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Michael P. Gutzmer
Nebraska Public Power District, mgutzmer@newcenturyenvironmental.com

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VEGETATION DYNAMICS AT THE GERALD GENTLEMAN STATION MITIGATION SITE, LINCOLN COUNTY, NEBRASKA

Michael P. Gutzmer

Nebraska Public Power District
1414 15th Street
Columbus, Nebraska 68601

ABSTRACT

Gerald Gentleman Station (GGS), located in southwestern Nebraska near Sutherland, is the newest and largest electric generating facility in the Nebraska Public Power District (NPPD) system. In August 1994, NPPD constructed a 9.2-mile long railspur between GGS and the Union Pacific Railroad to create competition in the coal-hauling market. A multi-objective criteria analysis was used to identify a railspur route with the optimal combination of low environmental impact, favorable engineering characteristics and economic feasibility. Based on jurisdictional delineations, the GGS railspur impacted 1.95 acres of wetlands. Construction of the wetlands to mitigate for those impacted acres was initiated during winter 1993–94 in primarily two areas near an existing wetland complex adjacent to Sutherland Reservoir. In April, 1994, the south excavation site was seeded with a floodplain mix and the north side was left to natural vegetation establishment. The south excavation area, which was seeded, contained significantly more wetland, submergent, and emergent plant species initially, however after four years the difference in species number between the seeded and non-seeded sites was not significant. Hydrological effects from Sutherland Reservoir elevations may have played a stronger role in vegetative reestablishment and the resulting wetland plant community than any human activity such as seeding. Four years after construction, the mitigation site vegetation has re-established successfully with over 40 plant species and provides valuable palustrine habitat for a variety of shorebirds, waterfowl and other wetland fauna species.

† † †

NPPD owns and operates Gerald Gentleman Station near Sutherland Nebraska and in 1991–94 constructed a 9.2-mile-long rail spur between GGS and the Union Pacific Railroad to create competition in the coal-handling market in a deregulating utility industry (Fig. 1). A Section 404 permit was required, and jurisdictional delineations following the 1990 Unified Federal Method determined that the GGS railspur project impacted 1.95 acres. This consisted of 1.54 acres of isolated wetlands, 0.20 acres of slough wetlands and 0.21 acres of riverine wetlands. A multi-objective criteria analysis was used to identify a rail spur route with the optimal combination of low environmental, favorable engineering characteristics and economic feasibility. Ultimately, the analysis was effective in distinguishing the least damaging practicable alternative based on cost logistics, existing technology and environmental impacts.

The concept of succession is most closely associated with vegetation dynamics. As traditionally conceived by Clements (1916), it is a rather orderly, predictable and directional process of vegetation change in which one set of communities replaces another until a relatively stable system (climax) is established. It is primarily community controlled and, in the case of wetlands, the ultimate vegetation is believed to be an upland climax. Since vegetation change is not necessarily predictable and orderly, as is sometimes thought, it is often difficult to predict the ultimate vegetation at a given created site. Some wetland communities once created may be relatively stable; others may undergo directional or cyclic change, thus adding to the complexity of the ultimate vegetation (Kosler and Kentula 1990).

Odum (1971) set forth the concept of pulsed stability as related to wetland systems. Subjected to more or less regular but acute physical disturbance imposed from without, they are often maintained at an intermediate state in development. This may further reflect why traditional successional concepts frequently have limited application in wetland systems. Tidal wetlands, for example, may be maintained in a relatively fertile state by a "tidal energy subsidy" which provides rapid nutrient cycling and favors substrate aeration. Among the freshwater systems, prairie potholes are pulsed in an even more striking manner, often com-

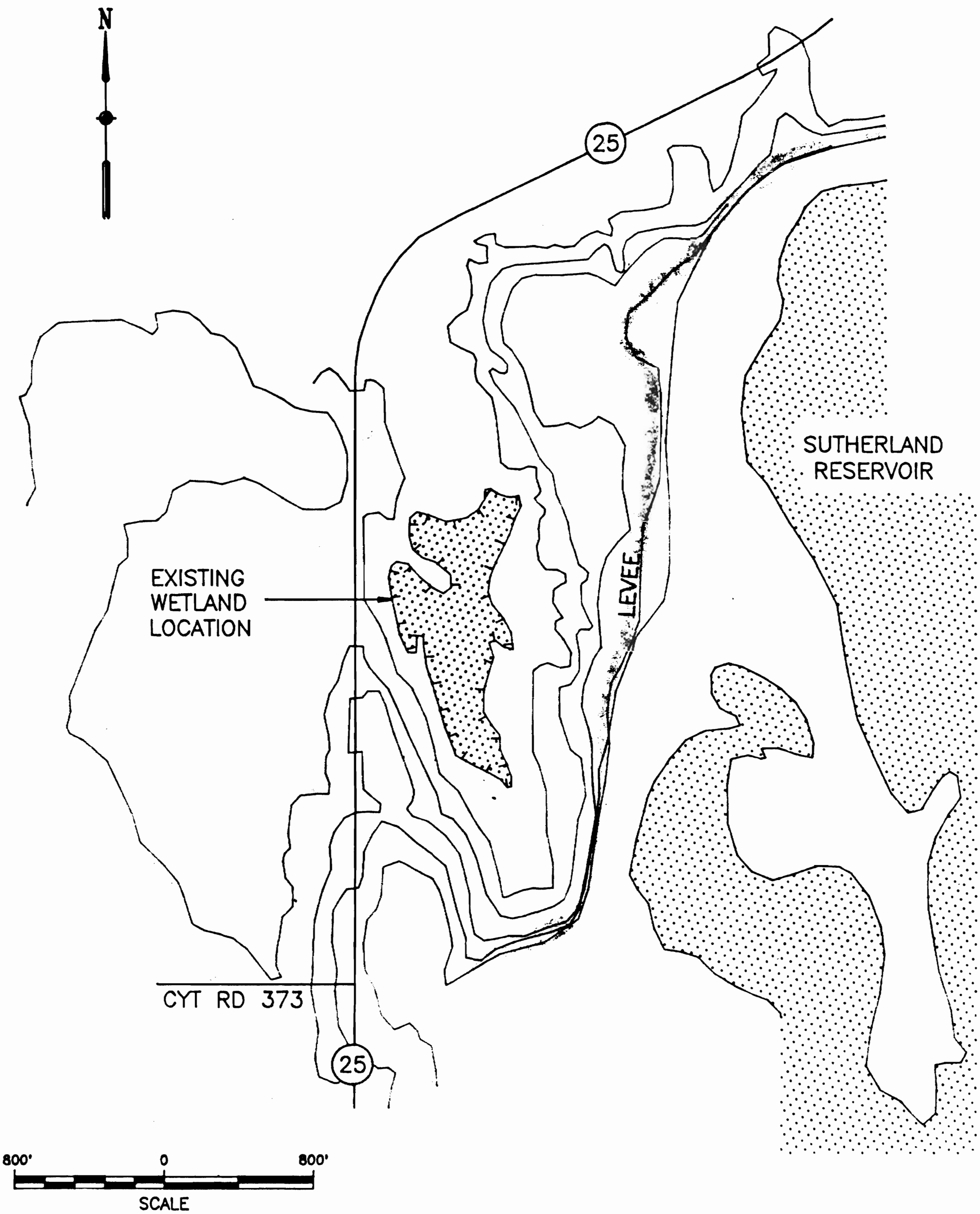

Figure 1. The mitigation site in Lincoln County, Nebraska.

pletely drying in droughty periods and then reappearing with adequate precipitation. During droughts, aerobic breakdown of the organic matter replenishes the nutrient supply to favor future productivity (Niering 1990).

The diversity and complexity of natural wetlands are principally the result of interactions of three important factors: 1) hydrology, 2) substrate, and 3) vegetation (Hammer 1997). The first two strongly influence the vegetation, as do climate and proximity to other wetlands. Since restoring or creating wetlands depends upon duplication of these factors and their interactions, an understanding of the ways they influence vegetation is important to proper selection of species, planting or establishment methods, and operating conditions.

The objectives of this study were to: 1) document vegetation re-establishment on the seeded vs. non-seeded excavation sites and compare plant species diversity and abundance, and 2) determine general re-establishment trends for plant species in wetland creation projects.

METHODS

NPPD was required to compensate for wetland losses at a ratio of 2:1 acre replacement. The wetland mitigation site near Sutherland Reservoir involved excavating to a pre-determined grade approximately four acres of land adjacent to an existing wetland near Sutherland Reservoir. The construction attempted creation of approximately 0.4 acres of semipermanent, 0.7 acres of seasonal, and 2.8 acres of temporarily flooded wetlands. Available information concerning topography, water levels, and characteristics of the existing wetland was used to develop designs for aerial extent and excavation depth that would support constructed wetlands. Two distinct areas adjacent to the northwest corner and southern tip of the existing wetlands were identified as wetland mitigation sites. The volume of soil removed from these sites was estimated at approximately 36,000 cubic yards.

Construction of the wetlands began in early winter, 1994, using NPPD equipment and personnel. Equipment required for construction included a scraper, front-end loader, and other necessary miscellaneous equipment. Russian olives, eastern red cedars and other shrub vegetation in the adjacent existing wetland vegetation were piled and burned to enhance the area as waterfowl habitat. Earthwork commenced in late January, 1994, on the south side. Approximately 6 inches of topsoil (active seed reservoir) was removed and temporarily stockpiled for later treatment. Spoil material was placed over approximately 11 acres along the face of the dam on the east side of the existing wetlands. Stockpiled topsoil was placed on the spoil to final grade, to help minimize runoff into the constructed wetland. Excavation on the south side was completed in mid-April, 1994. The area was then seeded with a general floodplain mix of Canada wild rye, *Elymus canadensis*; big bluestem, *Andropogon gerardii*; switchgrass, *Panicum virgatum*; reed canarygrass, *Phalaris arundinacea*; Virginia wild rye, *Elymus virginicus*; western wheatgrass, *Agropyron smithii*; and redtop grass, *Agrostis stolonifera*.

Approximately two acres were excavated on the north side of the wetland complex, and this was completed in mid-November, 1994. The exposed spoil areas, as well as new wetland areas, were prime areas for thistle encroachment and the entire wetland complex was treated with a 3-percent Rodeo™ solution and surfactant on June 26 and 30. A three-strand barbed-wire fence, including access gates, was placed to enclose the existing and mitigated wetlands and adjacent uplands (64 acres). Reseeding was conducted a second time on the south site in the spring (March) of 1995.

The excavated wetland sites were floristically studied by walk-through surveys through each area, a modification of the 10-minute walk-through method of Nagel (1995). Each area was carefully examined, from the submergent plant growth in the littoral zone of the standing water up to where the excavation stopped and upland vegetation started. Transects originated from the center of excavated area to undisturbed upland. Species were identified to the lowest possible taxon, and voucher specimens were collected and stored at the NPPD reference herbarium. At the end of each transect, the foliage was estimated for each species. The contribution to total biomass was estimated to the nearest 1 percent. There was no time limit, as in the method used in the Nagel (1995) study, because the effort was only focused on two sites and not several. Analysis of Variance (AOV) tests were used to statistically test comparisons of species between years and the number of species between the north and south sites from 1994 to 1997.

MITIGATION SITE CONDITIONS PRIOR TO CONSTRUCTION

Topography

The mitigation site is a wetland complex in an approximately 40-acre bowl-shaped depression bounded by State Highway 25 to the west, the Sutherland Reservoir dike to the east and south, and hills to the southwest and northeast (Fig. 1). The site was surveyed to produce a one-foot contour map of the area (Fig. 2). Elevations range from approximately 3,085 feet msl at the highest point of the dike to 3,026 feet

.re 2. Location of wetland complex, with acreages.

msl at the bottom of the deepest pond. In general, the existing 14 acres of wetlands are below elevation 3,031 feet msl at the north end of the site and below elevation 3,036 feet msl at the south end.

Soils

Wetlands prior to construction were in areas mapped by the Soil Conservation Service (1978) as Hord silt loam, 0 to 1 percent slopes. Although these soils are not considered hydric soils, the mapping unit also contains small areas of hydric Fillmore and Scott soils in depressions (such as this area). Hord soils tend to be deep, well-drained, nearly level soils in basins and swales of sand-loess transition areas on uplands. They have moderate permeability, high available water capacity, moderate organic-matter content, and natural fertility. The Hord soils are surrounded by upland soils including, to the north and east, Valentine fine sand, rolling. These are deep, excessively-drained, very steep soils formed on eolian sands. Valentine soils have rapid permeability, low available water capacity, low organic matter content, and low natural fertility. Soils to the west and southwest are mapped as Hersh soils, 5 to 9 percent slopes, and as Hersh and Anselmo soils, 9 to 30 percent slopes. In general, these are deep, well-drained, nearly level to steep soils on uplands. The soils have moderately rapid permeability, high available water capacity, very low organic-matter content, and low natural fertility.

Hydrology

Wetland hydrology is maintained primarily through fairly stable groundwater contributions as well as natural runoff contributions following rainfall. High groundwater levels in the area are maintained by the hydrologic head and seepage from Sutherland Reservoir (Table 1). The normal spring pool of the reservoir, at elevation 3,055 feet msl, is located 29 feet above the lowest point of the wetland mitigation site (at the bottom of the deepest pool). During yearly reservoir operation, water levels may vary from a high of 3,055 to a low of 3,042 feet msl.

Table 1. Elevation of Sutherland Reservoir in feet above mean sea level at the end of each month

	1994	1995	1996	1997
April	3050.9	3051.73	3050.1	3047.74
May	3047.75	3051.59	3051.41	3049.55
June	3051.73	3052.35	3053.3	3053.3
July	3050.08	3052.01	3052.55	3052.7
Aug	3046.16	3047.86	3048.03	3053.13
Sept	3046.69	3044.75	3046.71	3054.89
Oct	3045.62	3044.32	3048.5	3046.3

Existing wetlands include two open-water areas. Based on vegetation, the northernmost pond is approximately four acres and four feet deep at its normal elevation. The southern pond is approximately two acres and two feet deep at its normal elevation. Both ponds were originally thought to contain water year round but were observed to be dry in most fall and winters until reservoir levels rise in the spring.

Existing vegetation

The wetland complex was surrounded by upland rangeland that, with the wetlands, has been grazed by cattle over the past several years. Upland vegetation consists of a sparsely vegetated mixed prairie dominated by short- and mid-grasses, including sand bluestem, *Andropogon hallii*; little bluestem, *Schizachyrium scoparium*; switchgrass, *Panicum virgatum*; sideoats grama, *Bouteloua curtipendula*; prairie junegrass, *Koeleria pyramidata*; and six-weeks fescue, *Festuca octoflora*. Other common grasses are blue grama, *Bouteloua gracilis*; needle and thread, *Stipa comata*; prairie sandreed, *Calamovilfa longifolia*; sand dropseed, *Sporobolus cryptandrus*; indiangrass, *Sorgastrum nutans*; and Scribner panicum, *Panicum scribnerianum*. Common forbs include plains beebalm, *Monarda pectinata*; hoary vervain, *Verbena stricta*; prairie coneflower, *Ratibida columnifera*; Canada thistle, *Cirsium arvense*; snakeweed, *Gutierrezia sarothrae*; scarlet gaura, *Gaura coccinea*; velvety gaura, *Gaura parviflora*; purple prairie clover, *Dalea purpurea*; Rocky Mountain beeplant, *Cleome serrulata*; smooth ground cherry, *Physalis longifolia*; and wild rose, *Rosa* sp.

Surrounding the wetland prior to creation and enhancement, vegetation consisted of dense stands of cattails, *Typha angustifolia* and *T. latifolia*; inland rush, *Juncus interior*; and three-square rush, *Scirpus fluviatilis*, in seasonally flooded areas surrounding the open water (semipermanently flooded) wetlands. Inland saltgrass (*Distichlis spicata*) and slender wheatgrass (*Agropyron caninum*) occur in areas of temporarily flooded wetlands. Other common wetland species include bull sedge, *Carex lanuginosum*; willow herb, *Epilobium coloratum*; spiked lobelia, *Lobelia spicata*; fringed loosestrife, *Lysimachia ciliata*; smartweeds, *Polygonum* spp.; arrowhead, *Sagittaria* sp.; hardstem bulrush, *S. acutus*; softstem bulrush, *S. validus*; curly dock, *Rumex crispus*; watercress, *Nasturtium officinalis*; and duckweed, *Lemna* sp. Additional common forbs included western ironweed, *Vernonia baldwinii*; St. John's wort, *Hypericum* sp.; and ragweed, *Ambrosia* sp.

Woody species were limited to bands of shrubby Russian olives (*Elaeagnus angustifolia*) along the wetland perimeter, small scattered eastern red cedars (*Juniperus virginiana*), and one large cottonwood (*Populus deltoides*) located just south of the wetlands.

Table 2. Plant species percent composition in the north excavation area of the GGS mitigation site 1994–97.

	% Species Composition			
	1994	**1995**	**1996**	**1997**
Perimeter				
Ambrosia artemisiifolia	20	10	10	10
Bromus inermis	10	3	5	30
Cirsium arvense	35	10	15	10
Helianthus annuus	25	60	40	25
Stipa comata		2		5
Panicum virgatum		3	5	5
Phalaris arundinacea		5		5
Populus deltoides				2
Schizachyrium scoparium		5	15	3
Solidago missouriensis			5	2
Vernonia baldwinii	10	2	5	3
Shoreline/Littoral Zone				
Chara sp.		5	2	5
Cirsium arvense	35			5
Conyza canadensis	30	20	25	10
Echinochloa sp.		10	3	5
Eleocharis sp.			5	5
Glycyrrhiza lepidota			1	5
Gaura coccinea		5	3	5
Hordeum jubatum	10	10	25	10
Nepeta cataria			1	5
Najas guadalupensis			2	5
Polygonum amphibium		25	15	10
Polygonum pensylvanicum			5	5
Rumex crispus	25	10	5	15
Scirpus pungens		5	10	15
Perimeter # of Species	**5**	**9**	**8**	**11**
Shoreline # of Species	**4**	**9**	**14**	**14**
Total # of Species	**9**	**18**	**22**	**25**

RESULTS AND DISCUSSION

In 1994, nine plant species revegetated the non-seeded north excavation site (Table 2) compared with 13 on the south site (Table 3). Many of the species observed were the same, with the exception of significant stands of *Eleocharis* sp. on the south site (Table 3). *Eleocharis* sp. may have established so quickly and abundantly because the south site was inundated for several weeks prior to the north site receiving inundation from hydrological influences of increased Sutherland Reservoir elevations. Over the years, it has been observed that higher Sutherland Reservoir elevations in mid-to-late summer also maintain higher standing or open water levels in the wetland complexes adjacent to the reservoir. This trend was also evident over the past 4 years (Table 1).

In 1995, the number of species doubled to 18 on the north site and to 22 on the seeded south site. In 1995, again, many of the species observed were the same, with the perimeter and shoreline/littoral areas having the same species present and the approximate same percent composition or relative abundance. *Helianthus* spp. were common on both sites as well as *Cirsium* spp., *Rumex* sp., *Polygonum* spp., and *Hordeum jubatum*. *Agrostis stolonifera* and *Eleocharis* sp. were fairly common on the south site and not observed on the north site.

The number of species increased to 29 in 1996 on the south site, compared to 22 on the north site. *Helianthus*, *Conyza canadensis*, *Hordeum jubatum* and *Scirpus pungens* were the most common species observed at both sites. *Eleocharis* sp. was noted for the first time in the study on the north site and was still prevalent at the south site. In addition, catnip and scarlet gaura were found on the north site but not in

Table 3. Plant species percent composition in the south excavation area of the GGS mitigation site 1994–97.

	% Species Composition			
	1994	**1995**	**1996**	**1997**
Perimeter				
Andropogon gerardii			1	5
Cenchrus longispinus	10	5	2	5
Cirsium arvense	15	10	5	5
Conyza canadensis		5	5	5
Elymus canadensis		2	2	2
Helianthus annuus	65	60	50	10
Panicum capillare		1	1	1
Panicum virgatum	5	5	10	10
Phalaris arundinacea		5	10	20
Physalis virginiana		5	2	1
Populus deltoides				10
Schizachyrium scoparium	3	5	10	10
Solanum rostratum	2	5	5	5
Sorghastrum nutans				6
Vernonia baldwinii	5	5	2	5
Shoreline/Littoral Zone				
Agrostis stolonifera	5	32	10	5
Chara sp.			1	1
Cirsium arvense	5	3	2	1
Echinochloa sp.	5	5	5	2
Eleocharis sp.	65	15	15	5
Hordeum jubatum	5	10	15	5
Juncus bufonius			1	2
Najas guadalupensis			10	5
Phalaris arundinacea	5		5	5
Polygonum amphibium		10	5	10
Polygonum pennsylvanicum			5	1
Potamogeton pectinatus			5	1
Rumex crispus	10	5	3	5
Salix sp.				1
Scirpus americanus		10	10	40
Spartina pectinata		3	3	1
Typha latifolia (and *angustifolia*)		2	5	15
Perimeter # of Species	**7**	**13**	**14**	**14**
Shoreline # of Species	**6**	**11**	**16**	**17**
Total # of Species	**13**	**22**	**29**	**31**

the south site. Submergent vegetation (*Najas guadalupensis*) as well as *Chara* sp. was also documented. Fourteen upland or perimeter species were noted on the south site and eight on the north site.

The number of species continued to increase at both sites, with 25 at the north site and 31 at the south site in 1997 (Tables 2 and 3). The differences of species numbers between years were not significant ($p = 0.24$) nor was the comparison of species between the north and south sites after four years ($p = 0.18$). The reasons may be may be that high rainfall and water levels in the reservoir account for some of the slight increase in species diversity, which may be part of natural wetland succession. *Hordeum jubatum* was extremely abundant on the north site in early 1997, comprising almost 80% of the species present in the shoreline/littoral zone. However, as inundation occurred through the growing season, it was replaced by rapidly proliferating *Scirpus* spp. in the open water/shoreline areas.

There does seem to be a difference in species composition, however. Of the 40 different species identified at the two sites, only 16 are present in both. Thus the coefficient of community is only 57%. After only four years that may not be much difference; however, early inundation at the south site coupled with possible substrate/soil differences and seeding may dictate enough variation to account for differences in species observed.

CONCLUSIONS

Initially, wetland vegetation on the south side recolonized with more species than the non-seeded area on the north. The numbers of shoreline wetland species were the same in both the north and the south sides after 3 years of establishment. The increase in species in 1997 on the south side and on the north side may be partly explained by natural wetland-succession trends due to the existing seed bank on the site, and by some partial assistance and influence by shore birds and waterfowl.

It appears that the wetland hydrology for both the north and south excavation sites is a more significant factor in reestablishment than seeding over the four-year study period (i.e., hydraulic connection to Sutherland Reservoir).

Table 1 indicates that an increase in water levels in the Reservoir during July and August may have directly affected the water levels in the newly excavated mitigation sites. The south site normally fills a month to two months earlier, which may help explain the slightly higher number of species on the south site. An understanding of the ecological processes involved in wetland vegetation development is essential to wetland managers concerned with wetland creation. Ascertaining a sound hydrologic system is basic in any attempt to re-create a wetland system since the vegetation and associated fauna are dependent upon a consistent but usually fluctuating hydrologic regime. Hydrologic manipulations can also greatly modify what species will become established or decline in abundance. Traditional succession-climax dogma seems to have limited usefulness in interpreting vegetation change in wetlands. Thus an understanding of the complex of factors involved in the process, including chance and coincidence, makes the task of the wetland manager even more challenging especially on a site to site basis.

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