WETLAND RESTORATION ON THE PLATTE RIVER FLOODPLAIN IN NEBRASKA

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ABSTRACT

This paper highlights attempts to restore wetland habitats on the floodplain of the Platte River. Restorations have included clearing and disking river channel areas to maintain an open-vegetated braided stream as well as a number of experimental plantings aimed at re-establishment and enhancement of wetland sedge meadows and lowland mesic prairies. Groundwater pumping, dam and dike construction, land contouring, and a variety of re-seeding strategies have been used. Re-establishing the diverse flora of native wetland sites has been a challenge. Although native grasses and a few common forbs found in the seedbank have successfully been re-introduced, 60 to 70% of the wetland species present on native sites are missing. The lack of these wetland species suggests that the surface and groundwater hydrology needed to sustain them may be absent, and that the restoration sites do not fully emulate the hydrology of native areas. Inadequate seed sources and the limited capacity of many indigenous species to self-seed or colonize sites probably contributes to low forb diversity as well. However, high diversity plantings, using a hundred or more species in seed mixes, and extensive land contouring, show promise in the restoration of wet meadows that look and appear to function similarly to native sites.

INTRODUCTION

Over the past 100 years, water development in the Platte River basin in Colorado, Wyoming, and Nebraska has reduced stream flows in the Platte. Hundreds of small diversion canals and a series of reservoirs on the North Platte River and in Colorado provide water for irrigation and power generation and have contributed to the alteration of the river's flow regime. Annual flows have been reduced by 50 to 75% (Williams 1978, O'Brien and Currier 1987). Historically, open channel riverine habitat with little tree and shrub growth was prevalent along much of the river. Flow reductions have allowed woody vegetation to develop over much of the riverbed, reducing open-channel area by as much as 70 to 90% (Eschner et. al., 1981, Currier 1982, Sidle et al. 1989, Currier in press). Lowered water tables, accelerated drainage, and conversion of prairie to row-crop agriculture has also reduced wet meadows adjacent to the river. Depending on the river reach, these meadow losses have ranged from 20 to 70% (Currier et al., 1985, Sidle et al., 1989). Such changes have reduced the nesting, roosting, courtship, and feeding habitat for a number of native migratory birds, including the sandhill crane, whooping crane, waterfowl, shorebirds, least terns, piping plovers, and grassland nesting species (U.S. Fish and Wildlife Service 1981, Currier et at. 1985).

The Platte River Whooping Crane Trust, The Nature Conservancy, and the National Audubon Society have acquired nearly 5,000 ha of riverine, wet meadow, and cropland habitat for migratory birds during the past 15 years. These lands are scattered along the 125-km Big Bend reach of the Platte in central Nebraska. Management has been directed at developing a habitat complex consisting of 3.5 km of open river channel and adjacent wetlands and wet meadows. Heavy equipment has been used in the river during low flow periods to remove tree and shrub growth and to maintain an active riverbed through periodic mowing and disking. Woodland vegetation clearing and disking over a number of years has been relatively successful in maintaining about 40 km of open channel areas. But these techniques are only effective, however, in combination with subsequent high scouring flows. Flow management remains the single most important element in maintaining open channel areas (Currier in press, 1996).

In contrast with the relative success in maintaining open channel wetland habitat on the Platte, various techniques for re-establishing wet meadows on the river are still being evaluated. Most of the emphasis of this paper has therefore been given over to a review of specific techniques employed and their relative success in restoring wetland meadow habitats on the river. Logically, one must first understand how existing wet meadows function ecologically and hydrolgically before attempting to replicate or restore them. However, wet meadows are a complex, dynamic system that are difficult to understand.

Native meadows consist of a complex of grassland and wetland areas within close proximity to the channels of the Platte. They are confined to the floodplain, and for the most part are found within 0.5 to 2 km of the river's channels. Their hydrology is typified by pooled or ponded water during a portion of the year (primarily spring and early summer) with interconnections to the river through a common groundwater table and occasional surface overflows (Hurr 1983, Henszey and Wesche 1993)(Figure 1). Groundwater and surface water fluctuations are common (Figure 2), and are primarily driven by changes in river stage and to a lesser degree by precipitation events (Henszey and Wesche 1993). A dynamic interaction exists among the main channels, side channels, backwaters, and wet meadows. High groundwater levels are hydrologically linked to short-term "pulse" or "peak" flood flows which recharge meadows and create overbank flooding. Such events are instrumental in redistributing nutrients, seeds, and organisms between the river system and isolated wetlands and wet meadows (Jelinski and Currier 1996).

Mesic or moist prairies, sedge meadows, emergent cattail and bulrush marshes, wetland swales, ponds and sloughs, and lowland savannas are all aspects of wet meadows. Although generally flat to sloping, meadows can have a rolling or "corrugated" surface topography that includes lowland sloughs and upland sand ridges. The common thread among these diverse types of wet meadows is a high groundwater table, a surrounding matrix of prairie, and the presence of scattered wetlands, poor drainage, and nutrient-rich soils (Currier 1989).

Although dominated by prairie grasses, sedges, and marsh emergents, wet meadows support more than 200 species of wetland and grassland plants. Woodland and shrubs provide another vegetative component, but they are generally confined to meadow perimeters. The variety of plants and microhabitats in meadows provides habitat for a wide variety of organisms from birds and amphibians to earthworms, snails, and insects. Platte River wet meadows provide some of the most important migratory feeding and nesting habitat for wildlife in central Nebraska (Krapu 1981). More than 150 species of birds use wet meadows and their associated wetlands to obtain both plant and animal foods (Currier et al. 1985,). The seeds, tubers, insects, ground beetles, spiders, insect larvae, and other organisms found in wet meadows form the bulk of forage for these species, but these organisms also sustain mice, rodents, snakes and predators located higher in the food chain.

Wet Meadow Restoration Model - Comparison with Native Sites

Underlying our restoration efforts, is an attempt to replicate the species composition and hydrology at native wet meadow sites on the river. Our model for comparison has been two native sites, Mormon Island Crane Meadows (a high diversity, very wet site) and the Binfield Site (a drier and lower diversity area) were used as benchmarks for comparing plant species composition and diversity. These native sites represent two of the largest remaining wet meadows in the Platte River valley. They provide a good cross-section of the plant species found on managed, native areas in the valley, and also represent a variety of management strategies (e.g., continuous versus rotational grazing and early versus late haying). Management at the native sites involved grazing and haying rotations and has been aimed at increasing plant production, maintaining a higher stature and diversity of vegetation, and promoting native species.

The purpose of this discussion is to examine the results of 4 representative types of wetland restorations on the river in comparison relation to native sites. Although both wetland and more mesic and upland prairie species are represented in these restorations, the success of wetland species establishment is examined in particular because these species define the character of wetland sites. A high diversity (i.e., 100 species or more) planting is also examined in detail to determine its initial status and its potential application as a widespread restoration technique.

STUDY SITES AND METHODS

Field-11 Site - Grass Reseeding

Field-11 is a 24-ha site near Grand Island that was reseeded to prairie grasses in 1988. The area had been in crop and alfalfa production for approximately 40 years. Big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*), and little bluestem (*Schizachrium scoparius*) were drilled into a sorghum stubble cover crop, following a standard Soil Conservation Service technique. Non-local commercial seed from eastern Nebraska was used in the planting. Occasional haying and prescribed burning has been used on the site to suppress rank weeds (primarily annual sunflowers *Helianthus annuus*) and to encourage the growth and expansion of native grasses and forbs. Wet meadow forbs were allowed to colonize the site, but no seeding of these species was undertaken. Field-11 is a moderately dry site with a few poorly drained areas, however, no attempts were made to enhance the local hydrology.

Johns Site - Wetland Site Restoration

The Johns site, located near Elm Creek is a 125-ha site where a floodplain forest (40 to 50 year old trees) was removed in 1985 to develop an open grassland meadow. This restoration is an attempt to restore a wet meadow in its historic landscape position immediately adjacent to the river channel. Trees were primarily chain-sawed and burned, although a small sawmill operation salvaged some lumber for pallets and packing material. Stump regrowth and noxious weeds (e.g., musk thistle, *Carduus nutans*) were chemically controlled by aerial spraying with Banvel and 2,4-D. Prescribed burns were also used to help control woody regrowth. The site was not seeded; grasses, sedges, and herbaceous vegetation were instead allowed to colonize from local sources. Although the Johns site is located within the high banks of the river, no direct river flows cross the property because of a diversion dike located 1 km upstream. Hydrology was enhanced on the site by constructing three low-level dikes (2 meter maximum height by several hundred meters in length) to temporarily store water during high groundwater or river stage periods. Flood flows in 1995 caused 2 of the 3 dikes to breach, but they were rebuilt during the summer of 1996. Soils are very sandy riverwash and quite porous.

Uridil Site - High Diversity Seeding

The Uridil Site near the town of Wood River, is a high-diversity seeding with extensive hydrologic and wetland enhancement. This former 32-ha wet meadow site had been leveled, drained, and row-cropped for approximately 25 years. This site was planted with a high-diversity seed mix of more than 100 species of grasses and forbs. These were collected from local seed sources (road ditches and native meadows), by hand and with a combine. The area borders the south channel of the river and lies on a high island between the middle and south channels. The site occasionally experiences overbank and backwater flooding, but to enhance hydrology, the area was scraped and recontoured to re-create a more serpentine drainage pattern that is characteristic of native wet meadow sites.

Wildrose Wetland Site - Shoreline & Marsh Enhancement

This project was designed to enhance the habitat around an abandoned sand and gravel operation at the Wildrose Site located next to the middle channel of the Platte River, near Alda (Figure 5). Topsoil had been removed from a 16-ha area of a wet meadow where the gravel operation was undertaken. The soil was stockpiled in a berm, and the remaining area became a combination of open-water marsh, a relatively deep lake (9 m or more), and two large sand spoil piles. The lake area was dynamited to stabilize the site in 1993. Then approximately 35,000 cubic meters of topsoil from the stock-pile was redeposited along the lake margin to enhance shallow water shoals and other habitats used by migratory birds and waterfowl. In addition, the sand spoil piles were enhanced as nesting habitat for least terns and piping plovers.

Along the shoreline, where shallows were created, tubers of marsh emergents, including burreed (*Sparganium eurycarpum*), river bulrush (*Scirpus fluviatilis*), and soft-stem bulrush (*Scirpus validus*), were planted to encourage a rapid growth of a diverse plant community that would displace or discourage dominance by cattail (*Typha x glauca*). Wetland species were seeded along the north and west edge of the basin, including burreed, soft-stem bulrush, blue vervain (*Verbena hastata*), water plaintain (*Alisma plantago-aquatica*), and smartweeds (*Polygonum lapathifolium, P. hydropiperoides, P. persicaria*). On the uplands surrounding the lake, a mixture of native grasses (big bluestem, indiangrass, switchgrass, and little bluestem) and forbs (purple and white prairie clovers (*Petalostemon purpureum, P. candidum*), bundleflower (*Desmanthus illinoensis*), goldenrods (*Solidago canadense, S. rigida*), and asters (*Aster simplex, A. ericoides*) was planted in the spring of 1994.

Survey and Analysis

General plant surveys (releve' plots) conducted in 1993, 1994, and 1995 at the 4 restoration sites and the 2 native sites were used to assess the presence and absence of species. Quantitative cover values were also recorded at each site along stratified line transects. Sampling was stratified in order to represent the highly variable distribution of species found at the sites. Percent cover was estimated for all species by cover classes within meter-square plots. Presence and absence of wetland species was compared between the restoration and native sites to determine the percentage of species that were re-introduced in the restorations after 3 to 5 years of development. The species list used for the native sites was compiled as a composite of all the species found at the Mormon Island and Binfield sites. Because the flora in the native sites was somewhat variable, this composite list may overstate the species diversity in native sites. However, it also insured that the complete heterogeneity found in native sites was considered in the analysis.

Dominance diversity curves (after Whittaker 1975) were also developed based on the quantitative cover values for the sites. Although quantitative data was collected at the Wildrose wetland, it was not used to develop a dominance-diversity curve for that site because high water in the basin had limited the development of shoreline wetland vegetation during the 1994-95 sampling. These curves illustrate a combination of species richness and species importance at each of the sites, and provide a quick means of comparing the biodiversity at native and restoration sites.

RESULTS

A comparison of species found at the restoration and in native wet meadows sites is presented in Figure 3. Woodland species were a minor component at all the sites, and averaged less than 1 percent of total cover. Grasses were the dominant cover type in both the native and restoration areas (34% to 50% cover). Disturbed species were common on all the restorations (13% to 31% cover), and were less abundant on native sites. Wetland species, in general, were less common on the restoration sites than at native sites, particularly in comparison with the Mormon Island where 35% of the cover was dominated by wetland species. Because wetland species are an essential element in gaging the success of these restorations, they were examined in greater detail. A number of wetland forbs were missing from the restorations (Table 1). For instance, of the 59 wetland plant species found on the native sites, only an average of 21 were present in the restorations. The high-diversity planting at the Uridil site had the greatest number of wetland species, but still had only 44% of the wetland species found on native sites.

Among the 4 restoration sites, the wetland species varied considerably. Field-11, which lacked any extensive wetland depressions, contained very few wetland species characteristic of deep water and saturated soil conditions. On the other hand, a number of these species were present at the Johns, Uridil, and Wildrose sites where standing water wetlands either occurred naturally or had been created or enhanced through dike construction and land contouring. However, some aspects of the native flora, including sedges and rushes were noticeably lacking from most of the restoration sites. In addition, a number of mints and some minor forb components found in native wet meadows (e.g., field mint *Mentha arvensis*, skullcap *Scutellaria lateriflora*, among others) were also missing. Although the diversity of species that have been successfully re-introduced in the 100-species mix used at the Uridil site has been quite impressive, it actually represents only about 50% of the species that were in the original seed mix (Table 2). In many cases, these species were introduced in very small quantities and may have been inadequate to allow establishment. Furthermore, the microhabitats needed to allow some species to develop (e.g., sedges) may not be present on the restoration sites.

Dominance-diversity curves were used to visually examine species richness and importance at the various sites (Figure 4). Importance values represent the log of the average percentage cover value for each species. The species sequence represents the rank order listing of the species from the most important on the left to the least important on the right. The curves in Figure 4 have been offset on the sequence axis, but their relative positions are unimportant. The total length of the sequence (i.e., the number of species) and the relative shapes of the curves are the important chacteristics in the dominance-diversity relationship. The least structurally complex and diverse Uridil site had a simple geometrically shaped straight-line curve. The sigmoid and more complex shapes of the curves for the Mormon and Binfield native sites, on the other hand, indicate a far greater species richness as well as a more complex organizational structure of the vegetative community (i.e., a more even distribution of cover among many species, rather than dominance by a few common species). The Johns and Field-11 sites had intermediate shapes indicating some sorting of their species sequences as the sites develop and mature. In general, however, the dominance-diversity curves indicate that the restorations are a long way from reaching the complexity and diversity of native wet meadow sites.

DISCUSSION

Recreating the diversity and complexity of wet meadow communities on altered and degraded sites is a difficult task. With drainage and conversion to cropland, most elements of the native vegetation and hydrology have been irretrievably lost. We can only hope that some semblence of the native condition can be restored. Although some seeds, tubers, and other vegetative plant parts can remain dormant in the soil for many years, tillage and physical disturbance of the soil interrupts the growth and reproduction of many of these species, while chemical herbicides and pesticides undoubtedly have eliminated others. One has only to survey an abandoned crop field to see that the majority of species present in adjacent grasslands are usually absent. Changes in drainage, depth to groundwater, structure of the soil profile, water percolation, nutrient distribution, and other physical alterations also effect the ability of species to recolonize a site. The ecological structure of native plant and animal communities may have taken thousands of years of co-evolution to achieve. As a result, restoration attempts over the short-term, may never fully replicate native meadows. Instead, a more realistic goal should be to achieve as nearly as possible, the development of native wet meadow sites that appear and tend to function similarly to native sites.

Because the restoration plantings reviewed here are all relatively recent (3 to 10 years old), the interpretation of the data needs to be approached with caution. A variety of techniques have been used at the sites, including different seed mixes (or no seeding), hydrological enhancements, and differences in land management. In some instances, the restoration efforts have been very encouraging. Grasses have successfully been established at the restoration sites including the Johns site on the former river floodplain where they have self-seeded. In addition, high diversity seed mixes and the development of variable topography at restoration sites through ground surface contouring, appear to be quite successful as well. At the Uridil site, for instance, a broadly diverse flora has initially become established, even though only about 50% of the species that were initially seed have appeared so far in the planting. Likewise, seeding of wetland species with seeds and tubers of emergent plants has also been relatively successful along the lake margin of the restoration at Wildrose. If water levels had been lower during the period when the seeding was done, the results would probably been even more impressive at this site.

On some of the early plantings undertaken by the Trust and others, such as in Field-11, only a few grass species were introduced. It is clear that some elements of the native flora are missing from these sites. It was hoped that with time that additional species would immigrate to such sites, either through wind dispersion or through bird or other animal droppings. However, our initial findings suggest that immigration or development of species from residual seedbanks may be a very slow process. Overseeding and seedling transplants have been used on a few sites to introduce additional forb diversity, however, it is too early to determine the results of these attempts. Based on the results of the high-diversity Uridil planting, it appears that the earlier forbs are introduced, the more successful they will be in developing and competing with native grasses. Early development of tallgrass prairie species can suppress and overshadow the development of forbs. While a diverse mix of grasses and forbs often occur on native sites where resources have efficiently been partitioned, such a division may not occur where a few species are allowed to dominate early in the early stages of successional development. Mowing, haying, grazing, burning, or other techniques that reduce this dominance may need to be applied in order to enhance species diversity in restorations.

Some of the restorations we have undertaken have resulted in significant new habitat that has filled a niche in the Platte River ecosystem. Field-11, for instance, has over the short-term, provided some of the most structurally diverse habitat along the Platte, and some of the highest densities of breeding birds anywhere in the valley (Savidge & Siebert 1992). As time goes on, however, and weedy species decline in such plantings, their structural and species diversity will undoubtedly decline. The keys to developing long-term diverse habitats are probably establishing both a diverse mix of native species, as well as re-creation of the variable ridge and swale topography found on native sites.

Although the high diversity planting at the Uridil site has shown great promise as a way to restore Platte River wetlands, we suspect that over time, that the species in this planting will also tend to sort themselves into a more clumped distribution in which some species will be greatly reduced, and others will be eliminated. In other words, the effort of planting over a hundred species may be for naught if eventually many of these species are eliminated. However, at this point, we are not certain what will happen over the long-term. We do not know which species will ultimately remain in the flora and therefore we do not know which species are the most important to collect and seed into these plantings. We also need to evaluate the role of residual seed found in the soil seedbank in filling the gaps in such restorations.

The most discouraging aspect of our restoration attempts has been the lack of native wetland species at some of the restoration sites. It appears that the major factor responsible for the lack of wetland species is a lack of the necessary ground and surface water hydrology to sustain them. Attempts to enhance wetland hydrology have produced mixed results. Windmill pumping at the Uridil site was not very effective in creating widespread surface water wetlands, or in enhancing the wetland flora. The development of low-head dams at the Johns site, and the recontouring of sloughs at the Uridil site have been moderately successful in creating ponding and pooling of water on the ground surface, but they have resulted in wetlands that physically and functionally appear very different from those found on native sites such as Mormon Island (Figure 5). The Mormon Island site is characterized by high soil saturation, a groundwater table that is at or near the soil surface during a portion of the year, and a hydrologic connection to stage levels in the river channel (Henszey and Wesche 1993).

Our experimentation on the river over the past few years indicates that it will be difficult to replicate this hydrology (Currier 1994, Currier and Goldowitz 1994). A further complication is that as a result of water development and drainage over the past 100 years, groundwater levels have undoubtedly declined in many areas. Many former wet meadow sites, therefore, which have a potential for restoration, are situated at considerably higher elevations relative to the groundwater table than they were historically (see O'Brien and Currier 1987). This has been one of the factors we have considered in suggesting recontouring of the surface topography on restoration sites. If the groundwater table has declined, however, it will be necessary to scrape areas to a much lower elevation than would have been present historically. This will add significantly to the costs of restorations, and will be difficult to accomplish on a large scale.

CONCLUSIONS

The results presented here should be considered and weighed as we continue with attempts to restore wetlands and wet meadow habitat along the Platte. High diversity seed introductions and ground surface contouring appear to be valuable techniques in re-establishing wet meadows and other wetlands along the Platte. However, the full impact of our management techniques and restoration attempts will probably not be known for decades. The preliminary results of our restoration attempts are valuable in understanding the kinds of habitat we are creating, the value of the habitat to migratory birds, and whether the result is habitat that resembles and functions ecologically like native sites.

Before we can be successful in re-establishing wet meadow and other wetland plant and animal communities, however, we must first be successful in restoring hydrologic conditions. Not only is the appropriate hydrology necessary to allow colonization and expansion of wetland plants; it is also necessary to sustain invertebrates and other aquatic organisms that serve as an important food base for cranes, waterfowl, and a wide array of other migratory birds. Techniques to manipulate ground water and surface water have been only marginally successful, and in many areas the soils and species characteristic of wetland sloughs and swales have not developed very readily. Fluctuating river flows and base groundwater levels that mimic the historic river flow regime appear to be essential elements in providing the necessary hydrology to maintain and restore wetland areas along the Platte.

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Table and Figure Captions.

Figure 1. A slough filled with standing water on a Platte River wet meadow in the spring. By summer these sloughs normally have little or no standing water.

Figure 2. A profile of the surface and groundwater levels at Mormon Island Crane Meadows. Ground water levels fluctuate throughout the year but are generally highest in the spring when precipitation and river stage levels are normally high.

Figure 3. Percentage cover of growth forms in three restoration sites (Uridil, Johns, Field-11) and at two native sites (Binfield, Mormon). Wetland species tend to be lacking in most of the restoration sites, although native grasses have been successfully re-established.

Figure 4. Dominance-diversity curves comparing restoration (Uridil, Johns, Field-11) and native (Binfield, Mormon) sites. The linear and less sigmoid curves for the restoration sites indicate that they have yet to reach the complexity and diversity of the vegetative communities in native sites.

Figure 5. The complex drainage patterns in a Platte River wet meadow are difficult hydrologic conditions to replicate in restorations and may limit the re-establishment of some wetland species.

Table 1. List of wetland species found in native wet meadows and comparison with species present in recent restorations.

Table 2. Prairie and wetland plants used in high-diversity plantings in wet meadow restorations. Over 100 species were included in the seed mix, but many were introduced in relatively small quantities. Species marked with a * are those that seeded into plantings within the first two years.

TABLE 1. List of wetland species found in native wet meadows and comparison with species present in recent restorations.

Species	Common Name	Field-11	Johns	Uridil	Wildrose
Agropyron caninum	slender wheatgrass	x		x	
Alisma subcordatum	water plantain			x	x
Ammania coccinea	tooth cup				x
Andropogon gerardi	big bluestem	x	x	x	x
Apocynum sibiricum	dogbane	x		x	
Asclepias incarnata	swamp milkweed	x		x	x
Aster simplex	panicled aster	x	x	x	x
Calamagrostis inexpansa	northern reedgrass		x		
Carex aquatilis	water sedge	x	x		x
Carex brevior	sedge				
Carex gravida	sedge				
Carex lanuginosa	sedge				x
Carex meadii	Mead's sedge				
Carex stipata	sedge				
Carex scoparia	sedge				
Carex vulpinoidea	fox sedge				
Echinochloa crus-galli	barnyard grass		x	x	
Eleocharis acicularis	little spikerush				x
Eleocharis macrostachya	spikerush		x	x	x
Fimbristylis puberula	fimbristylis				
Glyceria striata	mannagrass				
Helenium autumnale	sneezeweed		x	x	
Juncus bufonis	toad rush				
Juncus balticus	baltic rush				
Juncus dudleyi	Dudley rush		x		
Juncus torreyi	Torrey's rush		x	x	
Leersia virginica	rice cut-grass				x
Lobelia siphilitica	blue lobelia				x
Lobelia spicata	pale-spike lobelia				
Lycopus americanus	American bugleweed			x	x
Lycopus asper	horehound			x	
Lysimachia thrysiflora	tufted loosestrife				
Lysimachia ciliata	fringed loosestrife				
Lythrum dacotanum	winged lythrum			x	
Mentha arvensis	field mint			x	
Mimulus glabratus	monkeyflower				
Panicum virgatum	switchgrass	x	x	x	x
Phalaris arundinaceae	reed canary grass	x	x		x
Phyla lanceolata	fog fruit		x	x	x
Polygonum hydropiper	water pepper				
Polygonum lapathifolium	pale smartweed				
Polygonum nutans	water smartweed	x			x
Polygonum persicaria	lady's thumb				
Sagittaria latifolia	arrowhead				
Scirpus pungens	three-square		x	x	x
Scirpus atrovirens	green bulrush				
Scirpus fluviatilis	big river bulrush		x		x
Scirpus validus	softstem bulrush		x	x	x

TABLE 1. Continued.

Species	Common Name	Field-11	Johns	Uridil	Wildrose
Scutellaria lateriflora	skullcap				
Sium sauve	water parsnip				
Solidago canadensis	Canada goldenrod	x	x	x	x
Sorghastrum avenaceum	indiangrass	x	x	x	
Spartina pectinata	cordgrass	x	x	x	x
Sparganium eurycarpum	burreed				x
Spenopholis obtusata	wedgegrass	x	x	x	
Teucrium canadense	American germander				
Typha x glauca	hybrid cattail		x	x	x
Verbena hastata	blue vervain		x	x	
Vernonia fasciculata	western ironweed	x		x	
	TOTAL	14	21	26	22
	MISSING SPECIES	45	38	33	37
Percentage of natives (59 species) present		24%	36%	44%	37%

TABLE 2. Prairie and wetland plants used in high-diversity plantings in wet meadow restorations. Over 100 species were included in the seed mix, but many were introduced in relatively small quantities. Species marked with a * are those that seeded into plantings within the first two years.

Species / Common Name	Species / Common Name
* *Achillea millefolium* - yarrow	* *Elymus canadensis* - Canada wild rye
* *Agropyron caninum* - slender wheatgrass	*Equisetum arvense* - horsetail
* *Alisma subcordatum* - water plantain	*Eragrostis pectinacea* - lovegrass
Allium canadense - wild onion	* *Eragrostis trichodes* - sand lovegrass
* *Alopecurus aequalis* - shortawn foxtail	* *Eupatorium altissimum* - tall Joe-Pye weed
Ammania coccinea - ammania	*Fimbristylis puberula* - fimbrystilis
Amorpha canescens - leadplant	* *Gaura parviflora* - velvety gaura
* *Andropogon gerardi* - big bluestem	*Geum canadense* - white avens
Anemone cylindrica - thimbleweed	*Glyceria striata* - mannagrass
Antennaria neglecta - pussy toes	*Glycyrrhiza lepidota* - wild licorice
* *Apocynum sibiricum* - dogbane	* *Grindelia squarrosa* - gumweed
Artemisia ludoviciana - silver sage	* *Helenium autumnale* - sneezeweed
* *Asclepias incarnata* - swamp milkweed	*Helianthus grosseserratus* - sawtooth sunflower
* *Asclepias speciosa* - showy milkweed	* *Helianthus maximiliana*- Maximillian sunflower
* *Asclepias syriaca* - common milkweed	*Heliopsis helianthoides* - false sunflower
Asclepias verticillata - whorled milkweed	* *Iva annua* - marsh elder
* *Aster ericoides* - heath aster	-*Juncus dudleyi* - Dudley's rush
* *Aster novae-angliae* - New England aster	*Juncus tenuis* - rush
* *Aster praealtus* - willow-leaf aster	* *Juncus torreyi* - Torrey's rush
* *Aster simplex* - panicled aster	*Koeleria pyramidata* - Junegrass
* *Astragalus canadensis* - Canada milkvetch	*Kuhnia eupatorioides* - false boneset
Astragalus crassicarpus - buffalo bean	* *Lactuca canadensis* - Canada wild lettuce
* *Bouteloua curtipendula* - sideoats grama	*Leersia virginica* - rice cutgrass
Bouteloua gracilis - blue grama	*Leptoloma cognatum* - fall witchgrass
Calamagrostis inexpansa - northern reedgrass	*Lespedeza capitata* - bushclover
Calamovilfa longifolia - sand reed	*Liatris glabrata* - small blazing star
Callirhoe alcaeoides - pale poppy mallow	*Liatris punctata* - dotted gayfeather
* *Callirhoe involucrata* - purple poppy mallow	* *Liatris pycnostachya* - thickspike gayfeather
* *Calylophus serrulata* - serrate-leaf primrose	*Lobelia siphilitica* - blue lobelia
Carex brevior - sedge	*Lobelia spicata* - palespike lobelia
Carex gravida - sedge	* *Lotus purshianus* - deer vetch
Carex lanuginosa - sedge	* *Lycopus asper* - horehound
Carex meadii - Mead's sedge	* *Lycopus americanus* - american bugleweed
Carex scoparia - sedge	*Lysimachia ciliata* - fringed loosestrife
Carex stipata - sedge	* *Lythrum dacotanum* - winged lythrum
Carex vulpinoidea - fox sedge	* *Mentha arvensis* - field mint
Chrysopsis villosa - golden aster	*Mimulus glabratus* - monkey flower
Cirsium altissimum - tall thistle	*Mirabilis nyctaginea* - 4 o'clock
Cirsium flodmani - Flodman's thistle	* *Monarda fistulosa* - bergamot
* *Coreopsis tinctoria* - plains coreopsis	* *Oenothera rhombipetala*- evening primrose
* *Crepis runcinata* - hawkbeard	* *Oenothera biennis* - common evening primrose
* *Dalea leporina* - Dalea	*Osnomodium molle* - marbleseed
* *Desmanthus illinoensis* - Illinois bundleflower	*Panicum virgatum* - switchgrass
* *Desmodium canadense* - Canada tickclover	*Penstemon grandiflora* - shell-leaf penstemon
Desmodium canescens - hoary tickclover	*Penstemon gracilis* - slender penstemon
* *Desmodium illinoense* - Illinois tickclover	*Penthorum sedoides* - stonecrop
* *Desmodium paniculatus* - panicled tickclover	* *Petalostemon purpurem* - purple prairie clover
Dichanthelium lanuginosum - panicum	* *Petalostemon candidum* - white prairie clover
Dichanthelium oligosanthes - Scribner panicum	* *Phyla lanceolata* - fog fruit
* *Eleocharis macrostachya* - large spikerush	*Polygonum lapathifolium* - pale smartweed
Eleocharis compressa - flat-leaf spikerush	*Polygonum nutans* - swamp smartweed

TABLE 2. Continued.

Species / Common Name	Species / Common Name
Polygonum persicaria - lady's thumb smartweed	*Sium sauve* - water parsnip
Potentilla arguta - prairie cinquefoil	*Smilacina stellata* - false solomon seal
Potentilla norvegica - cinquefoil	* *Solidago canadensis* - Canada goldenrod
Praenanthes aspera - rattlesnake root	* *Solidago rigida* - stiff goldenrod
* *Pycnanthemum virginianum* - mountain mint	* *Sorghastrum avenaceum* - indiangrass
Ranunculus macounii - Macoun's buttercup	* *Spartina pectinata* - cordgrass
* *Ratibida columnifera* - upright coneflower	* *Spenopholis obtusata* - wedgegrass
Rosa arkansana - Arkansas rose	* *Sporobolus asper* - tall dropseed
Rosa woodsii - woodland rose	*Sporobolus cryptandrus* - sand dropseed
* *Rudbeckia hirta* - black-eyed susan	*Stipa spartea* - porcupine-grass
* *Sagittaria latifolia* - arrowhead	*Stipa comata* - needle and thread
* *Salvia pitcheri* - pitcher sage	*Strophostyles leiosperma* - wild bean
* *Schizachrium scoparius* - little bluestem	*Teucrium canadense* - American germander
Schrankia nuttallii - sensitive briar	* *Thalictrium dasycarpum* - meadowrue
Scirpus atrovirens - green bulrush	*Tradescantia bracteata* - bracted spiderwort
Scirpus fluviatilis - big river bulrush	*Typha x glauca* - hybrid cattail
* *Scirpus pungens* - 3-square	* *Verbena urticifolia* - elm-leaf vervain
* *Scirpus validus* - soft-stem bulrush	* *Verbena stricta* - wooly vervain
Scutellaria lateriflora - skullcap	* *Verbena hastata* - blue vervain
* *Senecio plattensis* - ragwort	* *Vernonia fasciculata* - western ironweed
* *Silphium integrifolium* - rosinweed	* *Vernonia baldwinii* - Baldwin's ironweed
Sisyrinchium angustifolium - blue-eye grass	*Viola pratincola* - prairie violet
Sisyrinchium campestre - white blue-eye grass	

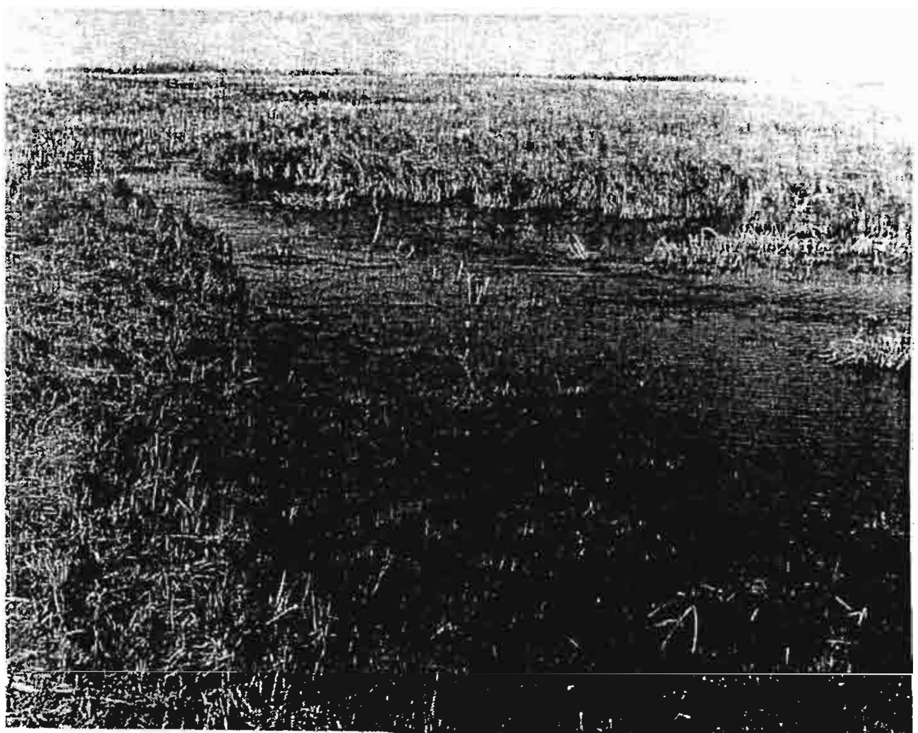

Figure 1. A slough filled with standing water on a Platte River wet meadow in the spring. By summer these sloughs normally have little or no standing water.

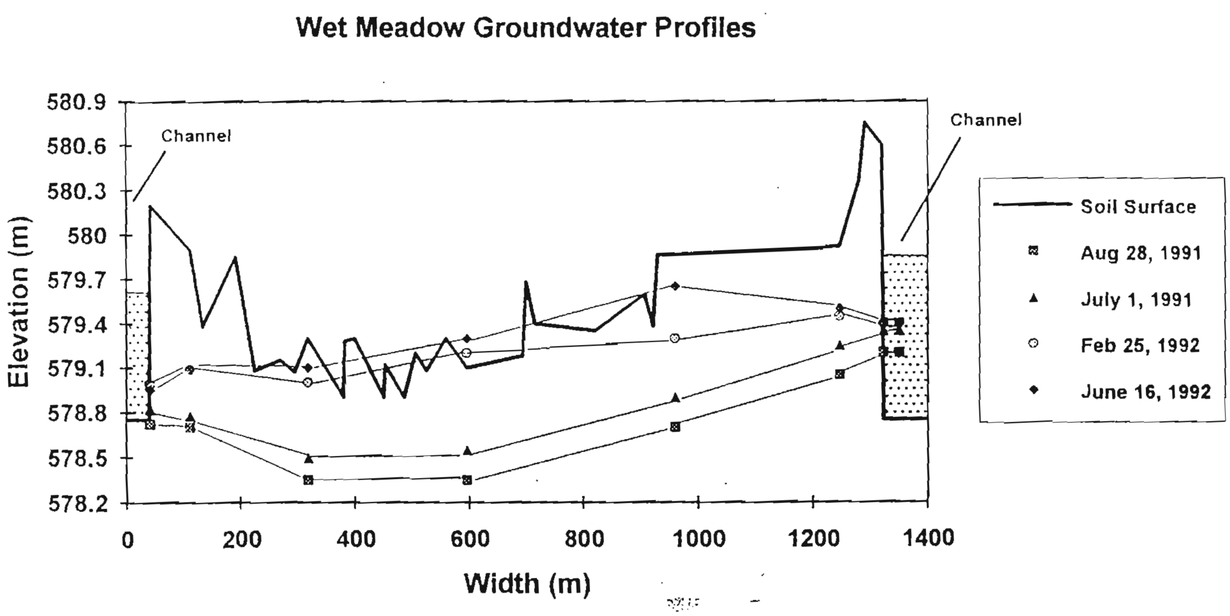

Figure 2. A profile of the surface and groundwater levels at Mormon Island Crane Meadows. Ground water levels fluctuate throughout the year but are generally highest in the spring when precipitation and river stage levels are normally high.

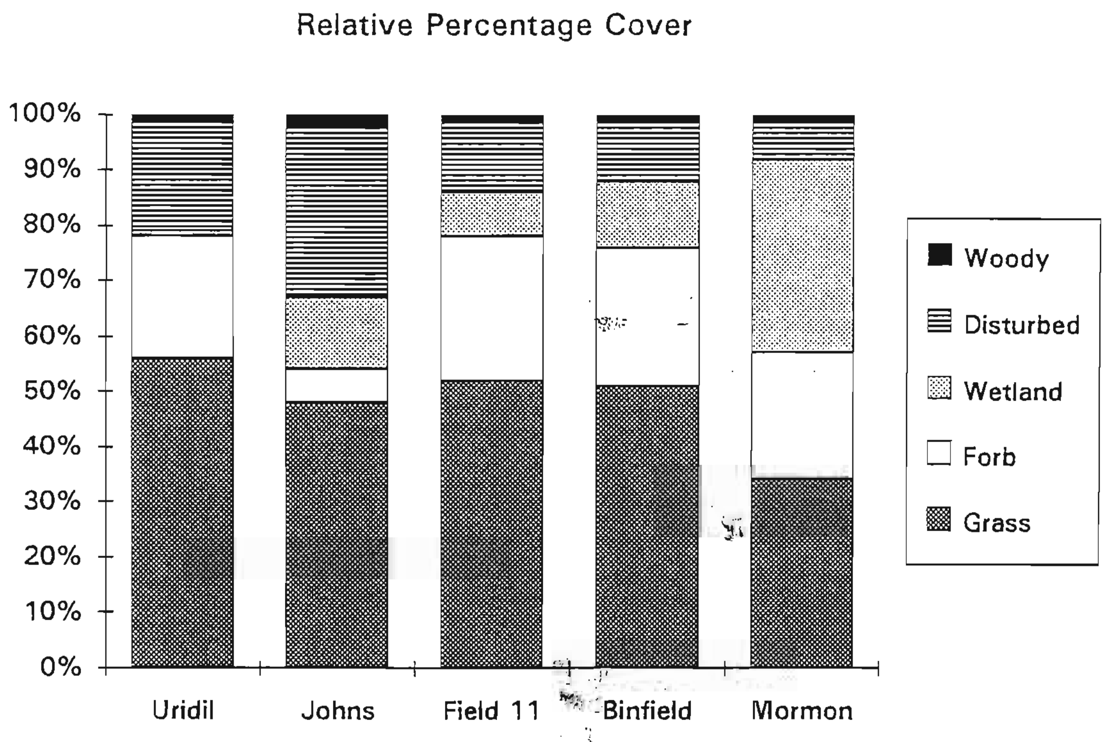

Figure 3. Percentage cover of growth forms in three restoration sites (Uridil, Johns, Field-11) and at two native sites (Binfield, Mormon). Wetland species tend to be lacking in most of the restoration sites, although native grasses have been successfully re-established.

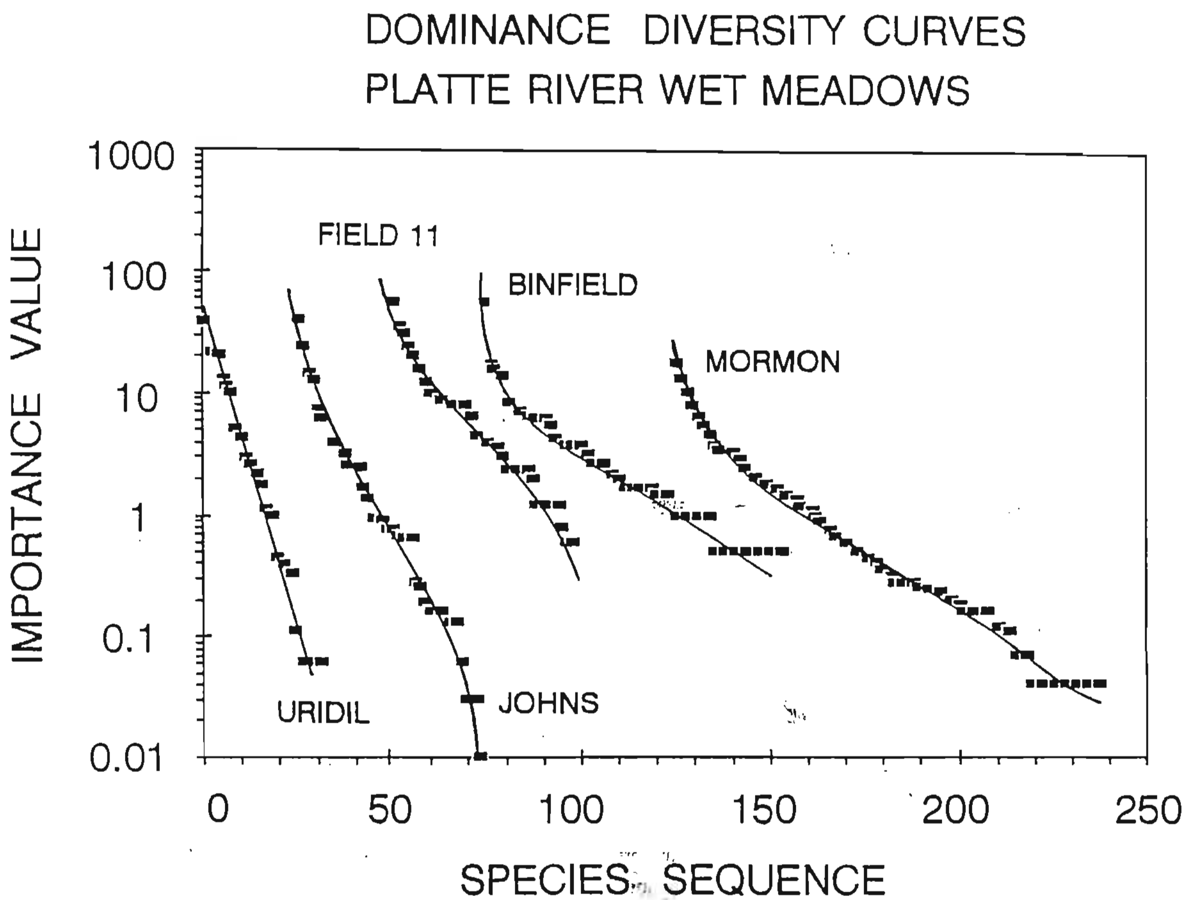

Figure 4. Dominance-diversity curves comparing restoration (Uridil, Johns, Field-11) and native (Binfield, Mormon) sites. The linear and less sigmoid curves for the restoration sites indicate that they have yet to reach the complexity and diversity of the vegetative communities in native sites.

PENNSYLVANIA ACADEMY OF SCIENCE

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March 16, 1996

Overnight Thursday

Dr. Paul J. Currier
Platte River Trust
2550 N. Diers Ave.
Suite H
Grand Island, NE 68803

Dear Dr. Currier:

I am writing to you at the suggestion of Dr. John Schalles to extend an invitation on behalf of the Pennsylvania Academy of Science to author a chapter on the topic **Wetland Restoration in the Platte River System** for the forthcoming book Wetlands and Associated Systems being published by the academy. The Pennsylvania has extensive experience in the publication of books on environmental topics with the most recent being **Environmental Contaminants, Ecosystems and Human Health** published in November 1995 and **Forests: A Global Perspective** being released in May 1996.

We ask all authors to limit their chapters to 20-22 double spaced type written pages and, if at all possible, we would appreciate receiving chapters by ~~30 June 1996~~. The academy is not in a position to offer financial assistance to authors, but all authors will receive a copy of the book.

Please inform me as soon as possible if you are in a position to author a chapter for Wetlands and Associated Systems.

Thank you.

July 15, 1996

national & international perspective
Text, tables, & Figs.
not > 20-22 pgs.
Photos - maps & graphs - ready for public.

Sincerely,

Fred J. Brenner, Ph.D.
President and Co-Editor
Certified Senior Ecologist
Certified Wildlife Biologist
Professional Wetland Scientist