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Past and present landscapes of the Kimmes-Tobin Mitigated Wetlands, Foxboro, Douglas County, Wisconsin

Donald W. Davidson, Richard D. Gitar, William Bajjali & Derek S. Anderson

Summary: The study area was 190 hectares of reconstructed wetlands, located on Hilpiper and County Road C in Foxboro, Douglas County, Wisconsin. It was a devastated area that has been reconstructed, following a long history as a cleared grazing and haying farm. The site was a wetland creation project, which relies on surface drainage and rainfall over substrate with a low infiltration rate.

The site was revegetated by natural reseeding except for some planting of the berm with *Phalaris arundinacea* by the Department of Transportation (DOT). In December 1997, scrub shrub, wet meadow, shallow marsh, deep marsh, and aquatic bed species all were present and mapped. A total of 111 taxa were found in the wetland cells during the study of Kimmes-Tobin from 1993 to 1997. Three plant species tended to dominate the approximately three-foot transition between standing water and the construction berm: *Typha latifolia, Scirpus cyperinus* and *Phalaris arundinacea*.

Sampling was carried out during the height of the growing season, in mid to late July of 1993 to the fall of 1997. Transect quadrats were used to obtain vegetation data. The final wetland delineation acreage was 69.2 hectares on the 190 hectares property. This land was used to replace wetlands destroyed by the construction of highways. Acreage left over was banked for use by DOT, for impacts within the Lake Superior watershed.

It was concluded from the prevalence indices and weighted averages calculated from transect data that there was high probability (WA < 2.0) that the area meets hydrophytic criteria, as only two cells had a PI or WA that was over the 2.0 limit. It is concluded from these results that the vegetation objectives of the mature wetland, sought by the DOT and requested of Donald W. Davidson as botanist, was met.

Keywords: mitigated wetlands, Kimmes-Tobin, wetland construction, mitigation, flora of Wisconsin

Wisconsin is located in the northern United States, between Lake Superior to the north, Lake Michigan to the east, and the Mississippi River to the west, with a total area of 145,210 km^2. Glaciers have sculptured and shaped the landscape of the state. In the north it scraped the tips off hills, leaving rich earth deposits and approximately 15,000 small size lakes. Five different geographic regions were established in the area by the action of the glaciers: the Lake Superior Lowland, the Northern Highland, Central Plain, Western Upland, and the Eastern Ridges and Lowlands (Great Lakes Plains).

The small area of the Lake Superior Lowland extends 8 to 32 km inland. The Lake Superior Lowland occupied portions of Douglas, Bayfield, and Ashland Counties in northwestern Wisconsin. The total area was estimated to be approximately 3,237 km^2, not including the 6,216 km^2 of the features that were submerged beneath the waters of Lake Superior, which stands 183 m above sea level.

Wisconsin was originally very rich in wetlands throughout the northern part of the state. Many of these wetlands had been destroyed by development, including the construction of highways. The Kimmes-Tobin Mitigated Wetlands project was undertaken to replace the destroyed wetlands caused by the construction of State Highway 35 and U.S. Highway 53. The mitigation site was located in Douglas County south of Lake Superior (Fig. 1).

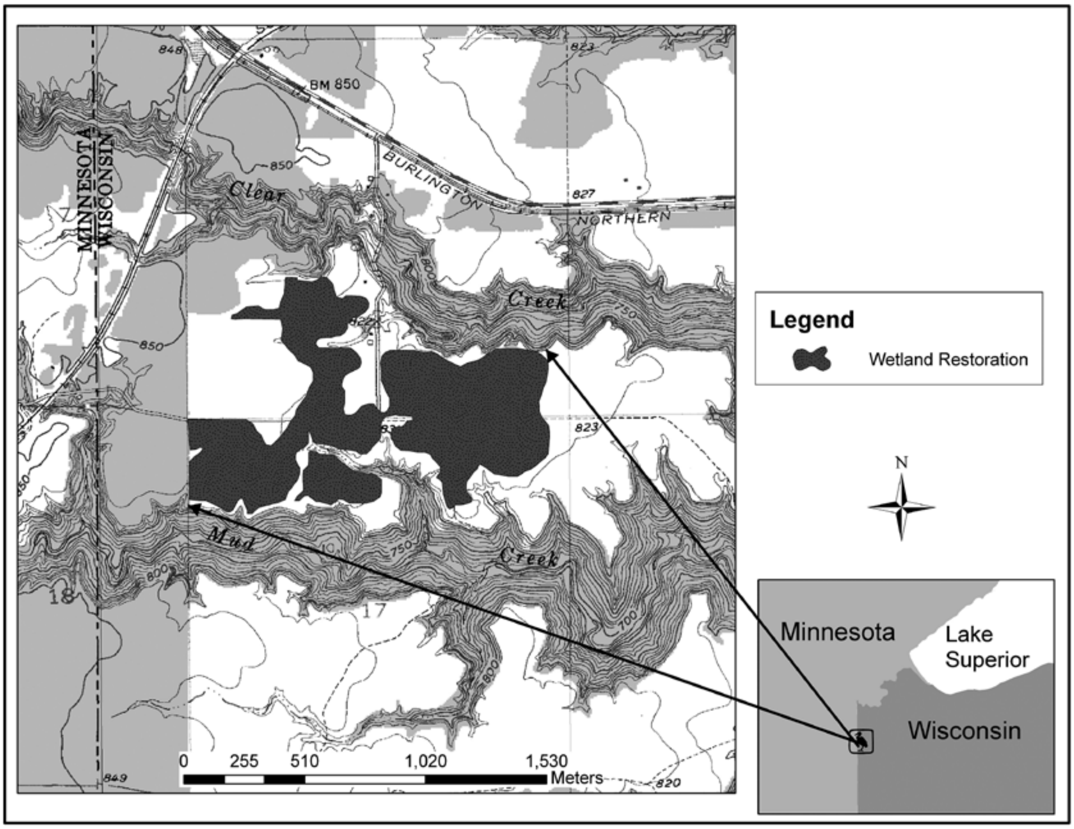

Figure 1. Kimmes-Tobin wetland location in northwest Wisconsin.

The temperature in Wisconsin was variable through the year, varying from an average high of 28.2° C to a low of -14.8° C. Precipitation varied across the state. Two rainfall stations close to Kimmes-Tobin wetlands were chosen to characterize the amount of rain on the Lake Superior Lowland. Figure 2 shows the total precipitation in Superior and Foxboro and demonstrates the fluctuation of precipitation between l990 and 2000. The eleven-year average precipitation was almost identical in both stations: 72.5 and 73.1 cm in Superior and Foxboro, respectively. The average rainfall for the wetland site was about 88.9 cm annually (DOT 1997).

History and present vegetation of northwest Wisconsin

This ecosystem study in plant succession within the Kimmes-Tobin wetlands in Douglas County, Wisconsin, followed the work of Clements (1963). The Kimmes-Tobin area was originally forested. In the early 1900's it was cleared for agriculture; it has now been converted to wetlands.

Curtis (1959) studied the vegetation of Wisconsin from 1945–1959. Much of the logging and clearing of the land that was to occur had not yet happened and it was quite likely that the vegetation patterns present (though heavily cut-over and cleared) are still present in the region that Curtis mapped in the far north of Wisconsin.

Braun (1950) and Greller (1988) characterized the deciduous forest of North America as a tree-dominated vegetation type in which most of the woody taxa were winter-deciduous.

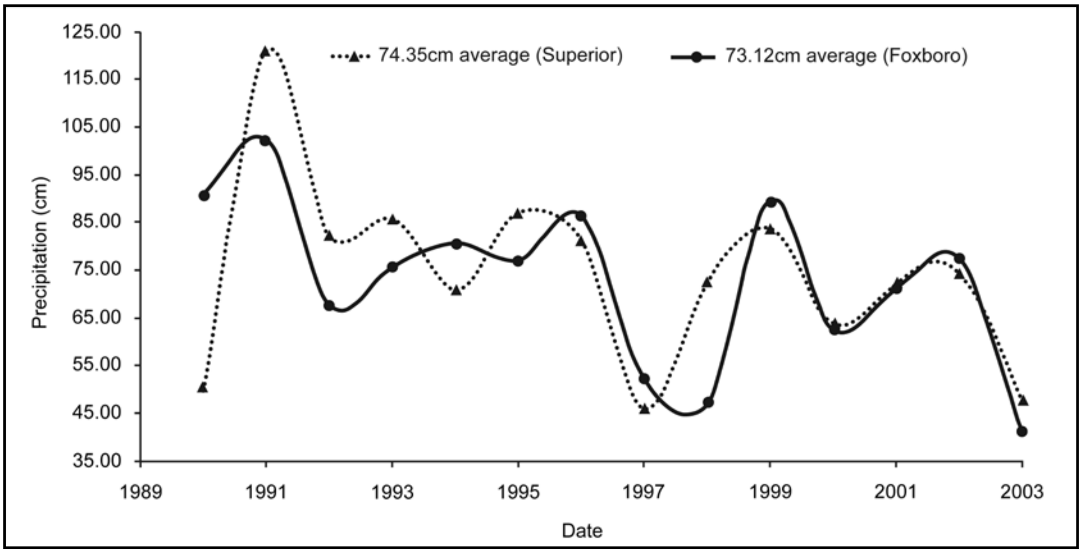

Figure 2. Total precipitation in the Superior and Foxboro area, Douglas County.

Typically, the mature forest canopy reaches 30 m and is closed. Greller's work was based largely on uncleared, mature forest vegetation in eastern North America. The forests that remain throughout the eastern United States today were largely successional, including the forest that surrounds the Kimmes-Tobin wetlands today.

The boreal forest was actually a circumpolar formation, with close similarities between the Eurasian and North American communities. Curtis (1959) points out that there was a limited development of boreal forest around the upper Great Lakes, mostly in northern Minnesota and Michigan.

Sweet (1880) reported a mixture of tree species for Douglas County. Along the lakeshore and reaching south as far as the Copper Range, there was a very dense growth of small trees consisting of approximately equal numbers of *Populus* sp., *Betula* sp., *Thuja* sp., and *Abies balsamea*. These trees usually were less than 30 cm in diameter and ranged between 6 to 25 m in height. Stands studied by Curtis (1959) had either *Abies balsamea* or *Picea glauca* as a member of the dominant canopy layer. *Pinus strobus*, *Thuja occidentalis,* and *Betula papyrifera* all had importance values slightly higher than those for *Picea glauca*. Three species of *Populus* and three species of *Acer* were also important members of the community. The far-reaching work of Maycock & Curtis (1960) dealt with the boreal and conifer-hardwood forests of the Great Lakes region and was the most comprehensive study ever attempted on the boreal forests of northern Wisconsin, about 50 km south of Lake Superior in Northern Wisconsin, which included the Kimmes-Tobin site in Douglas County. The remaining forests surrounding the study site near Foxboro were badly fragmented and probably bear little resemblance to the original boreal conifer-hardwood forests of far northern Wisconsin.

Curtis (1959) classified the region of Kimmes-Tobin as boreal forest; south of that he mapped conifer-hardwood forest. According to Cottam & Loucks (1965), *Abies balsamea* and *Picea glauca* dominated the boreal forest, and *Acer saccharum*, *Tsuga canadensis*, and *Betula alleghaniensis* dominated the northern mesic forest.

Curtis (1959) also discussed the flora of Wisconsin and noted the boreal elements. Many of the species he cited were actually circumpolar, since they occur in a similar climatic belt across Eurasia (Hultén 1937). Curtis included in the boreal element trees such as *Larix laricina*, *Picea glauca*, and *Abies balsamea*. These species would have been the dominant vegetation in the Kimmes-Tobin study site when Europeans settled in Douglas County in the late 1800's. Kuchler (1964) showed that the vegetation of the Kimmes-Tobin area was considered as Great Lakes spruce-fir forest. Kuchler's work is reflected in various ecological and plant studies of this region.

Kapustka et al. (1980) studied the vegetation of the Nemadji River basin in Wisconsin and Minnesota. Their findings showed that the vegetation represents a diverse cross-section of the major types present in the study area. Four principal types of vegetation were apparent (a) hardwood forest, dominated by *Populus tremuloides*; (b) coniferous forest, dominated by *Abies balsamea*; (c) mixed hardwood-coniferous forest, with varying amounts of *Populus tremuloides*, *Abies balsamea*, *Betula papyrifera, Picea glauca*, and *Quercus macrocarpa*; and (d) grass areas. This mixture of vegetation types was similar to the vegetation currently surrounding the Kimmes-Tobin wetland areas.

Soils formation

The surficial geology of northwest Wisconsin was associated with the glaciers that dominated in the Pleistocene. The Wisconsin glacier dominated the state with the exception of the southwest, also referred to as the driftless area. The red clay deposits of the Kimmes-Tobin area accumulated in glacial Lake Duluth up until the last glacier retreated (Ojakangas & Matsch 1982). Kapustka et al. (1980) sampled the soil from a depth of up to one-half meter deep at 35 locations in northwestern Wisconsin and adjacent Minnesota. Two general soil types were encountered: the Nemadji Newson Association and the Ahmeek-Ronneby-Washburn Association, which both were considered red clay mineral. Other types of soils were found within the boreal forest along Lake Superior such as True Podzols, Ontonagon, Pickford, and Ewen series. The soils varied in texture from clay to sandy loam.

Materials and methods

In order to carry out this study and identify the diversity of plants, vegetation, and flora various sampling transects and quadrat techniques were used. A total of 16 wetland cells were constructed and studied.

Eight permanent transects were established at the Kimmes-Tobin Mitigated Wetlands site in 1993 after construction was completed. They were designed so that the ends of the transects were permanently marked with steel posts. Transects covered the areas of potential shallow and deep marsh, aquatic beds, wet meadow, and islands. Transects were placed in such a manner that each of the plant communities present, or thought likely to develop, would be represented. Transects were also placed across (1) wetland depressions, (2) impounded wetland depressions, (3) wetland areas that border existing wetlands, (4) wetland areas that receive overflow, and (5) areas that do not receive overflow.

A statistical method was applied using the random number (Johnson & Kuby 2004). Quadrats of 10 m or 20 m were used randomly depending on the length of transects. This method was considered more reliable for collecting and observing vegetation data.

Sampling was carried out during the height of the growing season, in mid to late July of 1993 through 1997. Published data (DOT 1993, 1994) were also considered in this study, a total of 113 quadrats were read. The sampling procedure of the vegetation in 1993 and 1994 was randomly placed, while in 1995, 1996, and 1997 surveys were not conducted randomly. Therefore, quadrats were placed every 10 m for the entire length of each transect. It was felt that this method of quadrat placement would provide a repeatable and more complete profile of each cell in which a transect was located. Species presence was recorded and the percentage of cover was estimated using the Daubenmire (1959) cover scale. Plants not recognized in the field were collected and later identified. From these data, prevalence indices and weighted averages were calculated for all transects.

Vegetation readings were most often taken from a boat because disturbance of the red clay soils led to suspension of clay particles in the water column, which obscured the view of the plant species growing beneath the surface of the water. The line intercept method was used to collect data on shrub cover along the same transects used for monitoring herbaceous vegetation in quadrats. This method worked best with vegetation that does not reach heights that are over the sampler's head. Nomenclature for these studies followed Reed (1988) and Gleason & Cronquist (1991).

Finally, the wetland indicator status was assigned. This indicator referred to the likeliness that a plant would be found in a wetland or an upland habitat. The interpretation of each status level follows USDA (2008):

Obligate (OBL): occurs almost always under natural conditions in wetlands.

Facultative Wetland (FACW): usually occurs in wetlands, but occasionally found in non-wetland.

Facultative (FAC): equally likely to occur in wetland or non-wetland.

Facultative Upland (FACU): usually occurs in non-wetlands, but occasionally found on wetlands.

Obligate Upland (UPL): occurs almost always under natural conditions in non-wetland.

Kimmes-Tobin description

The elevation of Kimmes-Tobin wetland varies from 250 m in the vicinity of ponds P and D to 259 m in the area of pond A (Figs 3, 4). This is also reflected in the variation of the surface water elevation between 3 to 4.9 m among the ponds. The water content of the ponds relied completely on precipitation and run off. Figure 2 shows the variation of rain in Foxboro station located approximately 6.4 km from the wetland. The average annual precipitation in Foxboro was 77.9 cm (Midwest Regional Climate Center 2009). Groundwater did not contribute to the water mass balance, as the red clay was an impermeable layer that prevented groundwater from entering the system. Therefore, the water mass balance can be attributed only to precipitation, surface run off and evapotranspiration (ET). Inflow of surface water entered the main system principally through cells A, B, and F on the west side of the site and exited from cell O to Mud Creek on the southeast side of the site.

Concerning the cooperative agreement on wetland boundaries, the final delineation was performed by Department of Transportation (DOT), a County Committee (COC) representatives, Natural Resource Conservation Service (NRCS) representatives, and Department of Natural Resources (DNR) staff with assistance from University of Wisconsin - Superior (UWS) biologists. No seeding took place after construction grading.

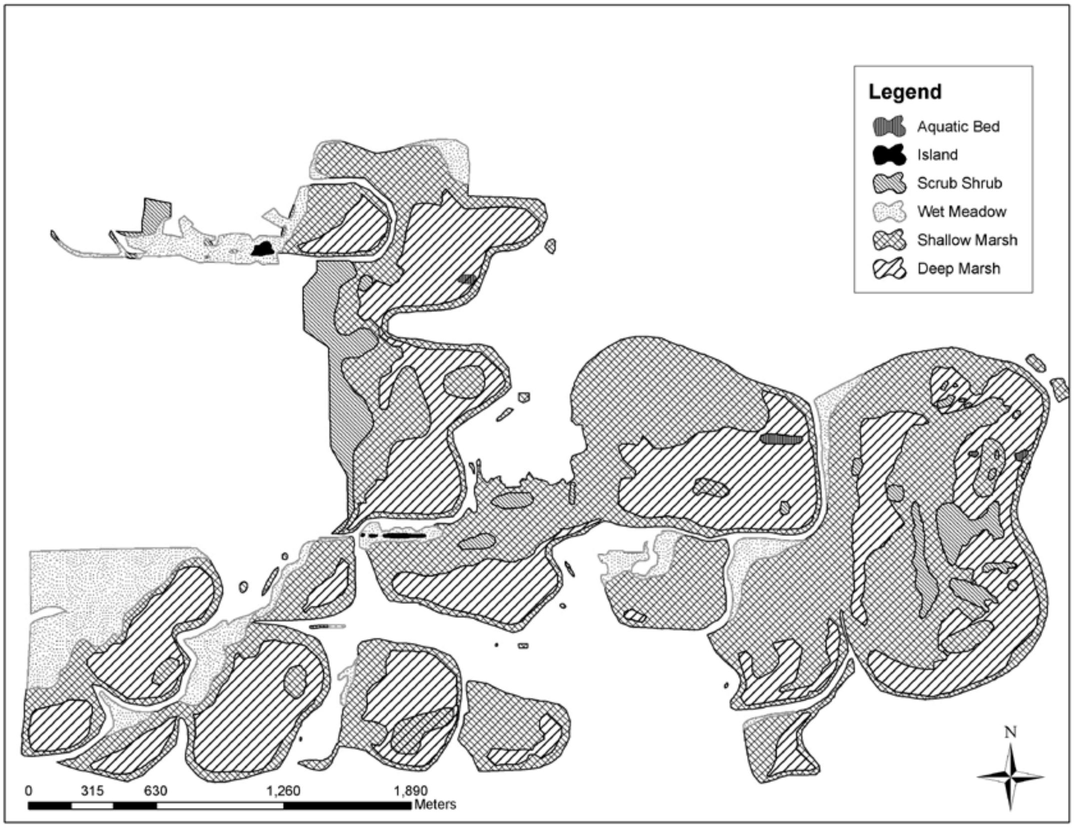

Figure 3. Kimmes-Tobin Mitigated Wetlands vegetation types.

Results

Vegetation and flora

Identification of representative plant species and their relative frequency and prevalence indices were made, and a general vegetation map was developed each year (DOT 1993–1997). The goal set by DOT in 1993 was to have 60% of vegetative species in delineated areas classified as obligate, facultative, and upland at the end of the 5-year monitoring period. At the end of the fieldwork in December 1997, scrub-shrub, wet meadow, shallow marsh, deep marsh, and aquatic bed species all were present and mapped (Fig. 3).

Table 1. Number of plants observed by wetland classification, each year of the field surveys.

Year	Obligate (OBL)	Facultative Wetland (FACW)	Facultative (FAC)	Facultative Upland (FACU)	Upland (UPL)	Total
1993	12 (30.8%)	13 (33.3%)	5 (12.8%)	7 (17.9%)	2 (5.1%)	39
1994	30 (54.5%)	9 (16.4%)	10 (18.2%)	5 (9.1%)	1 (1.8%)	55
1995	15 (41.7%)	7 (19.4%)	8 (22.2%)	6 (16.7%)	(0%)	36
1996	28 (47.5%)	12 (20.3%)	9 (15.3%)	9 (15.3%)	1 (1.7%)	59
1997	28 (48.3%)	12 (20.7%)	8 (13.8%)	9 (15.5%)	1 (1.7%)	58

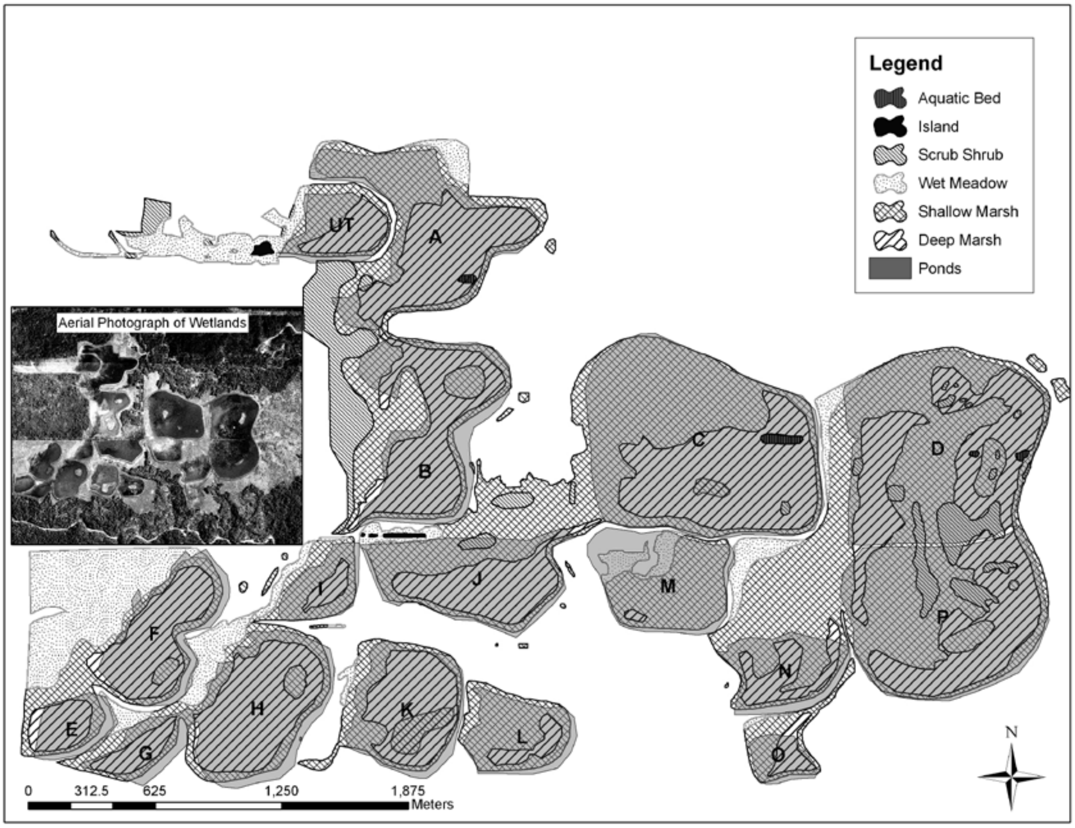

Figure 4. Kimmes-Tobin Mitigated Wetlands vegetation types with pond cells identified.

Table 1 shows the number of plants in the wetlands between 1993 and 1997 broken down by wetland indicator classification. The number of plants shows an increase with exception of 1995. In 1993 and 1994, there had been seeding by the DOT, which stabilized the berms against erosion. This was the reason for the dramatic increase in number of species in 1994. In 1995, the number of species declined noticeably and this was because the early successional species established in 1994 were not replaced by new seeding. The difference between 1996 and 1997 is not significant at this time. The obligate species were dominant and count for almost half of the species (48%).

Table 2 shows in detail the species that disappeared and appeared in 1997. It can be seen that 17 species disappeared and only 11 species appeared. These are all species that would disappear following brief colonization on a newly exposed surface such as the Kimmes-Tobin berms. Those appearing also includes early successional species such as *Agrimonia gryposepala*, *Cirsium arvense*, *Geum* sp., and *Rubus idaeus*, which would also seed in to a new exposed area like Kimmes-Tobin wetlands.

Prevalence index and weighted average between 1993 and 1997

A prevalence index (PI), based on the frequency of occurrence in quadrats, and the weighed average (WA), based on the indicator status and importance value (Federal Interagency Committee for Wetland Delineation 1989, Tiner 1988), was calculated for each of the eight transects (Table 3).

Table 2. Plant species that disappeared and appeared during the monitoring of the site in 1997.

Disappear	Appear
Agrimonia sp.	*Agrimonia gryposepala*
Agrostis gigantea	*Anemone canadensis*
Agrostis sp.	*Carex gynandra*
Calamagrosits canadensis	*Ceratophyllum demersum*
Carex stipata	*Cirsium arvense*
Carex suberecta	*Galium trifidum*
Cirsium sp.	*Geum* sp.
Eleocharis palustris	*Ranunculus acris*
Eleocharis sp.	*Riccia* sp.
Epilobium angustifolium	*Rubus idaeus*
Galium sp.	*Utricularia* sp.
Polygonum hydropiper	
Polygonum lapathifolium	
Rorippa palustris	
Rubus hispidus	
Sonchus sp.	
Vallisneria americana	

As seen in Table 3, in 1994 and 1995 only two transects (D and O) had a PI or WA equal to or greater than the 2.0 limit, based on the vegetation criteria set by the Federal Manual (Federal Interagency Committee for Wetland Delineation 1989). The high value of PI and WA in 1994 and 1995 was due to following species: *Phleum pratense*, *Solidago canadensis*, *Trifolium pratense*, *Agropyron repens*, *Festuca rubra*, *Potentilla norvegica* and *Lotus corniculatus*. The area of cell O was actually mostly upland and was outside the wetland limits as established in the final wetland determination.

Table 3. Prevalence index and weighted average (Federal Interagency Committee for Wetland Delineation 1989) of each transect by year. Transects with values greater than or equal to the 2.0 threshold outlined in the delineation guideline were indicated with bolding.

Prevalence index							Weighted average					
Transect	**1993**	**1994**	**1995**	**1996**	**1997**		Transect	**1993**	**1994**	**1995**	**1996**	**1997**
A	1.60	1.52	1.20	1.42	1.15		A	1.59	1.40	1.20	1.38	1.28
B	1.55	1.42	1.00	1.33	1.21		B	1.38	1.28	1.00	1.28	1.16
C	1.29	1.48	1.00	1.17	1.11		C	1.41	1.29	1.00	1.12	1.08
D	1.87	**2.22**	1.40	1.57	1.44		D	**2.05**	**2.08**	1.60	1.55	1.42
F	1.40	1.25	1.50	1.78	1.64		F	1.55	1.34	1.50	1.78	1.54
M	1.69	1.14	1.10	1.14	1.07		M	1.06	1.13	1.10	1.10	1.06
O	1.70	1.64	**2.00**	1.71	1.51		O	1.77	1.64	**2.10**	1.56	1.45
UT	1.83	1.32	1.20	1.63	1.21		UT	1.70	1.23	1.10	1.54	1.17
MEAN	1.62	1.50	1.30	1.47	1.29		MEAN	1.56	1.42	1.33	1.41	1.27

Table 4. Plant species with the three highest importance values along each transect.

Transect	Species	Importance value
A	*Phalaris arundinacea*	64.5
	Potamogeton foliosus	63.5
	Typha latifolia	29.6
B	*Potamogeton foliosus*	89.4
	Typha latifolia	47.2
	Scirpus validus	23.5
C	*Potamogeton foliosus*	97.6
	Typha latifolia	37.6
	Lemna minor	24.3
D	*Potamogeton foliosus*	59.4
	Carex sp.	34.1
	Myriophyllum sp.	32.1
F	*Potamogeton foliosus*	97.1
	Phalaris arundinacea	33.6
	Scirpus cyperinus	13.8
M	*Typha latifolia*	72.9
	Potamogeton foliosus	72.2
	Lemna minor	51.0
O	*Potamogeton foliosus*	81.8
	Typha latifolia	33.4
	Phalaris arundinacea	27.8
UT	*Potamogeton foliosus*	118.0
	Typha latifolia	48.7
	Phalaris arundinacea	31.5

Table 4 shows the plant species with the three highest importance values for each transect. Importance values were calculated by the relative frequency and relative dominance of each species (Daubenmire 1959). Four species dominated the wetland and they were over 83.3% of the total occurrences. *Potamogeton foliosus* was almost one third of the total species (33.3%), the second dominant was *Typha latifolia* and it accounts for one quarter of the total (25%), *Phalaris arundinacea* and *Lemna minor* are 16.6% and 8.3% respectively. *Potamogeton foliosus* existed in each cell and *Typha latifolia* existed in all cells with exception of cells D and F (Fig. 4).

Delineation

An important closure step in the 5-year monitoring process is the final delineation of the wetlands. This helps to evaluate the success of the site and establishes the amount of wetland acreage.

Data have been collected, observed, documented and the wetland hydrology site map prepared using GIS technique. The results of the observations, monitoring and interpretation can be found in the DOT publications (DOT 1993–1997). The final wetland delineation is presented in Figure 3 and Table 5, which emphasize the success of the mitigation site. The final acreage was measured

Table 5. Final wetland area delineation by vegetation type.

Vegetation type	Square meters	Hectares
Shallow Marsh	337,051.55	33.70
Deep Marsh	253,983.03	25.40
Wet Meadow	66,766.63	6.68
Scrub Shrub	33,579.04	3.36
Aquatic Bed	1,385.77	0.14
Island	841.46	0.08
Total	693,607.48	69.36

and the data breakdown is given in Table 5. The total area was measured using GIS tools and was estimated to be 69.4 hectares (693,607 m^2) of wetland on the 190 hectare property.

Vegetation types of the wetland

The wetland was divided into five types: Shallow Marsh, Deep Marsh, Wet Meadow, Scrub Shrub, and Aquatic Bed as shown in Figure 3 and Table 6 through Table 10. Several small islands, with a total of 0.085 hectares, which were not wetlands, were also listed as present.

Shallow Marsh (ShM): The shallow marsh areas were dominated by four types of persistent emergent vegetation (Table 6). This wetland type had standing water of less than 15 cm deep. Free-floating species such as *Lemna minor* and submerged species *Myriophyllum* sp. and *Potamogeton foliosus* were found in low numbers.

Deep Marsh (DM): The deep marsh areas were dominated by three main species (Table 7). The water depth in the deep marsh ranges between 15 cm and approximately 122 cm. The deep marsh was generally characterized by the presence of non-persistent emergent, floating or submerged vegetation.

Aquatic Bed (AB): The aquatic bed areas were dominated by two main submerged aquatic species (Table 8). The water depth was identical to the deep marsh.

Wet Meadow (WM): The wet meadow areas were dominated by three main species (Table 9). The lands that were associated with the wet meadow have no standing water but very moist soils. The soil could be smectite, a type of clay that is associated with red clay. The area in general is characterized by the presence of wetland grass and sedge species.

Scrub Shrub (SSh): This type was dominated by woody plants less than 6 m in height. It grew like the wet meadow on wet soil, but had some standing water. The scrub-shrub areas were dominated by two shrubs (Table 10).

The actual delineated wetland within the Kimmes-Tobin site was dominated by 12 plant species. For the purpose of this determination, dominance was defined as more than 50% areal coverage in an area of at least 0.37 m^2.

One aspect of plant species dominance at this site worthy of noting was that three plant species tended to dominate the approximately one meter transition zone between standing water and the construction berm. This transition zone was characterized by three bands of plants. The inner dominant plant species was *Typha latifolia*, the middle species was *Scirpus cyperinus*, and

Table 6. Dominant species in Shallow Marsh.

Species	Classification
Scirpus atrovirens	Obligate
Scirpus cyperinus	Obligate
Typha angustifolia	Obligate
Typha latifolia	Obligate

Table 7. Dominant species in Deep Marsh.

Species	Classification
Potamogeton foliosus	Obligate
Potamogeton natans	Obligate
Sparganium americanum	Obligate

Table 8. Dominant species in Aquatic Bed.

Species	Classification
Calligeron giganticum	Obligate
Potamogeton foliosus	Obligate

Table 9. Dominant species in Wet Meadow.

Species	Classification
Carex gynandra	Facultative Wetland
Phalaris arundinacea	Facultative Wetland
Scirpus cyperinus	Obligate

Table 10. Dominant species in Scub Shrub.

Species	Classification
Alnus rugosa	Facultative Wetland
Salix sp.	Facultative Wetland

the outer dominant species was *Phalaris arundinacea*. This 'tri-dominance' was seen along the edges of most of the cells.

Other related studies in the Upper Midwest

The importance of wetlands for non-prairie areas habitat, groundwater recharge, and water purification was being more widely recognized in the upper Midwest (Wisconsin Department of Natural Resources 1985), particularly because 11 million acres of wetlands in the lower 48 states were converted to other uses between 1950 and 1970.

Warne (1992) studied seed bank and vegetation dynamics in small, reconstructed wetlands in the Milwaukee region (southeast Wisconsin) that were 1, 2, and 3 years of age. These wetlands, constructed on agricultural land in Ozaukee County, Wisconsin, by the U.S. Soil Conservation Service, were examined for differences in their seed banks and standing vegetation. Warne (1992) defined seed bank to describe the viable seeds found in the soil or in the associated litter and also points out that seeds normally arrive on the soil in a dormant condition and require specific stimuli or conditions before they can germinate.

The reconstructed wetlands studied by Warne were 'successful' in the sense that the plant communities found in both, the seed banks and vegetation, are developing, with increasing age, into communities more typical of wetland rather than upland habitats.

A total of 119 species were found in the seed banks and vegetation in the emergent zone of the wetlands examined by Warne. Standing vegetation of all ages of wetlands contained a total of 101 species. Of these, 41% were wetland species, 27% were facultative species, and 33% were upland species. Post-hoc contrasts of the means of 1-year-old wetlands with older wetlands showed that the number of wetland species was significantly higher in the 2- and 3-year-old wetlands (Warne 1992).

Yencha (1993) studied 74 wetlands in northeastern Wisconsin in August 1992. A total of 137 taxa (114 species) were studied in this region, the number which is similar to that found at the Kimmes-Tobin site. The restored wetlands studied by Yencha were located in a region that had experienced intensive anthropogenic alteration, first by loggers and later by farmers who cleared and drained the land to grow wheat. Dairy farming was the main use of the land in the area. The wetland sites were constructed under the direction of the U.S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources.

Yencha reports that these wetlands are characterized by vascular plants uniquely adapted to the oxygen deficiencies of their environment. In the freshwater marshes (like those of Kimmes-Tobin), there are many submerged species of plants, including *Nymphaea* spp., *Potamogeton* sp., *Scirpus* sp., *Typha* sp., *Juncus* spp. and *Carex* spp. Plants in the surrounding uplands included grasses, *Polygonum* spp., *Solidago* spp., and *Bidens* spp. *Typha* sp. and *Phalaris arundinacea* were the most abundant plants in these marshes. At the time they were examined, the age of the sites after construction ranged from less than 1 year to more than 3 years (Yencha 1993).

Davidson et al. (2006, 2008) has also conducted similar studies within the region of northwestern Wisconsin. The results of these studies were similar to this study in that by the end of the monitoring there were enough wetland species dominating the site to classify it as a wetland according to the Federal Interagency Committee for Wetland Delineation (1989).

Discussion

Increases in the occurrence of several species, such as the obligate species *Sparganium americanum* demonstrated a trend toward wetland species dominance. The number of transects in which this species was found doubled during the period of the study, and observations of plant species outside of the transects showed that by 1997 it occurred in 10 of the 12 cells at this patch. Submerged and floating obligate species such as *Calliergon giganteum*, *Ceratophyllum demersum*, *Lemna minor*, *Myriophyllum* sp., *Riccia* sp., and *Utricularia* sp. had increased at that time in 1997. Each of these species occurred only in the last one or two monitoring years of our sampling. *Lemna minor* was listed as the third highest in importance value in transects C and M, and *Myriophyllum* sp. the third highest in importance value in transect D (Figs 3, 4).

The permit holder was required to control *Lythrum salicaria* at the site. This plant was not present at the site in any of the five monitoring years. However, although the 1994 report mentions that no purple loosestrife was found along County Trunk Highway C, it was present in 2000 along this road in fairly numerous populations. It was also now widespread along State Highway 35 (Fig. 3).

The three species with the highest importance values for each of the eight transects had either an obligate or facultative status. This was true for the last two years of the study (DOT 1996–1997). Only one transect in each of the previous 3 years (DOT 1993–1995) had a plant species that was not an obligate or facultative wetland species (Appendix). In 1994 and 1995, *L. corniculatus* Facultative (FAC) had the third highest importance value in transect O. In 1993, *Agropyron repens*, a Facultative Upland (FACU) species, was the plant species with the third highest importance value in transect M. These observations indicated that, as of 1997, this site was developing and progressing botanically toward a climax wetland community.

A total of 111 taxa were found for all the sites during the studies of Kimmes-Tobin from 1993 to 1997. These data were similar to those of two other studies of restored wetlands in the Green Bay region of Wisconsin (Warne 1992) and in the Milwaukee region (Yencha 1993), both of which had approximately the same number of taxa. Warne studied 10 wetlands with 119 species, whereas Yencha studied 74 wetlands with a considerably greater number of species (137).

Natural propagation from seed banks led to the establishment of significant vegetative cover in just one season. Wildlife, including Canadian Geese, had already begun to utilize the wetland habitat after the first year.

Reconstructed area

Harris (1984) points out that Curtis (1956) had documented the problem of clearing the forest vegetation of Wisconsin and converting this forest to agricultural land: Curtis took four time frames for a forested area in southern Wisconsin and watched it convert to grassland or a crop-field environment. This change was happening worldwide, and it was what happened to the Kimmes-Tobin site after the natural forests were cleared and the entire site was converted to agriculture. This conversion made possible the establishment of the wetland mitigation site of Kimmes-Tobin and its return to natural vegetation in the form of the 12 cells of the wetland now used as a wetland natural area (Fig. 3).

The volumes edited by Hutnik & Davis (1973) summarize many diverse types of devastated land issues. We feel that the Kimmes-Tobin site was in reality a major devastated area that has been reconstructed after a long history as a cleared grazing and haying farm. The Kimmes-Tobin wetlands area had been, for the most part, revegetated by natural reseeding.

Hutnik & Davis (1973) concluded that spoils of kaolin clay can be stabilized within 2 or 3 years by establishing a cover of *Lespedeza* sp., *Cynodon* sp., *Elymus* spp., *Festuca* spp., or *Paspalum* sp., the same phenomenon was observed in the red clay of Kimmes-Tobin wetland. *Sorghum* sp. or millet will provide a quick cover during the first summer. Nitrogen, phosphorus, and generally lime would be needed to establish and maintain an herbaceous cover. These plants cited were planted in the Kimmes-Tobin wetlands since the new berms were quite susceptible to erosion during summer and winter conditions.

Great Lakes coastal wetlands occurred along the Great Lakes shoreline proper and in portions of tributary rivers and streams that were directly affected by Great Lakes water regimes. These wetlands formed a transition between the Great Lakes and adjacent terrestrial uplands and are influenced by both (Minc & Alberts 1998). The wetlands of Kimmes-Tobin were not typical Great Lakes wetlands. They were not created by processes of Great Lakes origin except for the red clay soils on which Kimmes-Tobin has been built. They were created by man's use, planning, and construction.

The Appendix lists the total number of transects in which a given species occurred for each given year and the total number of transects for all 5 years. Note that the 5-year totals and percentages are based on a grand total of 40 transects (8 transects per year for 5 years). In this table, it can be seen the *Phalaris arundinacea* occurs in the highest number of transects (39 of 40 transects; 97.5%), followed by *Typha* sp. (32 of 40 transects; 80%), *Potamogeton foliosus* (31 of 40 transects; 77.5%), *Scirpus atrovirens* (26 of 40 transects; 65%), and *Glyceria grandis* (20 of 40 transects; 50%). These species indicated temporary reconstruction as 'junk' species. They must be replaced by natural Great Lakes wetland species in order to be successful.

Conclusions

The general goal of the Kimmes-Tobin wetland mitigation project was to compensate for wetland loss for DOT facilities development projects by creation of a wetland complex of aquatic bed, deep and shallow marsh and wet meadow wetlands. This site was initiated by the project specific need of highway projects on highways 35 and 53 in Douglas County during 1992 and 1993 construction seasons. Surplus acres after debiting from these two projects became part of the statewide bank system, specifically in the Lake Superior watershed.

The Kimmes-Tobin site was a wetland creation project, which relies mainly on a mass balance between the precipitation and ET. Based on the work by Clayton (1984), on the region's Pleistocene geology the site is in an area of uncollapsed off-shore sediment bounded on either side by valleys cut by mud and clear creeks. The red clay on the site was formed from a glacial lake plain and may be as deep as 57.9 m based on the well log from the on-site farm. The red clay is of negligible permeability and will prevent any vertical infiltration.

No facultative species were codominant with obligate and faculative wet species as was predicted. The prevalence indices and weighted averages calculated from transect data meet hydrophytic criteria. The WA calculated for the various species during the final survey year confirmed that the vegetational objective was met based on the DOT standard.

The wetland of Kimmes-Tobin had unique characteristics such as high water quality in the ponds, diversity of wildlife, and can function as a site for recreation and research. The quality of the water in the ponds is considered fresh and has a salinity of less than 200 mg/l. This emphasizes that the water in the ponds is originating from precipitation and surface run off.

The Kimmes-Tobin Mitigated Wetlands provide an excellent opportunity for public activity. It is also now considered a site for multi-interdisciplinary research at the University of Wisconsin-Superior.

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Addresses of the authors:

Prof. Dr Donald W. Davidson
Prof. Dr William Bajjali
Derek S. Anderson
Department of Biology and Earth Sciences
University of Wisconsin – Superior
Superior, Wisconsin 54880-4500
USA
E-mail: ddavidso@uwsuper.edu
wbajjali@uwsuper.edu
danders4@uwsuper.edu

Richard D. Gitar
Director of Water Quality
Fond du Lac Tribal Reservation
2101 14th Street
Cloquet, Minnesota 55720
USA
E-mail: richardgitar@fdlrez.com

Appendix. List of species and the number of wetland cells it was observed in at the Kimmes-Tobin Mitigated Wetland by year. Indicator status codes: OBL – Obligate Wetland; FACW – Facultative Wetland; FAC – Facultative; FACU – Facultative Upland; UPL – Obligate Upland (most likely indicator status are in parenthesis).

Species	Indicator	1993	1994	1995	1996	1997
Achillea millifolium	FACU	1			1	1
Achillea sp.	(FACU)			1		
Agrimonia gryposepala	FACU					1
Agrimonia sp.	(FAC)				1	
Agrostis gigantea	(FACW)		5		2	
Agrostis hyemalis	FAC		2			
Agrostis sp.	(FACW)	1			1	
Alisma triviale *	(OBL)		1		1	1
Alopecurus aequalis	OBL		2			
Anemone canadensis	FACW					1
Aster simplex	FACW	1				
Aster sp.	(FACW)	1				2
Beckmannia syzigachne	OBL		1			
Brassica sp.	(UPL)	2				
Calamagrostis canadensis	(OBL)	2	3	2	1	
Calliergon giganteum	OBL				1	1
Callitriche heterophylla	OBL		2			
Callitriche palustris	OBL	2				
Callitriche sp.	FACW		1	1		
Cardamine pennsylvanica	FAC	1				
Carex brevior	FACW		1	1		
Carex gynandra	OBL					3
Carex lacustris	FACW	2	2			1
Carex prairea	(FACW)			1		
Carex rostrata	OBL				1	1
Carex scoparia	OBL	2	5	1		3
Carex stipata	(FACW)				5	
Carex stricta	OBL	1				
Carex suberecta	OBL		2			
Carex vulpinoidea	OBL		1	4		4
Carex sp.	(FACW)	5	1	3	4	2
Ceratophyllum demersum	OBL					2
Chenopodium sp.		1				
Chrysanthemum leucanthemum	(UPL)				2	2
Cicuta sp.		1				
Cirsium arvense	FACU					1
Cirsium sp.	(FACU)				1	
Eleocharis acicularis	OBL		1	6		4

Appendix continuation: Species	Indicator	1993	1994	1995	1996	1997
Eleocharis ovata **	OBL	7	8		1	1
Eleocharis palustris	OBL				2	
Eleocharis sp.	(OBL)		2		1	
Elytrigia repens ***	(FACU)	1	2			
Epilobium angustifolium	FAC		1	1	1	
Equisetum arvense	FAC		1	1		
Equisetum sylvaticum	FACW				1	1
Erigeron sp.	(FAC)			1		1
Festuca rubra	FAC			3	1	2
Fragaria sp.	(FAC)	3	2	1	2	3
Galium trifidum	FACW					1
Galium sp.	(FAC)				1	
Geum sp.	(FAC)					1
Glyceria grandis	OBL		5	6	4	5
Gratiola neglecta	OBL	7	3			
Helianthus giganteus	FACW	1	1			
Hypericum canadense	FACW				1	
Iris versicolor	OBL			1	1	1
Iris sp.	(OBL)		1			
Juncus brevicaudatus	OBL		1	3		
Juncus effusus	OBL		3		2	1
Juncus filiformis	FACW				1	
Juncus tenuis	OBL		1			
Juncus sp.	(FACW)	2				
Lemna minor	OBL				5	5
Lolium temulentum	(UPL)		1			
Lotus corniculatus	FAC	1	4	2	2	2
Lycopus sp.	(OBL)				1	
Lysimachia ciliata	FACW	3				
Myriophyllum sp.	(OBL)				2	3
Panicum capillare	FAC		1			
Phalaris arundinacea	FACW	8	8	7	8	8
Phleum pratense	FACU	3	4	3	3	2
Plantago major	FAC	2	2	1	1	2
Poa sp.	(FAC)	5	2	1	2	2
Polygonum hydropiper	OBL		1		1	
Polygonum lapathifolium	FACW				1	
Polygonum punctatum	OBL		2	1		
Polygonum sagittatum	OBL	1				1
Polygonum sp.	(FACW)	4	2	1	1	2

Appendix continuation: Species	Indicator	1993	1994	1995	1996	1997
Potamogeton foliosus	OBL		8	7	8	8
Potamogeton natans	OBL		1	3	4	4
Potamogeton sp.	(OBL)		1			
Potentilla norvegica	FAC		1	1		
Potentilla sp.	(FAC)	1	1			
Prunella vulgaris	FAC	1	1		1	2
Ranunculus acris	FACW					1
Ranunculus sp.	(FACW)	4	1		1	2
Riccia sp.	(OBL)					1
Rorippa palustris	OBL				1	
Rubus hispidus	FACW				1	
Rubus idaeus	FACU					1
Rubus sp.			1	1		
Salix sp.	(FACW)	2	3	2	6	3
Scirpus atrovirens	OBL	4	5	7	8	2
Scirpus cyperinus	OBL	2	3		2	7
Scirpus validus	OBL		1	3	3	5
Scirpus sp.	(OBL)	6	5	2		1
Solidago canadensis	FACU		1			
Solidago sp.	(FACU)	2		1		
Sonchus sp.	(FAC)				2	
Sparganium americanum	OBL			2	2	4
Sparganium sp.	(OBL)				1	3
Sphagnum sp.	(OBL)				2	5
Taraxacum officinale	FACU	1			2	1
Trifolium arvense	(FACU)				2	
Trifolium pratense	FACU		1	1		1
Trifolium sp.	(FACU)	4		1	2	1
Typha angustifolia	OBL				1	3
Typha latifolia	OBL		3		1	8
Typha sp.	(OBL)	7	7	8	8	2
Utricularia sp.	(OBL)					1
Vallisneria americana	OBL		1	1	1	

Notes:

* Reported as *Alisma plantago-aquatica* in 1994

** Reported as *Eleocharis obtusa* in 1993 and 1994

*** Reported as *Agropyron repens* in 1993 and 1994