Absorption Ratio*:		
Soil Reaction (1:1 Water)*:		
Soil Reaction (0.1M CaCl2)*:		
Available Water Capacity (inches)*:		
Calcium Carbonate Equivalent (percent)*:		

- - These attributes represent from 0-40 inches or to the first restrictive layer.

Plant Communities

Ecological Dynamics of the Site:

The dominant visual aspect of this site is grass and sedges with scattered forbs and shrubs. The dominant plant community has tufted hairgrass, Nebraska sedge and other Carex species as major components. The site usually occurs within a complex of wetland sites. The soil surface of the site is typically slightly undulating causing small depressions and high spots with variable soil moisture characteristics. The plant communities found on these areas are sites within the complex. The dominant species in these included plant communities are as follows:

1. Shallow to depressions with the water table at or near the surface for the entire growing season are co-dominated by Carex spp. and Junus spp. These are Wet Meadow sites.

2. Deeper depressions with water slightly above the surface may have cattails, bulrush and Carex spp. This is the Marsh site.
3. Slightly higher areas that are drier during the growing season may have Nevada bluegrass, meadow barley, streambank wheatgrass, basin wildrye and some rushes. This is usually the Dry Meadow site.

Composition by weight is 80-90 percent grasses and grass-like, 5-15 percent forbs and 0-10 percent shrubs. The depression plant communities may have sedges and rushes species making up nearly 100 percent of the community and are inclusions.

In the last few thousand years, this site has evolved in an arid climate characterized by dry summers and cold, wet winters. The site has evolved on deep alluvial soils that are saturated to the surface in the beginning of the growing season to about 20 – 40 inches at the end of the growing season. Herbivory has historically occurred on this site at low levels of utilization. Herbivores include pronghorn antelope, mule deer, moose and Rocky Mountain elk.

Fire has had little influence on the development of the site. Rare wildfires can occur following consecutive drought years.

The conditions for the plant community of this site are highly variable due to a wide variation of soils, flooding frequency and duration, water table fluctuations, air and soil temperatures and competition between plants that are mostly rhizomatous. These conditions can vary within the site at a given location. At any one point within the site, one species can occupy nearly 100 percent of a small area. Another point nearby, may have another species fully occupying that area. Due to these situations, the plant community in this ESD is written broadly.

The soils within any complex of meadow sites are highly variable. Factors that affect the determination of the site include depth to water table at end of growing season, micro-topography and drainage class. Depth to water table and micro-topography are measurable features. Determination of drainage class requires the use of soil interpretation tables. Other interpretive factors that may be used for site determination are ponding frequency, depth and duration and flooding frequency, timing and duration.

Micro-topography is a feature that has a dramatic effect on depth to water table and the resulting plant communities. A few inches of change in surface elevation changes species composition and/ or production. Slightly undulating topography is common in meadow complexes, therefore, more than one site should be expected.

An infinite number of combinations of factors that influence the ecology of potential plant communities exist. For practical purposes, four plant communities where the depth to the water table drives the vegetative composition have been described. They are:

Dry meadow	Water table at >40" at end of growing season
Meadow	Water table at 20-40" at end of growing season
Wet meadow	Water table at 10-20" at end of growing season
Marsh	Water at surface to <10" at end of growing season

Most wetland species have a wide range of tolerance for variations in soil moisture. Most species occur in more than one site, although most are dominant on just one site.
The following table shows the amplitude of wetland species that occur on the four sites.

Ecological Amplitude of Meadow/Marsh Plants.

Grass and Grass-like Species

Scientific name	Dry Meadow	Meadow	Wet Meadow	Marsh
Leymus cinereus				
Danthonia califormica				
Carex filifolia				
Pascopyron smithii				
Poa secunda				
Juncus dudleyi				
Muhlenbergia richardsonis				
Hordeum brachyantherum				
Phleum alpinum				
Juncus balticus				
Juncus torrei				
Alopecurus aequalis				
Carex athrostachya				
Calamagrostis canadensis				
Deschampsia caespitosa				
Carex nebrascensis				
Glyceria striata				
Carex lasiocarpa				
Carex utriculata				
Carex aquatilis				
Eleocharis palustris				
Carex rostrata				
Carex hoodii				
Carex exsiecata				
Scirpus microcarpus				
Juncus effusus				
Beckmannia syzigachne				
Typha latifolia				
Schoenoplectus acutus				
Schoenoplectus pungens				
Sparganium erectum				
Schoenoplectus tabemaemontani				

Forb Species

Scienfific name	Dry Meadow	Meadow	Wet Meadow	Marsh
Arnica fulgens				
Pyrrocoma lanceolata				
Arenaria congesta				
Artemisia ludoviciana				
Achillea millefolium				
Wyethia amplexicaulis				
Pyrrocoma uniflora				
Ranunculus spp.				
Trifolium spp.				

Potentilla gracilis				
Senecio integerrimus				
Aster spp.				
Scientific name	Dry Meadow	Meadow	Wet Meadow	Marsh
Cirsium scariosum				
Symphyotrichum ascendens				
Iris missouriensis				
Senecio serra				
Helianthus nuttallii				
Camassia quamash				
Epilobium ciliatum				
Montia chamossoi				
Plantago major				
Alisma triviale				
Cicuta douglassii				
Argentina anserina				
Veronica anagallis-aquatica				
Symphyotrichum frondosum				
Polygonum bistortoides				
Triglochin maritimum				
Polygonum amphibium				
Symphyotrichum foliaceum				
Potamogeton natans				
Lemna minor				

The plant species composition of Phase A is listed later under "HCPC Plant Species Composition".

The Historic Climax Plant Community (HCPC) moves through many phases depending on the natural and man-made forces that impact the community over time. State 1, described later, indicates some of these phases. The HCPC is Phase A. This plant community is dominated by tufted hairgrass and Nebraska sedge. There are a wide variety of grasses and grass-like species and forbs that may occur in minor amounts. Some of these species may be dominant in small areas due to soil and water variations as stated above. Willows and shrubby cinquefoil can occur in small amounts. The plant species composition of Phase A is listed later under "HCPC Plant Species Composition".

The total annual production is 3600 pounds per acre (4032 kilograms per hectare) in a normal year. Production in a favorable year is 4500 pounds per acre (5040 kilograms per hectare). Production in an unfavorable year is 2500 pounds per acre (2800 kilograms per hectare). Structurally, cool season deep-rooted perennial grasses and sedges are very dominant, followed by perennial forbs being more dominant than shrubs.

Rangeland Health Indicators.

Rills: do not occur on this site.

Water flow patterns: Water flows over and through the plant community. Rarely are flows detrimental to the plants. The plants have adapted or evolved with this occurrence.

Pedestals: do not occur on this site. Some plants may be hummocked due to trampling damage. Terracettes do not occur.

Bare ground: data is not available. On sites in mid-seral status bare ground may range from 2-10 percent.

Number of gullies and erosion associated with gullies: None.

Wind scour: blowouts and depositional areas do not occur

Litter movement: Fine litter in the interspaces may move 6 feet or more due to seasonal flooding. Litter accumulates on the surface. There is little or no coarse litter developed on the site, and it will be removed from the site following seasonal flooding.

Soil surface stability: values should range from 3 to 5 but needs to be tested.

Soil surface structure and SOM content: The A or A1 horizon is typically ________inches thick Structure ranges __________ Soil organic matter (SOM) needs to be determined

Effect of plant community on infiltration: Deep rooted perennial grasses and sedges slow run-off and increase infiltration. The total vegetation cover should be >60 percent to optimize infiltration. The plant community does not depend on water infiltration alone, but on the water table. The water table controls rooting depth.

Compaction layer: is not present. Compaction layers can develop under stock trails made by livestock going to and from water or from long-term repetitive heavy grazing

Functional/ structural groups: Deep rooted perennial grasses and sedges >> perennial forbs> shrubs.

Plant mortality/ decadence: Normal mortality of grass and grass-like is slow and occurs as aging plants. This will go unnoticed due to regeneration from roots, seeds or other new plants filling the spaces.

Litter cover: Additional litter cover data is needed but is expected to be 45-60 percent to a depth of 0.5-1.5 inches. Litter accumulates on the soil surface.

Expected annual production: is 3600 pounds per acre (4032 Kg/ha) in a year with normal precipitation and temperatures. Perennial grasses and sedges produce 80-90 percent of the total production, forbs 5 15 percent and shrubs 0 10 percent.

Invasive and/or noxious species: include whitetop, Leafy spurge, Dock, Canadian thistle, reed canarygrass, foxtail barley, perennial pepperweed and teasel. Other invasive species may include meadow foxtail, redtop and Kentucky bluegrass.

Perennial plants: in all functional groups have the potential to reproduce in most years. Many of the plants reproduce vegetatively.

Function:

This site is suitable for big game and livestock grazing in the late spring, summer and fall. Wet soils can limit grazing opportunities, particularly early in the year.

This site can be used for hiking, access to fishing, hunting, viewing wildlife and plants, and horseback riding. The wet soils can limit access. Motorized vehicles can be very detrimental to the site especially when soils are saturated to the surface.

Due to the deep soils, fertility, inherent high productivity of the site, plants with rhizomes and relatively flat slopes, it is fairly resistant to disturbances that can potentially degrade the site. Site degradation is usually the result of lowering of the water table. This can occur with down cutting of adjacent stream channels or significant run-off following prolonged drought. This can result from on-site improper grazing or off-site conditions in the upper watershed. Once adjacent streams down-cut, concentrated flows lower the water table.

Impacts on the Plant Community:

Influence of fire:

This site usually does not burn from wildfire. If a fire occurs, it usually does not affect the plant community adversely. Most plants including shrubs sprout back after sufficient moisture and the next growing season

Influence of improper grazing management:

Season-long grazing can be very detrimental to this site. Excessive utilization is also detrimental. The grasses in the plant community will decline in the stand and sedges, rushes and forbs will increase. Continued improper grazing management will result in a stand of forbs and Kentucky bluegrass with sedges and rushes. The reduced ability of the community to withstand seasonal flooding is reduced and down cutting of adjacent streams can result or initiation of headcuts can occur. This down cutting will lower the water table and thus reduce the potential of the site

Good grazing management that addresses frequency, duration, and intensity of grazing can maintain the integrity of the plant community and the water table on which it is dependent.

Weather influences:

Because of the deep soils, the influence of the water table, seasonal flooding and run-on, the production of this site changes little during wet or dry precipitation years. The plant overall production can be influenced adversely with prolonged drought. Overall plant composition is normally not effected when perennials have good vigor.

Below normal temperatures in the spring can have an adverse impact on total production regardless of the precipitation. A hard, early freeze can kill some plants occasionally.

Insects and disease outbreaks:

Periodic disease and insect outbreaks can affect health of vegetation. Mormon cricket and grasshopper outbreaks occur periodically. Outbreaks seldom cause plant mortality since defoliation of the plant occurs only once during the year of the outbreak. An outbreak of a particular insect is usually influenced by weather but no specific data for this site is available

Influence of noxious and invasive weeds:

Annual and perennial weeds can compete with desirable plants for moisture and nutrients. The result is reduced production and change in composition of the plant community. The plants on this site are very good competitors to potential weeds.

Influence of wildlife:

This site is important for many species of mammals for food and life cycles. The site is primarily used in the late spring, summer, and fall by big game. Many birds use the site for food, nesting or brood raising in the late spring, summer, and fall. Sage grouse use the site for brood rearing and forage. Total numbers are seldom high enough to adversely affect the plant community.

Watershed:

The largest threat to degradation of this site is the lowering of the water table. Off-site conditions can affect the gradient of adjacent stream channels that can affect the water table. If the perennial grass and sedge cover is depleted, down cutting can be accelerated within the site. High run-off events from the adjacent uplands can severely damage or change the normal stream channel on the site. . As the water table is lowered, productive potential is lost. Eventually the water table is below the reach of the roots of the adapted perennial grasses and grass-like sedges and rushes. These are ultimately replaced by perennial forbs and shallow rooted grasses. Extreme down cutting and lowering of the water table can move the site across the threshold to a new, less productive site. Severe down-cutting can result in a plant community that resembles an upland site.

Plant Community and Sequence:

Transition pathways between common vegetation states and phases:

State 1.

Phase A to B. Develops with improper grazing management.
Phase B to A. Results from prescribed grazing.

State 1 to 2. Develops through permanently lowering the late growing season water table to 40 to 60 inches. This can occur with continued improper grazing management. It may also occur with proper grazing on the site, but channel erosion may continue if poor off-site conditions cause frequent and/or severe flooding.

State 2 to unknown site. Results from permanently losing the water table in the soil profile through down cutting of the stream channel. The site retrogresses to a new site with reduced potential due to significant loss of available soil moisture from the lowered water table. It occurs with continued improper grazing management or repeated significant run-off events.

Practice Limitations:

There are moderate to severe seeding limitations on this site due to difficulty in preparing adequate seedbed. Elimination of existing vegetation prior to planting is difficult in wet seasons and high water table periods. Grade stabilization structures may be needed to prevent further down-cutting of the channel. Other options for rehabilitation may include application of fertilizer, prescribed grazing and off-site livestock water development. Fencing of the site for better livestock control might be considered.

Plant Community Narrative:

State 1, Plant Community A. Historic climax plant community. The HCPC has tufted hairgrass and Nebraska sedge as co-dominant in the herbaceous layer. There are a wide variety of grasses and grass-like species and forbs that may occur in minor amounts. Some of these species may be dominant in small areas due to soil and water variations as stated above. Willows and shrubby cinquefoil can occur in small amounts.

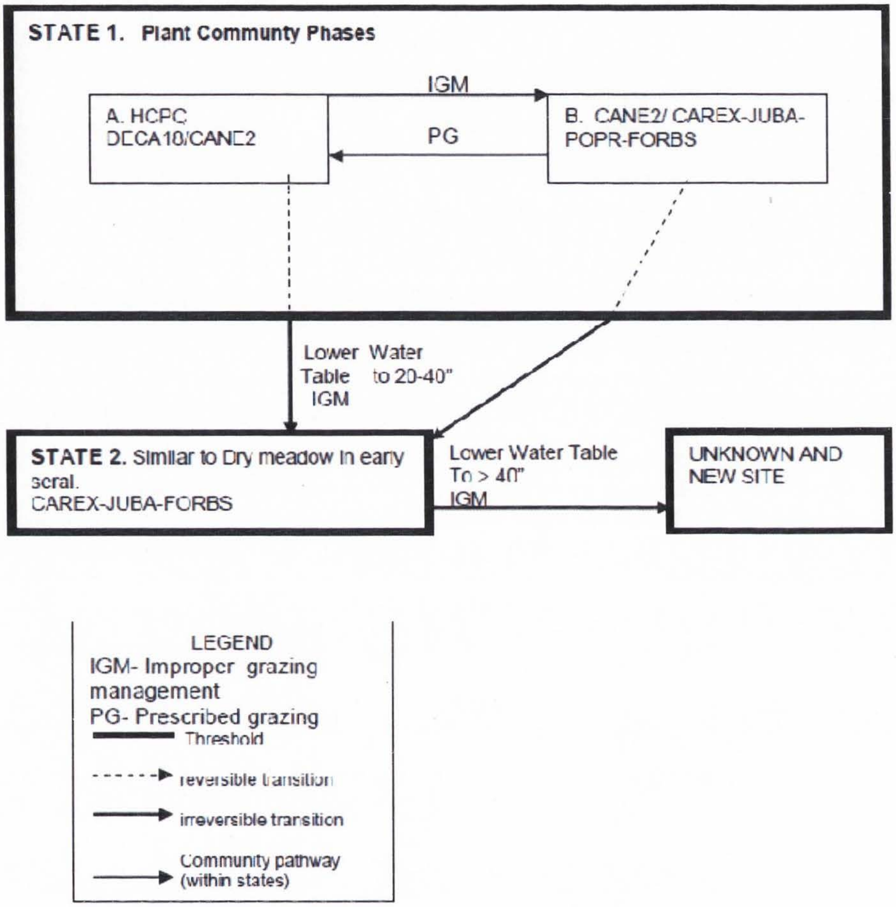
State 1, Plant Community B. This plant community is dominated by Nebraska sedge and other sedges and Baltic rush. Forbs have increased in the community and Kentucky bluegrass may have invaded. This phase has developed due to improper grazing management. The water table has not been lowered from that of Phase A.

State 2. This plant community is dominated by Nebraska sedge and other sedges and Baltic rush but the overall production potential of the site is much lower than State 1. There is an increase in forbs and grasses that require less soil moisture. Kentucky bluegrass, redtop bentgrass and meadow foxtail may have invaded the community. This state developed due to continued improper grazing management and a permanent lowering of the water table from 20-40 inches to 40-60 inches below the surface. This state can be similar to Dry Meadow in early seral state. The site has crossed the threshold. This state cannot be returned to State 1 without raising the water table. This might be done using structures or bio-engineering over time, but the plant community may take many years to approach the plant community in State 1.

Unknown new site: This plant community has gone over the threshold to a new site. Site potential has been reduced. Significant loss of available soil moisture has occurred due to the loss of a water table. Some soil loss from the surface has occurred. This state has developed due to continued improper grazing management and lowering or loss of a water table. The new site may be similar to upland sites such as Loamy Bottom other loamy sites in early seral state.

State and transition model diagram:

The Historic Climax Plant Community (HCPC) moves through many phases depending on the natural and man-made forces that impact the community over time. The HCPC is Phase A. The plant species composition of Phase A is listed later under "HCPC Plant Species Composition".



HCPC Plant Species Composition:

Common/Group Name	Plant Symbol	Group	% Comp	lbs./acre
Grasses and Grass-likes				
Tufted hairgrass	DECA18		10-20	375-675
Nebraska sedge	CANE2		5-25	375-675
	CAAT3		0-5	0-113
Baltic rush	JUBA		0-10	0-225
	HOBR2		0-5	0-113
	CACA4		0-2	0-45
	GLST		0-5	0-113
	PHAL2		5-10	188-337
	ALAE		0-2	0-45
	JUTO		0-5	0-113
Forbs	**Plant Symbol**	**Group**	**% Comp**	**lbs./acre**
	TRIFO		0-2	0-45
	POGR9		0-2	0-45
	SEIN2		0-2	0-45
	ASTER		0-2	0-45
	CISC2		0-1	0-23
	EPCI		0-1	0-23
	RACY		0-2	0-45
	HENU		0-2	0-45
	MOCH		0-2	0-45
	PLMA2		0-2	0-45
	IRMI		0-2	0-45
	SYAS3		0-2	0-45
	CAQU2		0-1	0-45
	ALTR7		0-2	0-45
	SESE2		0-2	0-45
	RUCR		0-2	0-45
Shrubs	**Plant Symbol**	**Group**	**% Comp**	**lbs./acre**
	SALIX		0-5	0-113
	DAFL3		0-5	0-113

Annual Production lbs./Acre	Low	RV	High
Grasses & Grass-Likes	2125	2975	3825
Forbs	250	350	450
Shrubs	125	175	225
Total	2500	3500	4500

Growth Curve:

Growth curve number: ID0814
Growth curve name: Meadow
Growth curve description: State 1, HCPC

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

0	0	0	5	20	20	35	20	10	0	0	0

Growth curve number: ID0815
Growth curve name: Dry MEADOW early to mid seral.
Growth curve description: State 2

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	10	20	25	25	10	10	0	0	0

Ground Cover and Structure:

Ground cover by vegetation and litter is 90-95 percent.

Soil Surface Cover-

Plant Basal Cover:	no data
Microbiotic crusts:	no data
Litter:	no data
Surface Fragments:	no data
Bare Ground:	no data
Other:	no data

Ground Cover (Vertical view)-

Plant Canopy Cover (species or groups):	no data
Microbiotic Crusts:	no data
Litter:	no data
Surface Fragments:	no data
Bare Ground:	no data

Structure of Canopy Cover-

Herbaceous:	no data	Height: 1-2 ft.
Shrub:	no data	Height: 2 ft.
Tree:	none	

Ecological Site Interpretations:

Animal Community:

Wildlife Interpretations:

This site is poor to fair habitat for open land wildlife, fair habitat for woodland wildlife, fair to good habitat for wetland wildlife. It is good habitat for waterfowl, shorebirds, muskrat and beaver whenever it is adjacent to stream and ponds. It provides some food for moose, elk, deer, some upland game birds and songbirds, and provides brood rearing areas for sagegrouse.

Grazing Interpretations:

This site is best suited for livestock grazing in the late spring, summer and fall. Wet soils can limit grazing opportunities, particularly in the late spring.

Estimated initial stocking rate will be determined with the landowner or decision-maker. They will be based on the inventory, past use history and type, condition of vegetation, production, season of use and seasonal preference. Calculations used to determine estimated initial stocking rate will be based on forage preference ratings.

Plant Preference by Animal Kind:

Plant list for Beef Cattle and Rocky Mountain Elk.

DECA18
CANE2
JUBA
PHAL2
SALIX

Plant list for Sheep, Mule Deer, and Pronghorn Antelope.

DECA18
CANE2
JUBA
PHAL2
SALIX

Hydrology Functions

Soils in this site are generally grouped in hydrologic group D. When hydrologic condition of the vegetative cover is good, natural erosion hazard is slight.

Recreational Uses

This site presents an aesthetically pleasing view of lush vegetation consisting primarily of grasses and grass-like plants. When livestock or big game are grazing or browsing on the site it presents a pleasant pastoral panorama. Hikers and fisherman often traverse the edges of this site. Picnickers and campers frequent the site in late summer and early fall as sometime adjacent shaded wooded areas become less pleasant on cool days. Vehicular use can be very detrimental to this site, especially during wet weather and high water table conditions.

Wood Products

None

Other Products

none

Supporting Information

Associated Sites:

Dry Meadow
Wet Meadow
Riparian sites
Loamy Bottom
Upland sites

Similar Sites

Dry Meadow
Wet Meadow

Inventory Data References

Information presented here has been derived from NRCS clipping and other inventory data. Also, field knowledge of range-trained personnel was used. Those involved in developing this site description include

Dave Franzen, co-owner, Intermountain Rangeland Consultants, LLC

Jacy Gibbs, co-owner, Intermountain Rangeland Consultants, LLC

Jim Cornwell, State Rangeland Management Specialist, NRCS, Idaho

Dan Ogle, Plant Materials Specialist, NRCS, Idaho

Chris Hoag, Wetland Plant Ecologist, NRCS, Idaho

Data Source	Number of Records	Sample Period	State	County

State Correlation

none

Type Locality

No data

State: **County**: **Latitude**: **Longitude**:
Township: **Range**: **Section**:
Is the type locality sensitive? (Y/N): No data **General Legal Description**: no data

Field Offices

American Falls
Blackfoot
Burley
Driggs

Ft. Hall
Idaho Falls
Malad
Pocatello
Rexburg
Soda Springs
St. Anthony

Relationship to Other Established Classifications

No data

Other References

USDA, NRCS.2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov.) National Plant Data Center, Baton Rouge, LA 70874-4490 USA

USDA NRCS. 1992. Major Land Resource Area, Owyhee High Plateau, Range Site Descriptions. Reno, Nevada.

USDA NRCS. Major Land Resource Area, Owyhee High Plateau, Range Site Descriptions. Portland, Oregon.

USDA, Forest Service. 2004. (www.fs.fed.us/database/feis/plants.).

Site Description Approval

_______________________________ _______________
State Range Management Specialist Date

_______________________________ _______________
State Range Management Specialist Date

_______________________________ _______________
State Range Management Specialist Date


Headgate
Diversion dike
New Channel
Riparian Area

Trout Creek Reclamation Project – NWW 2007-1180

Response 4 - Overall Goals and, Monitoring and Measurement Plan

This plan provides goals and, monitoring and measurement for three distinct activities for this project, 1) creation of wetland plant community diversity in the seep areas, 2) channel stability and riparian plant community density in the reclaimed channel, and 3) creation of aquatic habitat in the reclaimed channel.

Creation of Wetland Plant Community Diversity in the Seep Areas

Goal: Increase plant species diversity and habitat diversity by removing select areas of cattails in the cattail dominated plant communities in the wetland seeps. The goal is to increase the number freshwater emergent species along with additional open, deeper water habitat.

Monitoring and Measurement: Two monitoring transects will be set up in two of the five wetland seeps to be modified. These transects will be photographed pre-modification and once a year for three years after construction. A person qualified in wetland plant identification will describe the wetland plant species composition along these transects during annual monitoring and submit the results with the photos. Transects will be located with posts that extend a minimum of 36 inches above grade at each end of the transect.

Channel Stability and Riparian Plant Community Density

Goal: Along the reclaimed Trout Creek establish a healthy and robust riparian plant community composed of native and naturalized, grasses, forbs, woody shrubs and trees. Noxious weeds are controlled and at density equal or less than typical healthy riparian plant communities in the area.

Monitoring and Measurement: Annually the entire length of the reclaimed channel will be walked looking for areas of bank instability and erosion, specifically cut banks. Eroding bank areas will be photographed and a description of activities to be undertaken to stabilize that location will be submitted with the annual report. Once an erosion site is identified for remedial action it will be monitored yearly and any additional actions needed reported in the annual report.

The riparian plan community along the reclaimed trout creek shall be monitored annually at three transects. These locations will be marked with a post at each end of the transect ends and the post shall extend a minimum of 36 inches from the ground. Targets for plant establishment are 60% cover at the end of the first growing season, 80% cover at the end of the second growing season and 90% cover at the end of the third growing season. Areas that do not meet these targets will receive supplemental planting or seeding. The annual report will provide pictures at these transects and a person qualified to identify wetland and riparian plants will describe the plant species composition.

Stenberg 3.7.08