Delta Working Landscapes

Jeff Hart
Delta Ecofarm
Walnut Grove, CA 95690

Abstract

The Delta Working Landscapes project, funded by the former CALFED Ecosystem Restoration Program, is designed to implement environmental measures on working farms in the Sacramento – San Joaquin Delta. This particular project, implemented by Hart Restoration, Inc. (now Delta Ecofarms), was involved with the planting of native species along farm borders, levees and ditches forming hedgerows and buffers intended to provide wildlife habitat, reduce weed populations, and improve water quality. For this project, over 100,000 plants were installed along approximately 58,330 linear feet on five different farms in the northern portion of the Delta. The project had mixed results. Obstacles to success include pervasive use of herbicides throughout the region, vigourous weed competition, reluctance of farmers to value native plant species, and severe drought conditions for two of the three years of the project's duration. The most successful aspect of the project included ditch banks that provided sufficient moisture for plant establishment.

Introduction

Working landscapes are farms, forests and ranches that provide food, fiber and other economical products. CALFED Bay-Delta Program (CALFED) defined a working landscape as "A place where agriculture and other resource-based economic endeavors are conducted with the objective of maintaining economic returns on investments, while protecting and enhancing the landscape's ecological health and generating tax revenues that support their local governments"{California Bay Delta Public Advisory 2002}. Through restoration and innovative land management/farming strategies, working landscapes can often become surrogate habitat for wildlife.

The economic and resource value of the Sacramento–San Joaquin Delta (Delta) to California is tremendous. It is one of the most productive of California's agricultural landscapes. Approximately 60% of California's water supply passes through the Delta. The Delta's fish and wildlife resources include numerous species of special concern, such as anadromous Chinook salmon and resident smelt, waterfowl such as sandhill crane and pintail, and several species of plants. The Delta's farmlands, wetlands, and numerous sloughs and rivers provide a recreational resource for millions of Californians who boat, fish and hunt in the region. Various resource agencies and scientists are voicing concern of deteriorating environmental conditions in the Delta, as well as threats to the levee system from global warming and seawater rise that can potentially lead to widespread flooding of the region. This has economic implications locally, regionally, and state wide..

Recognizing this shortcoming, The CALFED Ecosystem Restoration Program, now managed by the California Department of Fish and Wildlife, sought to develop programs that assist farmers in integrating environmental projects integrated with agricultural activities in the Delta. In a 2005 solicitation proposal, CALFED recommended a number of environmental projects for consideration. These included practices such as soil management, landform/infrastructure improvements, water management, direct wildlife improvements, cropping/harvesting strategies, and weed and pest management. Some of these activities are most effectively done by farmers in the context of normal farming activities (e.g., cropping strategies), while others are best fostered through new and direct actions (i.e., hedgerows, ditch and levee plantings, and riparian and wetland development).

Delta Working Landscapes is a pilot program that includes a partnership of government (Delta Protection Commission and California Department of Fish and Wildlife), a nonprofit organization (Ducks Unlimited), private local enterprise (formerly Hart Restoration, Inc., now Delta Ecofarm), and landowners to implement demonstration projects of farm habitat improvement and environmentally friendly agriculture practices to benefit fish and wildlife, reduce erosion and sediment runoff, and improve water quality. These pilot projects were intended to provide a basis for understanding potential constraints and opportunities for resource enhancement, such as economic, social, cultural and environmental factors; and further to serve as a catalyst for adoption by other farmers. This report focuses on various hedgerow and buffer plantings projects.

Goals and Objectives

The goals of implementing the working landscape pilot projects are: 1) to improve the environmental quality of existing working landscapes in the Delta through a variety of demonstration projects; 2) to develop an educational mechanism and economic model to transfer environmentally friendly farming knowledge, techniques and practices to other Delta farmers and stakeholders; 3) to facilitate environmental compliance through overcoming disincentives and increasing incentives towards achieving these goals. Specific objectives include: 1a) creating vegetated buffers on ditch banks and hedgerow plantings that would improve water quality by reducing runoff of sediment and pesticides before these materials reach rivers and sloughs in the Delta; 1b) vegetating levees with native grasses, sedges and other low-growing species that will stem erosion and lessen the threat of flooding, as well as creating habitat and reducing maintenance costs; 1c) creating wildlife friendly habitats such as native grassland plantings, riparian forests and wetlands in areas where it is uneconomical to farm.

Working Landscapes Models

Figure 1 and Table 1 outline conceptual models and benefits for the Delta Working Landscape Project. It shows the beneficial relationships between restorative actions of vegetative buffers to various physical, biological, economic and social/cultural parameters. For hedgerow, ditch, levee and bankside berm environments, vegetative buffers stabilize soil and reduce erosion, lessen the likelihood of levee failure, reduce pesticide use, improve water quality and wildlife habitat, and reduce maintenance costs (Earshaw 2004; Long and Anderson 2010; Hart, personal opinion).

Native plant vegetative buffers that separate farmlands from wetlands and other water bodies serve a multitude of functions. They improve water quality (Gilliam 1994; Lowrance 1984; Mitsch and Jorgensen 1989; Rogers and Dunn 1993), including nitrogen and phosphorous removal (Fustec et al 1991) and sediment removal (Clark et al.1985; Cooper et al. 1987). The use of wetlands has been specifically considered from the perspective of treating agricultural runoff as non-point sources (Baker 1992), removing pesticides (Rogers and Dunn 1993), and arresting land and bank erosion (Karr and Schlosser 1978). Vegetative buffers can also reduce herbicide use by creating sustainable landscapes that resist invasion by weeds, thereby reducing the ongoing maintenance costs. Vegetative buffers alongside ditches and waterways, compared to levee plantings, serve a greater function in water quality improvement. Vegetative buffers alongside both ditches and levees generally improve conditions for indigenous wildlife species dependent upon native plant species.

The techniques and environmental benefits of planting and establishing various native perennial plant species are known to restoration practitioners, but it is possibly not known to many farmers who are involved with the traditional economic considerations of commodity farming. Through repeated tillage and application of herbicides, farmers are involved in a weed-herbicide/disking cycle that contributes to ongoing maintenance costs and hinders environmental benefits. By planting and establishing native perennial plants as ground cover, exotic weeds can be competitively excluded through shading, resource depletion, increased niche occupation, and other concepts of plant community invasibility (Burk and Grime 1996; Porkorny 2002; Sheley and Carpinelli 2005). Several specific types of enhancements are described below.

<u>Hedgerows</u>. Hedgerows consist of closely spaced shrubs and trees that are planted to form a barrier or to mark a boundary between properties and fields. Hedgerows are old concepts that date back several thousand years, going back to the Neolithic Age. In the context of Delta Working Landscapes, hedgerows have been visualized as consisting principally of native shrubs and trees, with additional understory grasses and herbs, that serve several functions: creation of wildlife habitat, buffer to restrict pesticide drift, and reduction of weeds by providing overstory competition. Modern “clean” farming has eliminated the historic band of ruderal vegetation on farm edges that provides food and shelter for wildlife. Since these accidental strips of vegetation usually consist of weedy species, farmers in time favored the elimination of these problematic areas through mechanical methods and herbicide application. But farm borders can consist of beneficial plant species that are sustainable (Earshaw 2004; Long and Anderson 2010). In England, there is a long tradition of hedgerow plantings. Hedgerows are intentional linear plantings of favorable vegetation, such as grasses, forbs, shrubs and trees. Planted along the edges of farm fields, they attract beneficial insects, stabilize soil and provide ground cover for wildlife, act as windbreaks, suppress weeds, reduce pesticide use (Earshaw 2004). A number of native plants would be beneficial in our region, such as sedges (*Carex barbarae*, *C. praegracilis*), grasses (*Elymus triticoides*), native forbs (*Aster chilense, Helianthus californicus*), shrubs (*Baccharis pilularis, B. salicifolia*), and various tree species (*Quercus lobata, Acer negundo*, etc.).

<u>Vegetated Ditches</u>. Most ditches in the Delta are barren with steep embankments that lack wildlife values. In this condition, they serve as a conveyer of pesticides from farm fields to nearby wetlands and rivers. These ditches are constantly sprayed, and lacking a permanent, sustainable plant cover, require constant upkeep. An alternative approach is the establishment of native perennial plant species, such as grasses, sedges and rushes along ditch banks and on ditch bottoms. These vegetated buffer

strips can be done in conjunction with hedgerows. Together, this vegetation can catch sediment that would normally clog up the ditch system, and these plants can serve as a biological filter that will catch and transform pesticides before it reaches rivers and sloughs. These plantings will therefore serve to improve water quality, thereby improving fish and wildlife habitat in general. Research in the Mississippi River Delta demonstrated that from 60 to 99% of various herbicides were transferred to plant material within 1-3 hours following field runoff (USDA ARS, 2005). Moreover, farmers should benefit economically from the reduction of constant maintenance costs required to maintain barren ditch embankments. In the Delta, vegetative ditches could be constructed with a V-shaped design to foster more vegetative growth and allow for easier wildlife movement. By planting sustainable native grasses, sedges rushes and other wetland species, ditch vegetation could be fashioned to serve the purpose of water conveyance, but also reduce unfavorable weedy growth and thereby reduce maintenance costs. As mentioned above, these ditches could similarly serve as a filter to trap and transform pesticides before they reach the rivers and sloughs. <u>Landside and Waterside Levee Restoration</u>. Natural levees differ considerably from human constructed dikes. Natural levees were broad structures composed of naturally deposited materials and covered with abundant natural plant life. The thicket of plants, including the extensive root systems, resulted in relatively stable structures. The pre-reclamation delta landscape was a stable one, and though the islands flooded on a regular (daily/seasonal) basis, the levees did not experience catastrophic breaks as modern ones have (e.g., Jones Tract levee in 2004). Some aspects of modern levee maintenance run counter to known concepts that vegetation can contribute to landform stability (Gray and Sotir, 1996). For example, levees are often over-grazed and the use of herbicides is excessive, resulting in highly barren, erosive conditions.

The waterside of levees is managed differently than the landside. The waterside is a zone where plants must hold the soil together through current deflection, wave reduction, and root shear strength improvement. Another concern with Delta levees is their extreme porosity, due to their often sandy (non-cohesive) nature. Another benefit of appropriately located plant species is that these plants foster deposition of fine materials. Fine materials are recognized as a necessary ingredient to retard water piping through levees. The landside of levees should be managed as a short grassland environment that can foster visibility (to see levee breaks), yet provide enough cover to arrest potential erosion. Should islands flood, the inside levees can be subjected to extreme wave erosion. Therefore, a buffered armoring of plants – trees, shrubs – should be located just beyond the toe of the inside levee to potentially protect the levee from wave energy (Hart, 2013).

Figure 1: Restorative Vegetative Buffers Model

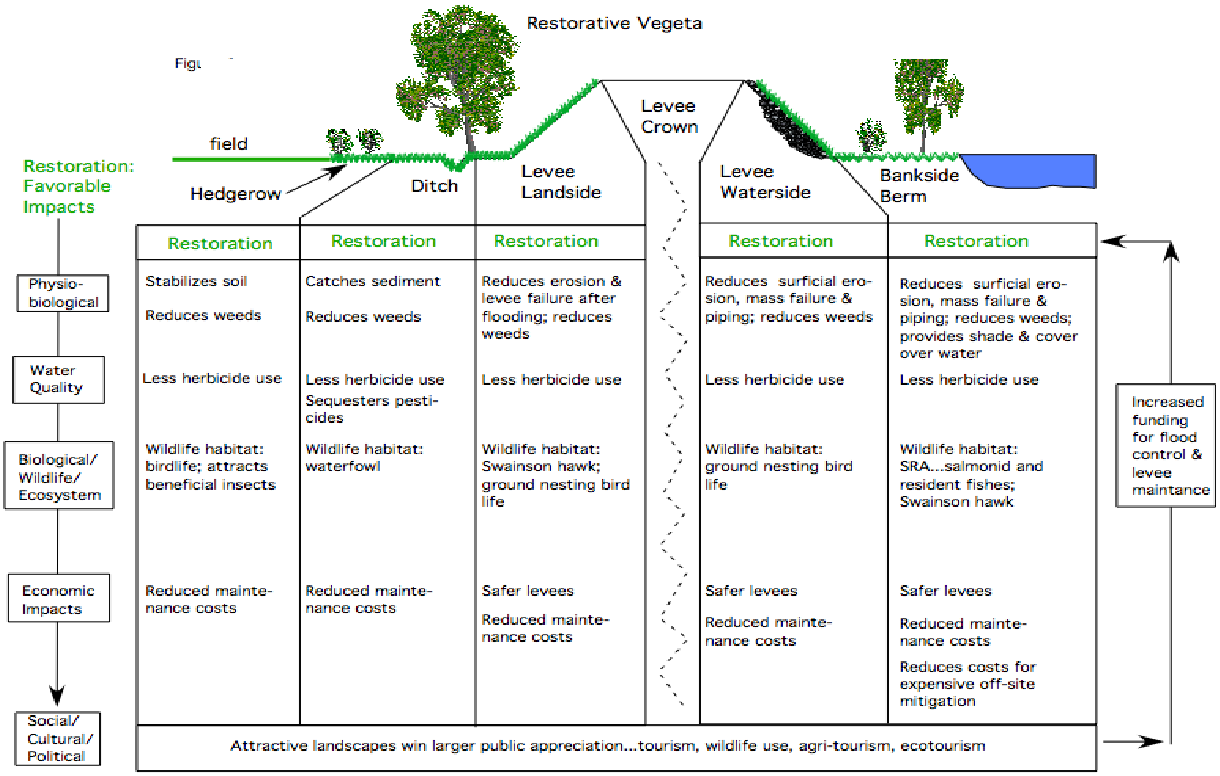

Table 1: Restorative Vegetative Buffers Benefits

Practice	Ecosystem / Landscape Benefits	Potential Species Benefits	Potential Agricultural Benefit
Vegetated Buffers	General wildlife/birds, erosion control, water filtration, erosion control	Native anadromous and estuarine fishes	Reduce expenses relating to weed maintenance on farm edges and effects of erosion. Assist with agritourism
-----ditchbank plantings	Erosion control, pesticide management	Game and non game species	Reduce expenses
-----hedgerow plantings	Wildlife, beneficial insects	Game and non game species	Attract beneficial insects, including native pollinators
-----levee/bank protection	Erosion control through biotechnical means	Native anadromous and estuarine fishes	Reduce expenses to reclamation districts for levee maintenance costs
-----riparian restoration	Provide shaded riverine aquatic habitat	Native anadromous and estuarine fishes	Protect river banks from eroding. Agriourism benefits
Semi-permanent Wetlands	Restore wetlands	Waterfowl	Provide waterfowl, income through hunting and agritourism
Tailwater return ponds/habitat	Reduce run-off of pollution to nearby waterways	Improve water quality for wetland dependent species	Recovery and reuse topsoil. Achieve water quality benefits/meet irrigated agricultural permit waiver requirements. Provide stored water

Methods

Study Area/Farm Selection

The Delta Working Landscapes process first involved seeking out individual farmers and reclamation districts in the northern Delta region to learn of potentially interested landowners (Figure 2). Farmers were then invited to observe established working landscapes on an existing farm to see if these types of environmental enhancements might be compatible with their farming operations. Some farmers expressed interest, some were ambivalent, and others didn’t believe their lands to be compatible with the goals of the project. The selection criteria involved the following parameters:

1. Personal knowledge of farmers representative of the area; this included a sampling of open ground, orchard and vinyard types of agriculture.

2. Openness and willingness of the farmers to try something different. Farmers are traditionally conservative and reluctant to try new things.

3. A response of the potential farmers to the types of plants and their beneficial impact on the landscapes in question. At this step in the process some farmers were interested, while others were not.

4. Availability of the landscape settings on particular farms. Some landowners farm right up to the edge of their properties with little room for hedgerows and ditch plantings, so these farmers were not receptive. Most farmers have available space, so they have been responsive.

5. Compatibility of proposed restorations with current farm practices. Our proposed plantings can't interfere with current economic practices on the farm. To the extent possible we emphasize that our plantings would reduce input.

6. Soil conditions suitable for adequate growth. Some sites are too clayey or too sandy for plant growth to be successful. Only the best sites with more loamy conditions will be utilized.

7. Sites that aren't initially too weedy. Sites that have especially noxious weeds will be avoided as the chance of success during the time period of this project is problematic. We will choose the cleaner sites where success will be better.

In the end, projects were implemented on 15 different sites on 5 different ranches in the northern region of the Delta (Table 2). These sites were selected on the basis of the willingness of landowners to participate and various site characteristics, such as weed populations, herbicide usage and soil suitability. All of the sites except one farm were planted with wine grapes, with one being planted with GMO corn.

Figure 2: Map of the North Delta Study Area

<u>Species and Planting Methods</u>

The native species planted included creeping wildrye (*Leymus triticoides*), sedge (*Carex barbarae*), rushes (*Juncus balticus, J. effusus*) and tules (*Scirpus americanus*). None of the farmers thought that larger stature plants such as trees and shrubs would be compatible with their farming operations. Reclamation districts and the California Department of Water Resources do not permit woody growth on levees. Farmers also do not favor woody growth along ditches as they need to be cleaned out periodically. A variety of sizes rooted planting materials were utilized, including small plugs and up to gallon-sized plants. These were hand planted with shovels and power driven augers.

Planting was done during late fall to early spring when sufficient soil moisture would likely favor plant survival.

Monitoring

To document plant establishment, data was obtained by randomly placing 3-meter square quadrants along representative sections of the installed 2011-2012 plantings. Cover classes of <1% (+); 1-5% (1); 6-25% (2); 26-50% (3); 51-75% (4); and 76-100% (5) were assigned to the plants in each quadrant. The species of native plants were lumped into one category as were the weed species. Photographs were collected during site monitoring to provide visual information on site conditions.

Table 2. Locations of Project Sites

Property	Location	Specific Sites
Herringer (Vineyard)	Netherlands Rd., near Clarksburg	3 Levee slope sites
	Netherlands Rd., near Clarksburg	Swale
	Netherlands Rd., near. Clarksburg	Buffer/border
Wilson Ranch (Vineyard)	South River Road and Courtland Road, south of Clarksburg	Levee slope
	S. River Rd & Co. Rd 141	Levee slope
	S. River Rd & Courtland Rd	Levee slope
	Waukeena Rd & Courtland Rd	Levee slope
Vino Farms (Vineyard)	Waukeena Rd	Ditch #1 and #2
	Lambert Road, near Hwy 5, near Walnut Grove	Ditch
	Vicinity of Clarksburg	Several different Levee slope sites
Van Loben Sels (GMO corn)	Vicinity of Walnut Grove	Levee slope
Winchester Lake (Vineyard)	Vicinity of Clarksburg	Ditch/lakeside

Project Implementation: Results

Implementation: Planting

Plant materials were installed in the fall of 2010, winter and spring of 2011, and the fall and early winter of 2011. Fifteen sites on 5 different ranches, totaling approximately 55,336 linear feet, were planted with nearly 101,450 plants along ditch banks and levee slopes (see Table 3). The results have largely been successful – in terms of initial plant survivability – but the outcome has varied from one site and ranch to another. The more successful outcome has occurred on the cleaner, relatively weed free sites using the larger-sized plant materials and especially on wetland sites bordering ditches.

An example of a relatively clean site included the levee slopes bordering the Wilson ranch, the results of a well-managed environment with few really invasive weeds. Another initially very successful site is the levee slope on the Van Loben Sels property. The levee slope previously had been aggressively treated with herbicides, so we were able to get started on a relatively clean site. We fortunately planted large and vigorous materials which survived; had we applied seeds or planted with smaller materials, success would have been problematic due to the apparent residues of herbicides.

The results were problematic where small plugs were installed such as at the Herringer property. The lack of success, is likely due to competition with annual grasses, compacted soils, possibly herbicide drift or soil residues and the extreme drought conditions seen in the past two seasons.

Some weedy sites planted with larger materials have done relatively well despite plant competition. For example, the plants planted along the ditches at Vino Farms near Clarksburg are surviving, but would do much better if there is selective use of broad-leaved herbicides or mowing is done until the plants are well established. Close coordination with the farming operations is needed since the nearby grape plants are sensitive to herbicides.

Wetland plants, such as tules and rushes, that have been installed in the wetted perimeters of ditches have done quite well, such as at Winchester Lake and the ditch along Lambert Road at Vino Farms.

Table 3. List of Properties and Plantings[1]

Site	Environment Planted	Plant Numbers	Species	Linear Ft.	Date Planted
1. Van Loben Sels	Levee slope	20,736	Grasses	2,995	2011
2. Vino Farms, Ranch 2 Lambert Rd.	Ditch	8,928	Tules, rushes, sedges	3,000	2011

Site	Environment Planted	Plant Numbers	Species	Linear Ft.	Date Planted
3. Vino Ranch 1	Ditch/levee slope/border	17,788	Tules, rushes, sedges grasses	17,425	2011
4. Winchester	Ditch bank	2,074	Tules	4,100	2011
5. Wilson	Levee slope	18,118	Grasses, sedges	8,948	2011
6. Herringer	Levee slope, swale, border	33,806	Grasses, sedges	18,868	2010
All sites		101,450		55,336	

[1]The six different ranches include 15 separate sites.
[2]Grasses = Creeping wildrye (*Leymus triticoides*), sedge (*Carex barbarae*)
[3]rushes = *Juncus effusus*
[4]*Tule: California tule (Scirpus callfornicus) at Winchester Lake and* three-square tule (*Scirpus americanus) for the Lambert Road site.*

Hedgerows, involving the use of shrubs and native trees were not implemented as part of this project as we found no farmers willing to allow such plantings. This is unfortunate, as these types of hedgerows, once established, are sustainable with little effort.

Monitoring

At the outset we considered a research and monitoring program to determine the success/failure of comparing the various proposed aspects of this program. This included the feasibility of native plant establishment using various techniques (container planting vs. seed drilling); reduction of maintenance requirements (native plant established vs. weedy ruderal); erosion attenuation (native vs. bare/weedy); and acceptability to farmers based on a variety of factors (cropping patterns, economic consideration, sociological). More specifically, the hypotheses we intended to test included:

- Hypothesis #1. Seed drilling is a less expensive method of native grass establishment than planting of plug plants.
- Hypothesis #2. Establishment of native grass cover, once established, will reduce maintenance costs along ditches.
- Hypothesis #3. Vegetated ditch banks will erode less than bare/weedy banks.

Wildlife was not monitored for this early stage of the project; while it is generally agreed that establishing native plant communities attract various species of wildlife, scientifically demonstrating increased use is beyond the practical scope of this project.

Performance evaluation – emphasizing plant establishment – was measured through periodic monitoring reports. The information collected included: 1) amount of habitat created such as acres or linear feet successfully installed; 2) percent cover of native vs. nonnative plants, with appropriate statistical measurements (cover, density); 3) photo documentation of before and after conditions; 4) farmer responses and interest in the project; 5) discovery and implementation of policies and incentive measures that could improve Delta resource values.

Not all of the originally suggested methods and protocols were implemented due to a variety of on-the-ground circumstances and challenging conditions (see discussion section).

Table 3 shows the results of the last monitoring which was done in early summer of 2012 and mid summer of 2013.

Table 3. Monitoring Results of 2010 Plantings, Hart Restoration Surveyed June 9, 2012 and August 11, 2013

Site	Percent Coverage (Native Plantings)	Percent Coverage (weeds)
Wilson Ranch, Clarksburg Site (levee slope)[1]	31.1%	3.8%

Site	Percent Coverage (Native Plantings)	Percent Coverage (weeds)
Van LobenSels Ranch (levee slope)[1]	55.7%	34.3%
Vino Farms Ranch (ditch #1)[2]	26.2%	36.8%
Vino Farms Ranch (ditch #2)[3]	58.8%	9.4%
Winchester Lake [4]	64.1%	0%

[1]Sedge (*Carex barbarae*) and creeping wildrye (*Leymus triticoides*)
[2]Sedge (*Carex barbarae*), creeping wildrye (*Leymus triticoides*) and rush (*Juncus effusus*)
[3]Rush (*Juncus effusus*) and three-square (*Scirpus americanus*)
[4]Tule (Scirpus californicus)

Most of the plants of the 2010 installation at the Herringer Ranch did not survive. Part of the explanation is that many of these installed plants were made up of tiny seedlings (plugs) compared to the installations at the other sites where larger and better rooted plants were utilized. Another possible reason for failure is pesticide drift, which even affected larger plantings.

Discussion

Several obstacles to successful installation of native, perennial plants on along ditches, farm borders and levee slopes on private working landscape farms were initially considered at the beginning of this project. Over the several years since this project began, additional concerns and issues have been discovered. Barriers and stressors to the success of the project include cultural/social, economic, and environmental factors.

Findings regarding farmer's attitudes toward environmental restoration and improvements were based on numerous discussions with farmers, not only for those that accepted this project but others who did not. While a more statistically based study based on extensive interviews would be required to fully understand the cultural and sociological context of farmer perspectives, these findings, while qualitative, are based on the author's extensive experience in the Delta.

Based on these discussions, we learned that individual farmers varied in their receptivity to the project, in part their interest being influenced by the kind of farming practiced. Farmers with annual crops (e.g., GMO corn) in the central Delta were generally not receptive to planting native plants along ditches, farmland borders or interior levee slopes. These open ground farmers of annual crops were reluctant to the planting native species on their farms because their method of weed control consists of broad scale aerial application of herbicides. As a result, these farmers could not ensure the survival of native plants given their methods of weed control. Conversely, farmers in the north Delta, growing perennial crops such as vineyards, were more open-minded about this program. Hence the disparity of where our efforts were directed.

We also learned that attitudes about the prospect of planting native plants on their property varied among individual farmers. Younger and more educated professional employees of the larger vineyards (e.g., Vino Farms) were particularly enthusiastic about having native species planted on the marginal, non-cultivated areas of the farms. Older and more established farmers showed less interest in this project. The environmental awareness of the younger employees may be related to their more recent training at colleges. Research to further explore these preliminary hypotheses are needed to clarify these issues, especially to compare with other regions.

As mentioned above, the different farming systems influence receptivity to planting native species on farms. On some farms – especially open field annual crops – herbicides are applied aerially, which results in herbicide drift and harm to native species. Herbicides are specifically applied along ditches, property boundaries and levee slopes to control noxious weeds. The principle herbicide used is Roundup, a contact herbicide that directly affects green, living plants. But other herbicides are commonly mixed in with Roundup, including Gold, made by duPont. This product is a soil residual that has long lasting efficacy as a pre- and post-emergent that affects young seedlings. This is one of the reasons why we choose larger, more mature plants for installation as they are more robust to the effects of soil herbicides compared to younger, more susceptible seedlings.

The situation at vineyards is different where grapes are particularly sensitive to herbicide drift, so wine grape growers appear to be more discriminating about when and where herbicides are applied. Moreover, weed management practices vary considerably even within a grape growing region: some vineyards permit perennial grasses to be grown between grape rows, while in other vineyards everything but the grapes is sprayed.

The widespread application of herbicides by traditional farmers and/or reclamation districts on nearly all plants that aren’t of direct economic value may have affected the outcome of this project. On one farm, despite the farmer communicating to the RD about the location of new native plant installations, the hired contractor none-the-less sprayed and killed several thousand native grasses. Long term application of herbicides would also appear to affect the quality of the soils to support native grasses. As mentioned above, soil build-up of chemical residues appears to render many irrigation ditches and levee slopes unsuitable for planting. Many ditch, borderlands and levee slopes have no plants growing on these sites what-so-ever. We learned that any planting of native species on these sites to be problematic. Sites that were excessively weedy -- due to lack of weed control -- have equally proved problematic because of competition from these alien species.

Soil conditions affected the outcome of the project. The sites varied somewhat with respect to soil types, varying from sandy, loam or hard packed clay sites. Loamy soils are the most suitable sites for planting success.

Different methods of planting were initially proposed: seeding, small seedling plugs and larger well rooted container stock. The per unit area cost increases from seeding, seedling “plugs”, and the larger well-rooted container stock. However, the suitability of these different methods varies with different site conditions. Broadcast application of seed material is best suited for clean sites with little weed competition. For this method to work, considerable prior site preparation is required that generally involves re-contouring, soil treatment (disking, roto-tilling, etc.) and/or the possible application of pre-emergent herbicides. Few sites in our project area were suitable for this approach. Many farmers feel that they don’t have enough room to re-contour a ditch bank. Reclamation districts and flood control agencies are also hesitant to alter levee slopes. The prior cleaning of sites with herbicides is also problematic in the vicinity of sensitive crops such as grapes. Moreover, seedling materials are more susceptible to soils with herbicides remaining in the soil as residuals than are larger, established plants that are hardier. A site (the Van Loben Sels ranch) that we intended to plant with seeds was deemed to be too polluted with chemical residuals for seed materials to have been applied. Instead, we planted larger rooted materials that initially thrived on the site. Seeding was done, however, along a re-contoured (the Lambert Road site on Vino Farms) site which initially appeared successful. This was the only site where adequate site preparation for seeding was attempted.

The success of planting also has varied with size of plants used in the initial installation. While the smaller seedling plugs are less expensive than the larger rooted container material, the latter are hardier for sites where competition from competing exotic species is a major obstacle to plant establishment. As will be described later, we have had poor success with the smaller sized plug materials planted at the Herringer site in which the entire planting of small sized materials appeared to have failed.

It was very difficult to find sites entirely suitable to test some of the original hypotheses. Many of the sites either were entirely barren due to widespread application of herbicides or were extremely weedy. The barren sites were generally associated with annual crops, such as GMO corn. Some initial plantings in these sites were problematic, apparently due to chemical residues remaining in the soil. Related to this widespread situation is the constant herbicide drift associated with ongoing agricultural practices. Conversely, many sites were extremely weedy; we largely excluded these sites, but even moderate amounts of weedy growth affected the success of planting. Another complicating factor was the extreme drought over the past two seasons which further impacted the potential success of the project. Due to these constraints, larger rooted plant materials were used rather than the risky installation of seed materials. Several specific hypotheses were originally proposed.

For hypothesis no. 1, Seed drilling is a less expensive method of native grass establishment than planting of plug plants. As explained above, site preparation including re-contouring and disking was not feasible on the sites available to us.

For hypothesis no. 2, the extent of which vegetated cover reduce maintenance costs, was also unrealizable, for several reasons. Most importantly, it would require several more years of establishment to be able to fully test this hypothesis. Second, it was thought that the farmers would be involved with maintenance activities, but only two farms expressed an interest or had the time to devote to the program.

Regarding hypothesis no. 3, measuring the extent of erosion control, also proved to be problematic. The locations where successful ditch implementations occurred proved to not have a problem with erosion. The ditch bank conditions at Winchester Lake include rock/revetment, thus there is little erosion. The bank conditions at the Vino Farms Lambert Road site consists of hardpan soils where erosion is also not an issue. Other sites where native plants were installed consist of an abundance of weedy species, so again erosion is not a problem. The ditches with barren steep banks are very common throughout the region. However, they are barren because of the widespread application of herbicides, so planting was not an option.

Conclusions: Lessons Learned

1. Certain types of farming operations are more amenable to planting native plant species along ditches and levee slopes. Large scale open field commodity crops (such as corn and wheat) are less likely to be compatible with these environmental enhancements as broad herbicide application (sometimes done by airplane) is incompatible with native plant survival.
2. Vineyards seem to be more compatible with planting native species as herbicide application is done in a more controlled manner.
3. Success or failure seems to be related to the size, structure and management of the farming operation. Small family-run farms may not have the time or the financial resources to break away from farming operations to participate in environmental enhancement. Larger farms -- and presumably with more resources -- seem to have more resources to participate in environmental enhancements..
4. The success and/or failure of this type of project will vary with inherent environmental conditions of soil types. Poor soil conditions, such as coarse sand or fine clay, are more difficult for plant growth. The most ideal environment is a well-balanced loam, which may be difficult to locate as most environments tend towards the clay end of the soil spectrum. Extremely sandy conditions, in the Delta, are often the result of former dredging operations that pile sandy river bottom materials onto levee slopes. These materials are often derived from former hydraulic mining activities which brought course materials downstream from the gold mining regions downriver to the Delta. Extremely clayey soils are often the result of dredging from ditches; these materials are then placed on ditch and levee banks.
5. The success and/or failure of this type of project will vary with pre-existing types of vegetation. Extremely weedy conditions, especially sites with blackberry and other perennial plants, are not easily converted to native plant communities. First, several years of weed control (often through spraying of herbicides) is required to prepare the site for planting. If native plants are installed within a weedy community, then competition with the weedy species reduces the success of the intended species.

6. The success and/or failure of this type of project will vary with past and ongoing land management practices. In particular, sites with long histories of herbicide application make for difficult conditions for native plant establishment.
7. The success and/or failure of this type of project will vary with moisture availability. Planting of moisture loving plants along ditches can be very successful, while planting on dry slopes (with either too much sand or clay) will likely have problematic results. Another factor for planting success along ditches will also be somewhat dependent upon the timing and seasonality of water availability. The timing and amount of water available in ditch environments may not be ideal for plant establishment. These factors must be understood before planting is planned.
8. The timing of planting is critical. There is a narrow window of opportunity for success. This is in the middle of fall after sufficient rains, but not too late in the season as conditions dry out by mid spring. Therefore, large planting crews need to be able to plant within a 2-month period. Starting earlier or waiting for a latter date requires expensive pre-irrigation or post-irrigation.
9. Some general weeding or mowing is required to reduce weed competition. Planting into annual grass communities is more feasible than planting into coarser weed communities as the former can be more easily controlled through mowing. The presence of rank weed species requires hoeing or the application of herbicides which can be expensive or problematic for survival of the native plant species.
10. The most successful environment for ditch and levee slope environments will therefore include: 1) better quality soils (such as loams); 2) inherently cleaner sites with fewer rank and/or perennial weeds; annual grasses are the least problematic for planting success; 3) certain cropping environments, such as larger vineyards with farm managers who share these environmental goals.
11. The size of the planting materials influenced survival. The larger the plant, generally, the greater the likelihood of survival. The use of seeds is not recommended except for weed free and tilled sites; this is more likely to occur in conjunction with newly constructed landscapes, such as re-contoured levees or ditch banks.
12. Two out of the three years of this project were classified as dry water years. As global climate change will likely worsen conditions for plant survival, other measures, such as dedicated irrigation systems, will likely be needed.

Literature Cited

Baker, Lawrence A. 1992. Introduction to nonpoint source pollution in the united states and prospects for wetland use. *Ecological Engineering* 1 (1): 1-26.

Burk and Grime. 1996. An experimental study of plant community invasibility. *Ecology* 77:776-790.

California Bay Delta Public Advisory 2002

Clark, Haverkamp, and Chapman. 1985. *Eroding Soils: The Off-farm Impacts.* Washington, D.C.: The Conservation Foundation, 1985.

Cooper, Giliam, Daniels, and Robarge. 1987. Riparian areas as filters for agricultural sediment. *Soil Sci. Soc. Am. J.* 51:416-420.

Earshaw, Sam. 2004. Hedgerows for California Agriculture. A Resource Guide

Fustec, Mariotti, Grillo, and Sajus. 1991. Nitrate removal by denitrification in alluvial groundwater: Role of a former channel. *Journal of Hydrology* 123:337-354.

Gilliam. 1994. Riparian wetlands and water quality. *J. Environ. Qual.* 23:896-900.

Gray and Sotir. 1996. Biotechnical and soil bioengineering slope stabilization; a practical guide for erosion control. In *Biotechnical and Soil Bioengineering Slope Stabilization; A Practical Guide for Erosion Control.*

Hart, Jeff. 2013. Personal opinion.

Karr and Schlosser. 1978. Water resources and the land-water interface. *Science* 201:229-234.

Long, R and J Anderson. 2010. *Establishing Hedgerows on Farms in California.* UCANR Publications.

Lowrance, Todd, Hendrickson, Leonard, and Asmussen. 1984. Riparian forests as nutrient filters in agricultural watersheds. *BioScience* 34 (6): 374-377.

Mitsch and Jorgensen. 1989. Ecological . In *Ecological Engineering: An Introduction to Ecotechnology.* New York: John Wiley & Sons.

Porkorny. 2002. Plant functional group diversity as a mechanism for invasion resistance.. Montana State University.

Rogers and Dunn. 1993. Developing Design Guidelines for Constructed Wetlands to Remove Pesticides from Agricultural Runoff. In *Created and Natural Wetlands for Controlling Nonpoint Source Pollution*.

Sheley and Carpinelli. 2005. Creating weed-resistant communities using niche-differentiated nonnative species. *Rangeland Ecology and Management* 58 (5): 480-488.

USDA ARS, 2005