

Revegetation of Reconstructed Reaches of the Provo River, Heber Valley, Utah

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In: Riley, L. E.; Dumroese, R. K.; Landis, T. D., tech. coords. 2006. National Proceedings: Forest and Conservation Nursery Associations-2005. Proc. RMRS-P-43. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 160 p. Available at: <http://www.rngr.net/nurseries/publications/proceedings>

Abstract: In 1999, the Utah Reclamation Mitigation and Conservation Commission began the Provo River Restoration Project to create a more naturally functioning riverine ecosystem between Jordanelle Dam and Deer Creek Reservoir. The purpose of the project was to mitigate for past impacts to riverine, wetland, and riparian habitats caused by the Central Utah Project and other Federal reclamation projects in Utah. Project implementation followed a management model where a great deal of planning and study preceded construction, which was closely followed by monitoring. Lessons applied to habitat restoration include: avoiding compaction; working with the natural disturbance regime of the river; and choosing the right plants for the site, including selecting the right size plant materials and outplanting at the appropriate density. Lessons learned include coordinating plant installation with plant availability and planting site availability, and irrigating during drought.

Keywords: fish habitat, wildlife habitat, native species, ecosystem restoration, riparian restoration

Introduction

Prior to the 1950s, the middle Provo River in Utah offered outstanding fish and wildlife habitat. This was due in part to the Provo River freely meandering through the Heber Valley. These bends in the river provided deep holes for fish and a dense streamside forest for many species of birds. This productive habitat was altered in the 1940s and 1950s when the river was dammed, channelized, and forced between dikes (figure 1). These dikes were constructed by the USDI Bureau of Reclamation (USBR) to contain high flows that came from additional water added to the Provo River from transbasin diversions. With the loss of the meandering channel came loss of fish and wildlife habitat.

In 1992, Congress created the Utah Reclamation Mitigation and Conservation Commission (Mitigation Commission) to assure that mitigation for the Central Utah Project (CUP) and other Federal reclamation projects in Utah was accomplished. With the creation of the Mitigation Commission, new standards were imposed on mitigation projects that can be summarized as an "ecosystem restoration" standard. With this mandate, the Mitigation Commission was directed to support mitigation projects that integrated multiple aspects of the environment.

Fish and riparian habitat in the middle Provo River was severely degraded as the result of earlier actions taken to develop Provo River waters for agricultural, municipal, industrial, and other purposes. Knowing the past productivity of the middle Provo River for fish and wildlife habitat, interest turned to the middle Provo River as a site for CUP mitigation.

The Provo River Restoration Project (PRRP) involved removing or setting back most existing flood-control dikes, restoring meanders, and reestablishing a floodplain along the middle Provo River. The project began in 1999 and is anticipated to continue through 2006. In addition to fish and riparian habitat restoration, this project included acquisition of angler access, modification of diversion dams to bypass instream flows, and recreation facilities planning and development.

Physical and Biological Studies

The PRRP followed a management model where a great deal of planning and study preceded construction, which was followed by monitoring. An interdisciplinary team of scientists contributed their expertise to PRRP by designing and implementing several studies. These biological and physical studies provided three essential components for restoration: 1) a thorough description of the existing physical condition of biological communities (that is, baseline condition); 2) a basis for restoration design; and 3) initiation of monitoring that enables managers to detect measurable change due to restoration activities and to make informed management decisions.



Figure 1—Provo River in Heber Valley before restoration.

Scientists involved in the physical studies included hydrologists, geologists, and geomorphologists. To understand the character of the middle Provo River, scientists reviewed the geologic history and geological setting of the Heber Valley. This provided insight into the natural Provo River condition prior to human disturbance.

Hydrologists evaluated old hydrologic records and used computer simulations of natural conditions and stream gauge records to reconstruct natural Provo River hydrological conditions. Many plants and wildlife species are adapted to and depend on seasonal variations of natural flows. Using information from hydrology studies, the Commission worked with the Central Utah Water Conservancy District, Provo River Water Users Association, USBR, and others to implement flows that mimic natural flow patterns while continuing to meet water user needs.

The forces of flowing water carve a river channel. Channel size, shape, and pattern are related to flow magnitude, duration, and frequency as well as valley soils and slope. River mechanics experts determined the forces and sediment transport capability of the middle Provo River. With this data, designers identified expected channel characteristics and designed channels that will be sustained by natural processes. The channels also should provide flow depths and velocities consistent with native species habitat needs.

Biological Studies

Biological studies helped designers: 1) determine the condition of the biological community, 2) understand habitat needs of native plants and animals, and 3) plan for desirable habitat conditions for plants and animals. A primary PRRP goal was to increase game fish populations and suitable habitat. Restoring a meandering river channel has its most immediate effects on game fish populations by quickly increasing availability of cover, suitable spawning areas, and rearing areas. The Utah Division of Wildlife Resources has three fish population sampling stations on the Provo River within the Project area. Aquatic invertebrate monitoring is being conducted using intensive, semi-quantitative techniques to monitor changes in aquatic insect populations over time. Preliminary results bear out what was anticipated—early colonizers moved into restored sections within 3 months of construction. A year after construction, many of the common Provo River insects are once again abundant (URMCC 2003a).

Birds—Birds, especially migratory songbirds, were one of the main groups of wildlife used to develop habitat restoration guidelines. Scientists completed a 3-year baseline study that included habitat analysis (URMCC 2003b). The study related the abundance of riparian birds to vegetation types. A statistical habitat analysis involved a variety of vegetation attributes (such as tree density, number of tree species, wetland coverage, shrub coverage, and so on) and the presence of certain birds.

Small Mammals—Surveys of small mammals were conducted prior to restoration in the hopes of providing a baseline species list and recommendations for enhancements during restoration (Gannon and Sherwin 2001). These enhancements would be intended to restore mammalian diversity and abundance to historical levels prior to river channelization and intensive agricultural activity,

Plant Species—A botanical study was conducted along the PRRP corridor to ascertain physical requirements for establishing native riparian and wetland plants (Stromberg and others 1999). Plant species were combined into groups according to their requirements for soils, ground water, elevation, flow regimes, and location in relation to river and wetlands. The various requirements are being used for revegetating reconstructed stream banks and wetlands.

Construction and Revegetation Planning

Construction planning began with the end in mind and attempted to minimize the amount of land alteration. This yielded not only a cost benefit, but also lessened the impact to the environment. Careful planning for the construction phase was required in order to minimize materials handling (including the harvest, stockpile, and placement of topsoil), minimize grading for haulage equipment, and dispose of excess material onsite.

The harvest, stockpile, and placement of topsoil were planned carefully so that materials were handled as little as possible. Topsoil harvest, stockpiling, and placement guidelines used for the PRRP were as follows:

1) Topsoil should be stripped from all areas to a depth of 18 in (46 cm) or to a depth where significant (>50 percent) rock, stone, cobble, and so on are encountered, whichever comes first.

2) Subsoil with <40 percent rock, stone, cobble, and so on should be stockpiled separately.

3) Subsoil with >40 percent rock, stone, cobble, and so on should be stockpiled separately, used to construct features, or removed.

4) The top 12 in (30.5 cm) of soil from areas where weeds are common should be stripped and spoiled (bury it deep!).

5) Topsoil and suitable subsoil should be used to the maximum extent possible (no less than 1 ft 130.5 cm) of topsoil over subsoil).

6) Topsoil/subsoil should be placed following all construction and final grading, and just before planting, to avoid any activity that would result in compaction or that would require re-working the site.

7) Topsoil and subsoil should be transported dumped in suitable locations/piles so that it can be spread with a backhoe bucket and not driven on (even by the backhoe) or compacted in any way.

Haul routes were minimized, and, to the maximum extent practicable, did not cross wetlands, wet areas, or constructed features. If crossing a constructed feature became necessary, compacted areas were ripped prior to topsoiling. No crossing was permissible on topsoiled areas (figure 2).

Onsite disposal of excess material can cause site impacts by disturbing additional area and possibly covering productive habitat. However, careful dispersal of excess material onsite will not only avoid transportation costs, but can reclaim disturbed habitats. For example, PRRP small mammal studies indicated that upland habitat for small mammals might be in short supply during high water events associated with periodic floods. For this reason, excess material has been used to raise the elevation of uplands in several areas in order to provide a refuge during high water events (figure 3).

Scope Of PRRP Revegetation

Prior to restoration, the Provo River main channel was about 10.4 mi (16.7 km) in length. Upon completion of the project, about 7.6 mi (12.2) of new channel will be constructed and 5.9 mi (9.5 km) of the original channel will have been converted to other wetland types. The result will be a Provo River main channel of about 12.1 mi (19.5 km) in length. To date, the PRRP has disturbed approximately 238 ac (96 ha) (table 1). To restore this area, 9,000 lb (4,080 kg) seeds have been broadcast, 388,000 bareroot or container plants have been outplanted (table 2) and 10,000 cuttings have been installed (willows or cottonwoods installed as



Figure 2—P R R P haul route. Note that the top foot of soil, which contains plant roots and seeds, has been stockpiled to the right of the road. This minimizes handling of the topsoil. Decommissioning of the route would follow the sequence of removing any road fill, grading to establish proper contour, ripping (if necessary), and replacement of topsoil.



Figure 3—Small mammal refuge created by ONS e disposal of excess material.

Table 1—Area in acres (exclusive of haul routes, stockpiles and staging areas) disturbed each year of PRRP construction (1 ac = 0.4 ha).

| 1998 | 1999 | 2000 | 2011 | 2002 | 2003-2004 | 2005-006 (planned) | Total (planned) |
|------|------|------|------|------|-----------|-----------------------|--------------------|
| 18 | 27 | 34 | 76 | 16 | 67 | 66 | 304 |

Table 2—Number of bareroot or container seedlings outplanted each year.

| 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006-2007 (planned) | Total (planned) |
|--------|--------|--------|--------|--------|--------|--------|------------------------|--------------------|
| 22,693 | 55,543 | 68,663 | 56,734 | 29,645 | 89,616 | 65,038 | 89,691 | 477,623 |

poles or wattles). It is anticipated that an additional 66 ac (27 ha) of disturbance will be restored in the next 2 years, requiring about 2,600 lb (1,180 kg) of seeds, 86,000 bareroot or container seedlings, and 2,000 willow or cottonwood cuttings.

Lessons Learned

Several important lessons learned by previous scientists were applied to the restoration of the Provo River, including: avoiding compaction; working with the natural disturbance regime of the river; and choosing the right plants for the site,

including selection of the right size plant materials and outplanting at the appropriate density.

Compaction severely inhibits root growth and water percolation. To the maximum extent possible, activities that would result in compaction were avoided. It should be noted that working soils when they are at or near field capacity (wet) often results in significant compaction.

Wherever possible, it was important to work with the natural disturbance regime of the river. Figure 4a shows the natural recruitment of hundreds of seedlings within a high flow channel following a single flood event, and figure 4b the natural recruitment of hundreds, if not thousands, of seedlings following three flood events. No trees or shrubs were

installed at this location, yet several cohorts of willow and cottonwood have successfully established because the natural disturbance regime of the river has been reestablished.

Research has verified that local adaptation promotes higher fitness under the specific ecological conditions of a site. Locally adapted populations often represent a "genetic memory" shaped by past selective events that, although infrequent (for example, 50-year freezes or 100-year droughts), are important agents of selection. The gene pool of plants well-adapted to local environments can be swamped through competition with a poorly adapted gene pool of nonlocal

plants if they outnumber the local plants. To maintain the genetic integrity of the local plant community, we have prescribed that plant materials be collected within a 100-mi (160 km) radius of the project and from an area with an elevation ranging between 4,800 and 6,500 ft (1,460 and 1,980 m) above mean sea level (elevations found within the project).

Choosing the right plants for the site required that plants be installed in groupings that mimicked natural plant associations and at sites that were appropriate from a soil, water, and sunlight perspective. At PRRP, we installed only native



Figure 4—High flow channel one flood event after construction (A) and three flood events following construction (B). Note that no trees or shrubs have been installed at this location. Natural recruitment accounts for the many hundreds of seedlings.

species found within the corridor. Topsoil is quite uniform, so soil type was not a major consideration.

Selecting the right size plant materials required balancing the cost of the various sizes of plant materials and the cost of installing them with their availability and survival and growth rate. In general, larger plants are more expensive, require greater expense to outplant, and experience greater transplant shock.

In 2004, the cost (in U.S.\$) of a bareroot seedling was about \$0.80, with a cost to install of \$0.39. For quart-sized materials, the seedling cost was about \$2.00, with a cost to install of \$1.85. At these costs, it was possible to install about three bareroot seedlings for every quart-sized seedling.

The following species outplanted as bareroot seedlings demonstrated particularly good survival and growth: cottonwood (*Populus angustifolia*), willow (*Salix lutea*, *S. lasiandra*, and *S. exigua*), Woods rose (*Rosa woodsii*), golden currant (*Ribes aureum*), red-osier dogwood (*Cornus sericea*), and boxelder (*Ater negundo*). Good results were obtained with bareroot chokecherry (*Prunus virginiana*) and serviceberry (*Amelanchier alnifolia*). Over all species, survival of bareroot seedlings after 1 year was estimated to be about 75 percent. The survival rate of quart-sized plant materials has not been estimated. However, even if assumed to be 100 percent, it is easy to see that the ratio of cost to survival favors planting bareroot seedlings as long as they are of good quality and available.

The planting density and floral composition (table 3) of shrubs and trees were selected based on the results of a study conducted by the University of Arizona (Stromberg and others 1999). In 1999 and 2000, we installed 1,700 shrubs/ac (4,250 shrubs/ha) and 400 trees/ac (1,000 trees/ha) in wetland/riparian areas. Because survival was higher than expected (75 versus 50 percent), in subsequent years we installed 1,200 shrubs/ac (3,000 shrubs/ha) and 300 trees/ac (750 trees/ha).

Table 3—Floral composition of plants installed at PARR.

| Common name | Percent of plants installed |
|----------------|-----------------------------|
| Cottonwood | 29 |
| Boxelder | 18 |
| Alder | 8 |
| Woods rose | 7 |
| Dogwood | 6 |
| Hawthorn | 6 |
| Golden currant | 5 |
| Birch | 4 |
| Chokecherry | 4 |
| Serviceberry | 4 |
| Willow—Coyote | 3 |
| Willow—Pacific | 3 |
| Willow—Yellow | 3 |
| Honeysuckle | 1 |

Typically, it is most desirable to broadcast seeds and install plant materials immediately prior to the period of greatest precipitation. For the PRRP, this would be in the fall, as most precipitation falls as snow between October and March. For this reason, we ordered plant materials to be delivered and outplanted in October 1999. The elevation of the PRRP ranges from about 5,000 to 6,000 ft (1,520 to 1,830 m above sea level). The elevation at the nursery supplying most of the plants is about 4,500 ft (1,370 m) above sea level. Unseasonably warm fall temperatures at the nursery, coupled with an early winter storm at the PRRP, made it impossible to outplant the plants that fall. Plants were over-wintered at the nursery and outplanted the following spring. We have subsequently changed to an early spring outplanting of plant materials.

We learned that if we outplant all plant materials before May 1, our survival is quite good (about 75 percent after 1 year). Earlier seems to be better; however, unpredictable spring weather often delays outplanting, making it impossible to finish before May.

Irrigation can be a mixed blessing. Irrigation immediately after outplanting reduces transplant shock and may increase survival by eliminating air pockets in the soil that can desiccate roots. It can also encourage shallow root systems, with plants unable to withstand site conditions once irrigation is halted, and may encourage weeds.

Our plan was to set up irrigation equipment, but to only water when plants showed signs of significant stress, such as wilting or dropping leaves. We would only irrigate long enough to reverse the stress. With this strategy, we hoped to encourage plants to develop deep root systems. Beginning in 1999 and continuing through 2004, we experienced a severe drought. Precipitation between May and September was almost nonexistent, and what precipitation did occur came in very few large storm events. For this reason, we started irrigating the first week of June and continued through September of each year. However, in the summer of 2005, following a winter/spring of higher than normal precipitation, were we able to reduce our irrigation frequency and refrain from irrigating areas with a high groundwater table.

Results

PRRP wetland mitigation will be considered successful when the following criteria have been met for 3 consecutive years without intervention: 1) the relative cover of hydrophytic vegetation has been 50 percent or greater; 2) the relative cover of weeds has been less than 5 percent; and 3) soils have been stable. Results of the 2004 plant community survey indicated that at most monitoring sites (40 out of 66), the relative cover of hydrophytic vegetation was greater than 50 percent. To date, 20 sites have met all three success criteria for 3 consecutive years, and an additional 21 sites have met all three success criteria for the past 2 consecutive years.

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