Incorporating Native Grass Planting into Riparian Restoration on the Sacramento River

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ABSTRACT. In the fall of 1999, Sacramento River Partners planted native grass seeds and plugs in a riparian zone at the US Fish and Wildlife Service's Ord Bend Unit in Glenn County, California to examine strategies for the successful introduction of native grasses. The Ord Bend Unit is part of the Sacramento River National Wildlife Refuge and is currently being restored to riparian woodland and savanna. Native grass was planted between the tree and shrub species on approximately half of the 100- acre site. Native grasses support a wide variety of wildlife species and provide important ecological benefits, yet native grasses are often not included as part of riparian restoration projects. This project intended to: 1) demonstrate that native grass could be successfully incorporated within a riparian restoration project, 2) use an ensemble of cultural strategies to provide a selective advantage to native grasses (and woody riparian species), and 3) to quantitatively compare the relative success of the native grasses planted at this site. We established replicated test plots of ten different species on the site to provide a comparison between species. The first year's preliminary results indicate that native grass species have been successfully established at the site, although success varied by species.

INTRODUCTION

Native grass is increasingly recognized as an important component of California riparian ecosystems. Native grass has been used for erosion control and to improve habitat, especially for game birds, but until recently, the planting of native grass within riparian restoration projects has been limited to small sites. With the evolution of planting designs toward more complex patterns, greater diversity, and meeting more complex ecological objectives, native grass will become an increasingly important component for cultivated restoration projects.

This paper details the strategies used to establish native grass over 50 acres at the Ord Bend Unit of the Sacramento River National Wildlife Refuge for the US Fish and Wildlife Service. The Ord Bend Unit represents one of the largest attempts in California to incorporate native grass within a riparian restoration project. We will examine the initial implementation of the project and outline the upcoming monitoring and maintenance plans for Ord Bend and other sites.

SITE SETTING

In 1995, the US Fish and Wildlife Service purchased a 111-acre property in Glenn County, California on the western bank of the Sacramento River (River Mile 184R). The Ord Bend Unit is a part of the Sacramento River National Wildlife Refuge (SRNWR). A 10-acre wetland winds through the center of the site, which is used by a wide variety of wildlife (Figure 1). The Ord Bend Unit straddles a project levee that was built in the mid-1950's. Material for the levee was excavated from the site, enlarging the wetland. The Ord Bend Unit was farmed for decades, but soil conditions made farming difficult.

Sacramento River Partners initiated riparian restoration at the Ord Bend Unit in fall of

1998. As part of the planning for the site, Sacramento River Partners completed a sitespecific unit plan (Treber and Thomas, 1999) that reviewed the available information on the physical and ecological conditions of the site. The unit plan examined the site's agricultural infrastructure, topography, soils, hydrology, vegetation, wildlife usage, and developed an ecologically appropriate restoration design. The plan called for a mixed riparian forest surrounding the wetland (and other wetter locations on the site) and valley oak woodland away from the wetland. An important component of the project is the incorporation of native perennial grasses within the restoration planting.

The unit was divided into eight fields. Although much of the Ord Bend Unit is above the 100-year floodplain (post-Shasta dam), many areas are subject to seasonal ponding due to the soil conditions. The Glenn County soil survey identifies four soil series across the site (Begg, 1968), and we excavated additional soil pits to gain a better understanding of the soil profile (Table 1). The combination of low permeability and low water capacity means that plants must endure waterlogged conditions in the winter and scarce available soil moisture in the summer. Discussions with previous lessees of the property, confirmed the difficulty in managing soil moisture and timing cultivation.

WHY RESTORE RIPARIAN VEGETATION AT ORD BEND?

On areas close to the river exposed to frequent flooding and other alluvial processes, native recruitment is often sufficient to allow native species, such as cottonwood and willows to grow. However, in areas further from the river (especially on dam controlled rivers), the influence of physical processes (such as flooding, sediment deposit, and erosion) diminishes, and biological processes (such as herbivory, competition, and seed predation) become more important and restoration activities are often warranted in such areas.

The Ord Bend Unit is a good candidate for active (or cultivated) restoration. Although the site floods from the wetland, it is rarely (especially with the altered hydrological regime) exposed to the forces of the river during floods. Flood events are critical for

Figure 1. Location of the Ord Bend Unit (Sacramento National Wildlife Refuge) restoration site, Glenn County California.

TABLE 1. Properties of the soil series found on the Ord Bend Unit from the Glenn County soil survey (Begg, 1968).

Soil Property	Hillgate Loam	Kimball Loam	Tehama Silt Loam	Wyo Silt Loam	Wyo Silt Loam, Deep Over Claypan
Mapping Unit	HgA	Kb	Tm	Wn	Wp
Percent slope	0-2%	0-2%	0-3%	0-2%	0-1%
Fertility	Low	Low	Moderate	High	Moderate to high
Texture	Light clay or silty clay loam	Clay loam	Silt loam	Silt loam	Silt loam
Depth of soil	Moderately deep	Moderately deep	Deep	Very Deep	Moderate to Very Deep
Drainage	Moderately well-drained	Moderately well-drained	Well-drained	Well-drained	Well-drained
Permeability	Slow to Very Slow	Very Slow	Slow to Very Slow	Moderate	Slow
Available water capacity	Low	Low	Moderate to High	Moderate to High	High
Plant growth limitations	Low available water capacity, water logging is likely	Low available water capacity, water logging is likely, perched water table may develop above the clay pan	Tillage pans may form; surface may seal over when irrigated	Traffic pans may develop and slow penetration of water	Traffic or plow pans form readily; hardpan at a considerable depth
Approximate area of soil type (acres)	15.5	7	24.5	25	25
Location at Ord Bend (Field number)	2,3,5	2,3	1,2	1,6,7	4,7,8

natural recruitment, especially for willows and cottonwoods. Except for the areas immediately adjacent to the wetland, few places would support willow or cottonwood recruitment. Furthermore, the abundant non-native species found on the site, such as annual ryegrass (*Lolium multiflorum*), black mustard (*Brassica nigra*), ripgut (*Bromus diandrus*), yellow star thistle (*Centaurea solstitialis*), Johnson grass (*Sorghum halepense*), and others pose stout competition for native plant seedlings. Dense non-native vegetation often harbors high populations of rodents, which can in turn prey on seeds and acorns and girdle young seedlings. Although data are limited, several studies of oaks (Griffin 1971, 1976, 1980; Knudsen 1984; McCreary 1989) show that a lack of viable acorns is not the major cause of poor regeneration, but the combination of competition from non-native species, browse pressure, and high rodent population contribute to poor oak regeneration. These factors probably exert similar pressures on the natural regeneration of other species.

WHAT ARE THE STEPS FOR ACTIVE RESTORATION?

Active restoration employs modern farming techniques such as intensive site preparation, regular weed control (using herbicides as necessary), irrigation, and planting of saplings from nursery grown container stock to complement the planting of seeds and cuttings. These intensive activities typically last only three years, but these practice "jump start" succession on the site. Restoration practices reduce plant competition from non-native species, and limit the negative effects of predation and herbivory. Figure 2 provides an overview of the process.

Riparian restoration projects in the Sacramento Valley now demonstrate a 70 percent (or higher) survival rate after three years of intensive management. The evolution of plant design and restoration techniques means that we can quickly develop complex, native plant speciesdominated habitat with demonstrable benefits to wildlife in a short time. For example, the numbers of neotropical migratory bird significantly increase within three years of restoration (Geupel et al., 1997, RHJV, 2000). As the native plants grow, they lessen the dominance of aggressive non-native species, and may allow for better opportunities for native species to recolonize.

HOW HAVE PLANTING DESIGNS CHANGED OVER TIME?

Over the past decade, riparian restoration has shifted from the demonstration of feasibility or cost-effectiveness to meeting more complicated objectives. Whereas the first restoration projects on the Sacramento River contained 2-4 species (mostly trees) planted in straight rows, the latest projects represent greater numbers of species planted in more complicated patterns that must meet ecological, hydrological, and other management objectives. For example, over 24 different plant species (representing trees, shrubs, vines, and herbaceous plants) have been planted at Ord Bend.

Planting designs have become more sophisticated as the techniques for establishing plants have become more refined, and as we implement recommendations based on wildlife monitoring. For example, Sacramento River Partners has implemented a number of measures based on recommendations from PRBO's bird monitoring. We build complex patterns into a project's planting design, such as clusters of understory species, using a computer database to

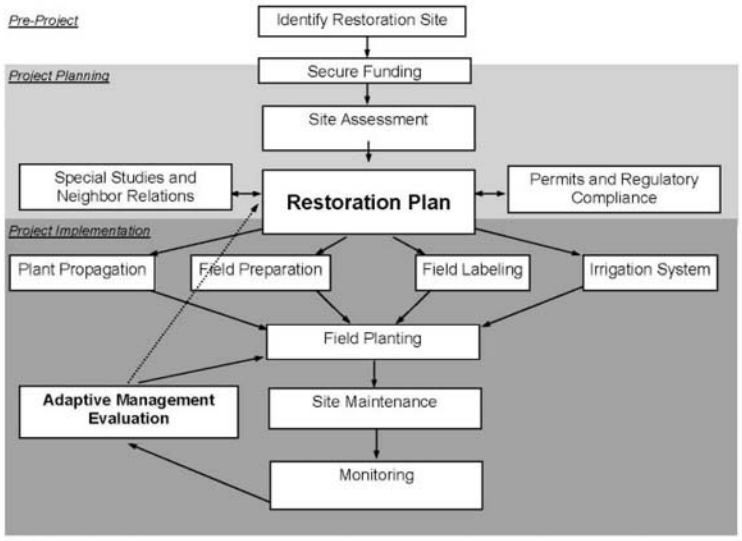

FIGURE 2. Summary of the Active Restoration Process

TABLE 2. List of species planted in the demonstration field trials at the Ord Bend Unit. These species were individually planted in plots, and some are components of the mixes used on the site.

Scientific Name	Common Name
Agrostis exarta (Agex)	Bentgrass
Bromus carinatus (Brca)	California bromegrass
Carax barbarae (Caba)	Santa Barbara Sedge
Elymus glaucus (Elgl)	Blue wildrye
Elymus trachycaulus (Eltr)	Slender wheatgrass
Hordeum brachyantherum ssp californicum (Hobr)	Meadow barley
Leymus triticoides (Letr)	Creeping wildrye
Melica californica (Meca)	California melic
Nasella cernua (Nace)	Nodding needlegrass
Nasella pulchra (Napu)	Purple needlegrass

generate a specific layout of the site. Our computer program is capable of producing labels that identify each planting location. The result is a complicated vegetative pattern that satisfies wildlife objectives, and matches plants to site-specific conditions. Incorporating native grass plantings within restoration projects is a logical next step in the evolution of plant designs.

WHY PLANT NATIVE GRASS INTO RIPARIAN AREAS?

Native grasses provide a number of benefits. Grasses reduce soil erosion, and may reduce non-point source pollution from agricultural lands. Along roadsides native grasses may reduce the threat of flooding, erosion and siltation, wildfire, and invasive weeds (Bugg et al., 1997). As a component of restoration projects, native grasses provide several benefits. Some native grasses are long-lived (10-20 years) and once established, compete well and reduce the dominance of invasive non-native species. They add to a more complicated vegetative structure and provide food and shelter for a variety of wildlife species. Although native grasses were undoubtedly a part of riparian communities, the clearing of land for agriculture and the introduction of nonnative species have dramatically decreased native grasses in the Sacramento Valley.

OVERALL STRATEGY FOR THE NATIVE GRASS PLANTING AT ORD BEND

Project Goals

The main goal of the native grass planting at the Ord Bend Unit is to demonstrate the feasibility of establishing and maintaining native grass within a riparian restoration planting. Native grasses were interplanted between woody species on 50 acres of the 111-acre unit. Another goal is to evaluate a number of species that might be useful for future restoration projects. This section will outline the procedures we used at the site and give some insight into the strategies selected.

Planting Strategy

Two main concerns governed the planting strategy for the site: reducing competition with non-native species and maintaining favorable conditions for native woody species. To minimize competition, we wanted to deplete the weed seed bank in the soil surface layer, minimize soil disturbance, and maximize establishment conditions for the natives after planting. Maintaining favorable conditions for native woody species and native grasses requires a careful balancing act. For example, many native grasses are cool season and drought tolerant and summer irrigations are unnecessary and can often promote undesirable species such as Johnson grass. Yet irrigation is often a critical step to establishing native woody species along the Sacramento River.

Species Selection

We set up replicated demonstration plots with a total of 10 native species, including Santa Barbara sedge (Table 2). However, we planted most of the site with a blend of four grass species from this list (the SRP Blend), and the perimeter of the unit with a different mixture of four species (road mix). Table 3 shows the mixtures (by weight) for these mixtures.

TABLE 3. Composition (per weight) of Grass Mix for Ord Bend. The SRP Blend was planted over most of the site, while the road mix was planted along the perimeter of the site. A total of 10 species were planted in the replicated demonstration plots. Both mixes shown below and each individual species were planted in the demonstration plots.

SRP Blend

Species	% per weight
Blue wildrye (Eltr)	20%
Meadow barley (Hobr)	40%
Creeping wildrye (Letr)	20%
Purple needlegrass (Napu)	20%

Road Mix

Species	% per weight
Bentgrass (Agex)	30
California melic (Meca)	30
Creeping wildrye (Letr)	20
Purple needlegrass (Napu)	20

Most of these species are riparian or wetland species. The original seed collection location was an important consideration for us. As part of the seed selection, we wanted to plant only Sacramento Valley ecotypes. Ecotypes are locally adapted variants of an organism that differ genetically from other ecotypes. Selecting an appropriate ecotype is important to maintaining the genetic integrity of local populations and may provide a long-term survival advantage for the planted individuals. Although making distinctions between ecotypes requires genetic testing or common garden techniques, we assumed that grass originating from the Sacramento Valley would be more appropriate than grass originating from other areas (some of the seed originated as close as Llano Seco, within 5 miles of the site).

Demonstration Plots

Sacramento River Partners incorporated a demonstration or test plot within the native grass planting. The plots provide: 1) a comparison between species, 2) a demonstration area for people interested in native grass, and 3) examples for early identification of species. The demonstration plots are located in the southern part of field 1. The plots were laid out as a replicated (2 replicates) random block design. To minimize any potential edge effects, the plots start away from the western (80 feet) and southern (130 feet) from the field boundary. The plots are 75 feet long and approximately 14 feet wide, with 10-foot buffers separating each unique plot. Both seed and plugs (Santa Barbara sedge and creeping wildrye) were planted in the plots. A total of 10 different species, plus the mixtures used (the SRP blend and roadside mix) were planted in the demonstration plots. A control with the drill (without seed) passed over the plot and a fallow control. The control with the empty drill was intended to examine any differences associated with soil disturbance.

Characteristics of the SRP Blend and Road Mix

The road mix contained a mix of low growing species for field operations and to maintain a firebreak and sod formers to help keep road drivable during wet conditions. The SRP Blend consisted of a mixture of creeping wildrye, blue wildrye, meadow barley, and purple needlegrass. We expected each of these to respond differently over time.

- Blue wildrye (Elymus glaucus) is a large perennial bunchgrass that competes well with nonnative vegetation. In comparison to meadow barley it is more drought tolerant, and we expect this species to start strong and once established to maintain itself over time.

- Meadow barley (Hordeum brachyantherum ssp californicum) is a short-lived fast growing perennial that prefers areas that are moist in the spring. We expect meadow barley to grow well for the first 2-3 years and then fade, except in the wettest areas. Meadow barley is intended, as a nurse crop, a plant that will compete well with the non-native species, yet will allow the other natives to grow when they become more established.

- Creeping wildrye (Leymus triticoides) is a long-lived, tall, perennial that grows rhizomatously (vegetatively). We expect slow initial establishment of this species, but the survivors will become more dominant.

- Purple needlegrass (Nasella pulchra) is a densely tufted, longlive, upright, perennial that is somewhat shade-tolerant. We expect purple needlegrass to establish slowly, but later to be an important but non-dominant part of community.

FIELD ACTIVITIES FOR THE NATIVE GRASS PLANTING AT ORD BEND

Cover Crop and Field Preparation

Restoration at the Ord Bend unit began late in 1998, with the site evaluation. Prior to restoration activities, the USFWS leased the Ord Bend unit to a local farmer to control weeds and maintain the irrigation system. We disked the site and planted a cover crop of peas and Fava beans (Table 4). The climbing peas used the upright Fava beans as a trellis, providing a dense blanket of vegetation that shaded many of the germinating annual winter weeds. The heavy competition reduced the vigor and seed production of such species as annual ryegrass and black mustard. The cover crop also provided a source of organic material and a slow release of nitrogen (which helped the site's poor soils). We created planting berms within the cover crop and planted native woody species in the spring of 1999. Later, the cover crop

was flattened to provide a thick thatch layer to suppress summer weeds.

Weed Control

Most native grass seedlings have low vigor and are often overwhelmed by non-native annual weeds. Most native grasses are shade intolerant, so we monitored the breakdown of the thatch layer carefully during the summer. We did not want to till the soil because it would bring new weed seeds to the surface, nullifying our efforts to deplete the surface seed bank. The thatch layer was very effective in suppressing weed growth, but we also applied Roundup™ (Glyphosate) to the summer weeds that grew through the mulch.

Although some herbicides are available that can selectively control warm- or cool-season grasses, no herbicides selectively control non-native grasses while sparing the native grasses that grow during the same season. We applied Roundup™ in November after the first rains had germinated the annual grasses just days before planting the native grass. Native grass generally grow better if they planted in the fall, because they can establish root systems and can compete better with weeds that might grow in the spring. In dry years, irrigation might be considered to germinate the non-natives in the late fall, but if conditions become too wet, planting may not be possible.

Native Grass Planting

We planted grass from seed using a Truax™ "no-till" drill. We also used plugs to increase the chances of establishment. The advantage of using plugs is that we can plant an established plant into the field; the disadvantage is that it is labor intensive and initial plant density is low. For example, we planted approximately 20,000 plugs of creeping wildrye and 10,000 plugs of Santa Barbara sedge over the 50 acres at Ord Bend. Using the no-till drill seed was planted at approximately 10 pounds per acre. Assuming that the seed mix contained an average of 50,000 seeds per pound, this application rate results in over 500,000 seeds planted per acre (this rough calculation does not account for the viability of the seed).

The advantage of a no-till drill is that it minimizes soil disturbance (and therefore does not expose buried weed seed), requires minimal seedbed preparation (can plant through plant litter), and fertilizer can be placed right next to seeds. We applied a low concentration of ammonium sulfate fertilizer during planting. Although plugs can be planted in wet conditions, the no-till drill requires conditions adequate for driving the tractor.

Maintenance

Once established native perennial grasses are good competitors. However, field and greenhouse studies indicate that native perennial grass seedlings have difficulty competing with introduced annuals (Brown and Rice, 2000). Mowing is an important tool to reduce the effects of competition. Mowing reduces the above ground competition from vigorously growing annuals, but unlike grazing, mowing can leave a thatch layer, which can also shade out the natives. To minimize the damage to the native grass and reduce the thatch layer, we typically mow at a height of 4-6 inches above the ground surface, and time the mowing to cut the developing weed seeds before they can mature. In 2000, we mowed in late spring. Once the native grass became dormant during the summer, we mowed frequently to maintain control of summer weeds.

Grazing, broadleaf herbicide applications, and prescribed burns are other tools typically used for establishing native grass, but pose special problems within the context of a riparian restoration. Because the native shrubs and trees are young they are susceptible to damage from grazing animals, drift from herbicide application, and heat damage from prescribed burns. Still, each of these provides some advantages over mowing and with care some of the negative effects can be minimized. For example, using a propane flamer can provide greater heat control than a prescribed burn. We are examining these potential of these options for the upcoming growing season.
Another potential option for weed control is chemical mowing, or the use of a broadspectrum herbicide at a sub-lethal dose. If applied at the right time, a sub-lethal dose of herbicide could theoretically favor perennial species by slowing down the growth of fast growing species. We have observed that the perennials appear to be more resistant to herbicides than the annuals but timing may be critical. Chemical mowing in native grass requires much more work, before assess whether it is a viable option.

Monitoring

We maintain a flexible monitoring approach to adapt to the overall management goals of the project. For example, we completed a qualitative assessment as the native grass grew during the first season, but did not conduct quantitative monitoring for the first year, because mowing made identification difficult. Mowing was critical to maintain adequate light levels for the emerging grass seedlings. Perennial grasses typically grow slowly during the first year and usually require two years to develop into a complete stand, so the second year information is probably more important.

We will institute a more formal monitoring protocol in the spring of 2001. These activities are in addition to the other vegetation monitoring we conduct on the site. Although documenting the establishment of the natives is important, it is the response of the weed populations that may trigger management actions on the site. Monitoring will include establishing photo point and photo plot locations, quantifying vegetative cover and size estimation, and documenting any areas with poor stands. These data will provide a good baseline to assess future changes in the native grass. One of the interesting interactions will be to note the effect of the growing forest on these species. We plan to write up the results of the monitoring for publication.

PRELIMINARY RESULTS

The preliminary results indicate that we successfully established native grass on 50 acres of the Ord Bend Unit. Preliminary assessment of the native grass planting in the spring of 2000 indicated a 90 - 95% stand establishment for SRP blend, with a few misses and skips (Cerus Consulting, 2000). We noted that where the soil or mulch was disturbed the growth of annual ryegrass was more pronounced. In several areas of the field, the initial lines of native seedlings are still evident, but the native plants are filling in these lines rapidly. The preliminary comparison of planting methods, indicate that direct seeding was far more cost-effective and produced better coverage than plug planting.

As expected for the SRP blend, meadow barley (*Hordeum brachyantherum ssp californicum*) was the most evident species across the fields planted. Blue wildrye (*Elymus glaucus*) was also evident on the site, but to a lesser extent than meadow barley. Purple needlegrass (*Nasella pulchra*) appeared mainly in the margins of planted areas, which may be a response to reduced competition. A few individuals of creeping wildrye (*Leymus triticoide*) were also found, but did not appear nearly as abundant as the blue wildrye. Two species California bromegrass (*Bromus carinatus*) and slender wheatgrass (*Elymus trachycaulus*) made impressive showings in the first year with almost solid stands in the demonstration plots. The upcoming monitoring will quantify the success of these species and the others planted in the demonstration plot and see if the initial success will hold over time. We will also assess differences between the three fields.

In spring of 2001, we will complete the Year 2 assessment, which will document the status of native grass on the site and provide a good idea on the future success of the planting. The preliminary results are promising that native grass plantings can be established and maintained within riparian restoration projects. In the fall of 2001, we will add native grass to 275 acres in riparian restoration in Butte and Glenn Counties. We would also like to incorporate another demonstration plot in these future plantings to discover how these species respond to conditions at another site.

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