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16. Abstract (Limit: 200 words)

This report describes a long-term study to monitor and evaluate the ecosystem recovery of seven wetland restorations in south central Minnesota. The study looks at the impact of planting on wetland restoration success in inland wetlands and develops a methodology to assess wetland restoration success.

The study focused on the following question: To what extent can revegetation stimulate overall biological recovery in isolated restoration sites? Researchers used aspects of ecosystem function and structure to characterize recovery rates in planted and unplanted restored sites relative to one another and to reference wetlands, as well as indices of biotic integrity for plants, invertebrates, birds, and amphibians in addition to other indicators of ecosystem structure, such as soil organic matter and water chemistry.

Researchers developed field protocols, created biotic indices, and established baseline monitoring on each site including an as-built topographic survey, installation of groundwater and surface water stations, characterization of soils, vegetation, and vertebrates. A long-term monitoring system is now in place that will allow for the assessment of ecosystem recovery of seven restored wetlands relative to four reference wetlands.

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FACTORS AFFECTING BIOLOGICAL RECOVERY of WETLAND RESTORATIONS

Final Report

Prepared by

Susan M. Galatowitsch, PhD
Departments of Horticultural Science and Landscape Architecture
University of Minnesota

Richard M. Lehtinen, MS
Department of Biology, University of Ann Arbor, Michigan

Rachel A. Budelsky, PhD
Department of Horticultural Science, University of Minnesota

Diane Whited, MS
Department of Landscape Architecture, University of Minnesota

John Mulhouse, BS
Department of Horticultural Science, University of Minnesota

John Tester, PhD
Department of Ecology, Evolution and Behavior, University of Minnesota

Anne Capistrant, PhD
Department of Biology, University of Eau Claire, Wisconsin

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Office of Research Services
First Floor
395 John Ireland Boulevard, MS 330
St. Paul Minnesota 55155

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EXECUTIVE SUMMARY

Several thousand wetlands have been restored within the past fifteen years in Minnesota through voluntary and regulatory wetland protection programs. Private landowners have received assistance to restore wetlands under the Conservation Reserve Program (CRP) established by the 1985 Food Security Act and state programs such as Reinvest in Minnesota (RIM). In addition, wetlands lost by filling or draining are required to be mitigated under the Minnesota Wetland Conservation Act of 1991 or previously under Section 404 of the federal Clean Water Act. For example, the Minnesota Department of Transportation completed 40 wetland mitigation projects statewide between 1985 and 1991 (Mn/DOT file information). The Minnesota Department of Transportation also constructed 34 wetlands to be added to the state mitigation bank established in 1991. Restored wetlands must be deemed adequate replacements for natural wetlands to be certified for the bank. Consequently, agencies and individuals engaged in mitigation banking in Minnesota need to know which sites will be most likely to succeed and to what extent revegetation is necessary to stimulate biological recovery. The purpose of the investigations included in this report were to 1) identify appropriate methodology for field monitoring and assessment of condition for Minnesota wetlands and to 2) initiate a long-term study of restored wetlands that will identify factors affecting ecosystem recovery.

Wetland restoration success is being evaluated on seven recently restored wetlands and compared to reference wetlands. Three of the restored wetlands have been planted with native vegetation; four are being allowed to recolonize through natural processes only. Sites were selected for the study so that a group of three wetlands within a locale (unplanted, planted and reference) has similar size, soil type, parent material, and anticipated hydrology.

Chapter One describes the field and laboratory procedures that were developed to assess the extent to which ecosystem structure and function of the restored wetlands is similar to reference wetlands (Task 3, in part). We determined that hydrology, water chemistry, soils, vegetation, fish, amphibians, and birds should be monitored to better understand the long-term patterns and processes in restored wetland systems and identify specific factors affecting restoration success. The approaches to hydrological measurements in this study are: (1) to estimate annual fluctuations in water levels within the wetlands and to use this information to calculate changes in water volume and storage and (2) to determine whether groundwater is an important contributor to the wetland. The aspects of water chemistry essential to monitor suggest how water source may affect recovery. Monthly measurements of oxygen, temperature, conductivity, alkalinity, and pH should be made. Every fifth year, anion and cation composition should be characterized. Restored wetlands typically have very different physical and chemical soil properties than natural wetlands (e.g., Galatowitsch and van der Valk 1996). Some of these, such as low carbon and nitrogen concentrations will likely have long-term affects on site productivity. Other chemical characteristics and physical characteristics, such as temperature, may affect seed germination. In this study, soil temperature should be measured every month. Also, every fifth year, soil texture and chemistry should be characterized. Plant communities should be surveyed to document the recovery of wetland vegetation diversity. Two techniques can be used to obtain a complete picture of vegetation recovery: small plots along an elevational gradient and floristic lists. Approximately 20 small plots (1 X 1 m) should be surveyed annually along each transect. All species present in the plot are identified and percent cover estimated. These plots can be used to monitor the reformation of plant zonation and to detect changes in the distribution of dominant species due to hydrology. A complete floristic list should be compiled every five years, by zone, to consider how diversity changes over time. These lists should be compiled in late May, early July, and late August every five years. While fish communities in seasonal to semi-permanent wetlands are often depauperate, they can be important consumers in wetland food webs (Peterka 1989). Based on results of a previous study (Galatowitsch et al. 1997), fish assemblages in wetlands will be effectively sampled by the methods already in place for sampling larval amphibians (minnow traps and aquatic activity traps). Amphibian populations should be monitored because they are thought to be good ecological indicators due to their need for both terrestrial and aquatic habitats, their trophic roles as carnivores, herbivores, and prey, and their thin, sensitive skin. The amphibian assemblages present at the wetland study sites should be sampled using three different methodologies. Larval amphibians can be collected using aquatic activity traps and minnow traps. These traps are placed every 20 m, along a water-depth gradient (30-90 cm) at each basin. This sampling technique documents successful reproduction of frog and toad species and is the only method of reliably detecting salamanders and newts. Chorusing surveys should be conducted at each wetland. These surveys are carried out late at night, the time period within which calling activity is thought to be the greatest. Visual encounter surveys should be conducted to detect adult amphibians. Breeding bird populations should be monitored because they provide an indication that the plant community is adequately diverse and structurally complicated enough to support breeding birds. Bird communities on study wetlands can be efficiently sampled using the point count method (Bibby et al. 1992).

Chapter Two explores how species assemblage information collected from monitoring can be used to interpret changes in wetland condition in response to land use stressors (Task 3, in part) for eight kinds of wetland in Minnesota. We evaluated land use on site and within 500 m, 1000 m, 2500 m and 5000 m of riverine, littoral, and depressional wetlands (n=116) in 3 ecoregions. Proportion of agriculture, urban, grassland, forest, and water were correlated with metrics developed from plant, bird, fish, invertebrate, and amphibian community data collected from field surveys. We found 79 metrics that relate to land use, including five that may be useful for many wetlands: proportion of wetland birds, wetland bird richness, proportion of insectivorous birds, importance of *Carex,* importance of invasive perennials. Since very few metrics were significant for even one-half of the wetland types surveyed, our data suggest that monitoring recovery in wetlands with community indicators will likely require different metrics, depending on type and ecoregion. In addition, wetlands within extensively fragmented ecoregions may be most problematic for indicator development because biotic degradation is historic and severe.

The field techniques and assessment methods described in the first two chapters are being used at the eleven wetlands (four groups) that are part of the long-term recovery study. The characteristics of the sites, including physical and chemical soil properties, water chemistry, groundwater gradients, breeding birds, amphibians, fish, planting plans, and vegetation, are described in Chapter 3 (Tasks 1, 2, 4). One group is located west of Minneapolis-St. Paul, in Carver and McLeod Counties. The planted wetland, Spring Peeper Meadow, managed by the University of Minnesota, was restored in 1996-7. The unplanted wetland, Carpenter Marsh, was restored in 1997. The reference standard for these two wetlands, is a marsh within Schaefer Prairie, a Nature Conservancy preserve. A second group is located on the eastern side of the Minneapolis-St. Paul metropolitan area, in Ramsey and Washington Counties. The reference wetland is located within the Lake Elmo Park Preserve. The planted and unplanted restorations (West Phalen and East Phalen, respectively) are managed by the City of St. Paul as part of Phalen Lake Park. These two sites were restored in 1997. The third group is located in southern Minnesota in Steele and Nicollet Counties. Big Dog Slough was restored by the Minnesota Department of Transportation in 1997. Woodcock Marsh, managed by the U.S. Fish and Wildlife Service was also restored in 1997. The reference wetland, Swan Oshawa Marsh, is managed by the Minnesota Department of Natural Resources. The fourth group is located in Big Stone Counties. Botker Marsh was restored (unplanted) by the USFWS in 1996. The reference site is located within the Victory Wildlife Management Area (DNR). A planted restoration was planned by the Mn/DOT in this area, but the site could not be purchased. Revegetation success ranged from 25% (West Phalen) to 64% (Spring Peeper), based on planted species observed the year following planting. In general, floristic diversity of planted sites was greater than unplanted sites. Soil temperatures of both planted and unplanted restorations were consistently higher than reference sites, especially in the spring. Water chemistry analysis suggests that restorations near roads (Botker, Spring Peeper) are receiving high salt loads. The water level fluctuations recorded during the first year indicate that most restored wetlands have a hydrologic regime comparable to reference wetlands. West Phalen is an exception, frequently experiencing extreme water level fluctuations (greater than 1 m.). Among restored wetlands, breeding bird diversity was highest at Carpenter, Botker, and Big Dog and lowest at East and West Phalen Marshes. Amphibian diversity was highest at Spring Peeper and Carpenter restored wetlands and lowest at East and West Phalen Marshes.

Wetland Ecosystem Monitoring Research Program: Sampling and Techniques Manual

Susan M. Galatowitsch, Richard M. Lehtinen, Rachel Budelsky,
Anne M. Capistrant, and John Mulhouse
University of Minnesota, St. Paul, MN 55108

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Introduction

In response to high rates of wetland destruction and the subsequent loss of wetland biota, wetland habitats have received legal protection in Minnesota. Several thousand wetlands have been restored in the last ten years through voluntary and regulatory wetland protection programs. These restored wetlands are meant to take the place of natural wetlands that have been lost. The success of wetland restorations, however, has not been evaluated adequately for inland wetlands of North America. Some of the specific questions that need to be addressed include the following: (1) Do restored wetlands contain the same organisms as natural wetlands? (2) Do restored wetlands perform the same functions as natural wetlands? (3) What factors affect the likelihood of restoration success? (4) Is natural recolonization adequate to restore native biodiversity? (5) Does planting facilitate wetland ecosystem recovery and the return of native biodiversity? We have attempted to answer these questions in a long-term monitoring project of seven restored and four natural wetlands.

Eleven wetlands were selected for this study (See Study Site Descriptions). Four of these are natural reference wetlands, four are unplanted wetland restorations, and three are planted wetland restorations. Every year we will conduct intensive field research to document the physical and abiotic environment in these wetlands as well as the flora and fauna that inhabit them. Specifically, we will be monitoring hydrology, water chemistry, soils, vegetation, amphibians, fish and birds. By monitoring these aspects of restored and natural wetlands we hope to better understand the long-term patterns and processes in these systems and identify specific factors affecting restoration success. This manual includes instructions for using the standardized sampling techniques and methodologies developed by the Wetland Ecosystems Monitoring Research Team.

General Sampling Configuration:

Most of the sampling and observation stations are based around two linear transects, three groundwater monitoring stations and one surface monitoring station. Transect stations were established along an elevational gradient at 30 cm (vertical) intervals. There are between eleven and forty transect stations per site, depending on the size and gradient of each wetland. Each sample station along a transect is marked with 8-10 ft long 0.5 inch aluminum conduit which has been driven into the ground approximately 4 ft. A University of Minnesota tag is riveted to each pole identifying the station number and transect direction.

On all data sheets and samples, the following site designator codes should be used:

Big Dog Slough	BIG	Botker	BOT
Carpenter	CAR	East Phalen	EAP
Lake Elmo	LEL	Schaefer Prairie	SCH
Spring Peeper	SPP	Swan-Oshawa	SWO
Victory	VIC	West Phalen	WEP
Woodcock	WDK		

(Data sheets are located in Appendix A and are referenced the first time they appear in the text.)

Permits:

While informal verbal or written permission to conduct research has been obtained for every site, some may also require permits or other formal authorization. The following table summarizes the requirements for each site:

Site:	*Contact:*	*Permit required:*	*Permit conditions:*	*Other:*
Big Dog Slough	MnDOT Robert Jacobson (612)779-5087	No	N/A	None
Botker Marsh	USFWS Darryl Haugen (320)589-1001	No	N/A	None
Carpenter Marsh	Walter Carpenter (612)825-9557	No	N/A	None
East Phalen	City of St. Paul Mike Kassen (651)266-6249	No	N/A	None
Lake Elmo	Lake Elmo Park Reserve Mike Pohlena (651)578-3688	Yes (for vehicle)	Vehicle permit must be renewed yearly.	A park gate key has been loaned to the study for the duration of the research.
Schaefer Prairie	The Nature Conservancy Garth Fuller (507)332-0525	Yes	No sampling of any fauna or flora of special concern, though requests can be resubmitted yearly. Field workers must explain research to prairie visitors and minimize disturbance	Written permission must be carried at all times (letter located in file).
Spring Peeper Meadow	MNLA Julia Bohnen (612)474-6886 ext. 238	No	N/A	None
Swan-Oshawa WMA	MNDNR Dennis Simon (507)225-3572	No	N/A	None
Victory Marsh	MNDNR Dave Soehren (320)289-2493	No	N/A	None
West Phalen	See E. Phalen	No	N/A	None
Woodcock	USFWS Mike Malling (612)858-0714	No	N/A	None

Hydrology

Many aspects of ecosystem recovery are governed by hydrology. The approaches to hydrological measurements in this study are: (1) To estimate annual fluctuations in water levels within the wetlands and to use this information to calculate changes in water volume and storage and (2) To determine whether groundwater is an important contributor to the wetland.

Activity:	*Frequency of Sampling:*
Collect water depth data.	Once during the last two weeks of the month from April through August each year.
Record water levels from piezometer nests and observation wells.	Once during the last two weeks of the month from April through August each year.
Calculate changes in water storage and surface area.	Once annually after all field data is available.

Locations of Sampling Stations:

Piezometer nests are clusters of PVC pipes at three locations on the periphery of the wetland. There are four piezometers in each nest at depths of 30.5 cm, 61 cm, 122 cm, and 152.5 cm, each labeled with colored tape (blue, red, yellow) designating both nest group and individual well depths. Stripes of each nest group color correspond to depths as follows: 1 stripe=30.5 cm, 2=61 cm, 3= 122 cm, and 4= 152.5 cm. Each nest also has a monitoring well at a depth of 61 cm which is designated by a single stripe around the cap.

A water depth monitoring station is located in each wetland at a transect pole in the deepest part of the wetland. The locations of these stations for each site is as follows, with the number representing the pole and the letter the transect direction (i.e. 4N = fourth pole of the north transect.):

Site:	*Station:*	*Site:*	*Station:*
BIG	4N	SPP	Mid piez. In both basins
BOT	3N	SWO	4N
CAR	8N	VIC	6S
EAP	5E	WDK	4W
LEL	6N	WEP	8S
SCH	7S		

Field Procedures:

Special equipment: measuring tape, weight, meter stick, LED probe, stiff retractable measuring tape, water-based marker.

Water Depth:

1. Proceed to designated water depth measuring station.

2. Allow the round weight attached to the measuring tape to gently settle on the bottom of the wetland, several cm from the pole.

3. Pull measuring tape taut.

4. Read the water depth to the nearest one-half centimeter and record on data sheet under "water depth at water level monitoring station."

Piezometer and Observation Well Readings:

1. Locate piezometer nest(s) and remove PVC caps. Measure distance (in cm) from top of uncapped pipe to ground surface at the designated orientation (either a notch cut in the pipe or a black mark). Record on data sheet under "depth to soil."

2. Use the LED probe to record water levels within the piezometers at each nest. (The LED probe is a narrow metal cylinder with two small prongs on the bottom. When water is contacted, the circuit between the prongs is completed and two red LED indicators on top of the probe light. Care should be taken to keep the prongs clean.)

In each piezometer, insert measuring tape with LED probe attached. Continue lowering the probe until the light indicates that water has been reached. (Note: A small amount of moisture in the bottom cap of the well may remain when the well is essentially dry. This moisture may cause an inaccurate reading of water depth when the LED indicator is used. If the field technician suspects the well is dry, he or she should use a measuring tape covered with water-based marker to ascertain if there is standing water. If any colored area on the tape dissolves, there is measurable water.)

3. Read the value on the measuring tape, adding 30.5 cm to account for the unmarked length of the probe, and record in the appropriate column on the data sheet. (Labeling Convention: Make sure data from each piezometer nest is specified by its color (red, blue, yellow.))

4. Repeat from Step 1 until the water levels in all piezometers and water-monitoring wells at the site have been measured.

Data Entry:

Well records are compiled in an EXCEL worksheet titled hydrology.xls with each site contained on a separate sheet in the main file. Individual nest records are entered in columns and each nest corresponds to a color on the data sheet. The length of the pipe and distance from pipe top to soil are already recorded, although distance from pipe top to soil should be remeasured intermittently. Comments can be entered in the last column as they apply.

Data Analysis:

Changes in storage and surface area are calculated using computerized basin maps created with SURFER (Golden Software, 1997). The basin maps (10 cm contours) were generated from field surveys conducted in 1998. These maps should be updated every ten years. Use the cut and fill routine to estimate the volume of water when water is at a given depth at a known station, then estimate surface area.

Determine the total head for each of the piezometers relative to the depth of the deepest well. Total head is the sum of the elevation head and the pressure head (U.S.G.S. 1989). Take the elevation head to be the depth of the well (below ground) substracted from the depth of the deepest well. The pressure head is the distance to water substracted from the length of the pipe. Compare the total head values for each piezometer nest to determine if there is an upward (groundwater discharge) or downward (groundwater recharge) gradient of water. An upward gradients exist when total head is lower for shallower wells than deeper ones (head loss).

Well Specifications:

Piezometer and observation well installation follows Soil Conservation Service methodology (1993). Both piezometers and observation wells are constructed of 1 inch diameter schedule 40 PVC pipe and permanently capped at the bottom. Piezometers have a horizontally slotted sampling zone of 18 cm (7 in) at the bottom of the pipe, covered by several layers of 1 mm mesh. Observation wells have a sampling zone of approximately 43 cm (17 in).

Piezometers and wells were installed by drilling a bore hole with an auger, placing the pipe into the hole, and filling with sand. The top of the bore hole was capped with bentonite clay and local soil. The open tops of the wells extend above the ground and have removable caps.

References:

Keckler, D. 1997. Surfer for Windows user's guide. Version 6. Golden Software, Inc., Golden, CO.

SCS (Soil Conservation Service). 1993. Installing monitoring wells/piezometers in wetlands. WRP Technical Note HY-IA-3.1.

U.S.G.S. 1989. Basic ground water hydrology. Water Supply Paper 2220. U.S. Government Printing Office, Denver, CO.

Water Chemistry

The aspects of water chemistry being monitored here will suggest how water source may affect recovery. Monthly measurements are made of oxygen, temperature, conductivity, alkalinity and pH. Every fifth year, anion and cation composition will be characterized.

In general, these data are to be interpreted along with the hydrological data. Another important aspect of water chemistry, macronnutrient pools (i.e., nitrogen and phosphorus) are not currently being monitored adequately for use in productivity studies. If funds become available to support the frequent sampling and analysis required of nutrient budgets, this activity will be added.

Activity:	*Frequency:*
Measure field temperature and dissolved oxygen content of wetland water.	Once during the last two weeks of each month from April through August each year.
Collect water samples for laboratory analysis (in house) of conductivity, alkalinity and pH	Once during the last two weeks of each month from April through August each year.
Collect water samples for detailed laboratory analysis (outside lab) of major and minor cations (Ca, Mg, Na, K, Al, Fe, Mn, P, Sr, Ba, Si); trace cations (Mn, Cr, Fe, Cu, Co, Zn, Ni, Pb, As, Se, Tl, Ba, Cd); and anions (F, Cl, NO2-nitrogen, NO3-nitrogen, Br, sulfate, PO4-phosphorus).	Once every five years during the last two weeks in May.

Location of Sampling Stations:

Each water chemistry sample location is associated with a piezometer nest (3 per wetland).

Field Procedures for Temperature, Alkalinity, Conductivity and Dissolved Oxygen Concentration Measurement:

Special equipment: Dissolved oxygen meter, 3" whirl-pacs (pre-labeled bags with site, date, nest color), 200 ml sample bottle, cooler and ice.

Note: Take these measures 1-3 hours after sunrise.

1. Label whirl-pacs with site name, date, and sample location.

2. Calibrate dissolved oxygen meter. (All persons should be trained in its use IN THE LAB before collecting data in the field.)

3. To locate sampling locations (3 per wetland) stand at a color-coded piezometer nest and face the wetland. Walk into the wetland to a water depth of 50 cm. Water data should be collected at this location, 20 cm from the water surface (or 30 cm from the bottom). If the wetland does not reach a depth of 50 cm, data should be collected from the deepest possible point, but at least 20 cm off the bottom of the basin. (Do not walk through a sampling site before measurements have been taken as the churning of water will influence readings.)

4. Measure temperature and dissolved oxygen levels and record on data sheet. If a waterproof oxygen meter is used then record measurements directly in the water. Ensure accuracy of readings by standing a few feet away from the measuring site and dangling the probe in the water at an arms length. If a waterproof meter is not used, collect a 100 ml sample, return to the wetland edge and record measurements immediately.

5. Record time at which measurements were taken.

6. Record one of the following sky conditions: clear or few clouds, partly cloudy, cloudy or overcast, fog, drizzle or showers. Sky conditions are on a numerical scale of 0-5, 0 being clear, and are listed on larval sampling and nest search data sheets. If the sky is changing, record what it was before the measurements were made.

7. After the dissolved oxygen and temperature readings are taken at a station, collect a water sample for further analysis in the laboratory. With one smooth motion submerge an empty, open whirl-pac to a depth of 20 cm, pulling it through the water sideways for several inches and lift it out. The bag should be no more than 2/3 full before sealing and some of the sample can be poured out if necessary. Water samples should be placed in a cooler as soon as possible and kept on ice until they can be frozen.

Laboratory Analysis (In-House):

Special Equipment: pH meter, magnetic stirrer, pipets, beaker (250 ml), graduated cylinder, buret and stand for titration, 0.02 N H_2SO_4 solution and conductivity meter.

1. Thaw samples by removing from freezer no more than 24 hours before analysis. Sample should be between 17 and 22 °C for analysis.

2. Measure the conductivity of a sample by inserting the conductivity probe into the whirl-pac, mixing sample gently before measuring. Be sure the probe is adequately submerged for accurate reading. (This will vary by instrument; check manual for directions.) Record conductivity reading on data sheet.

3. Measure 100 ml of sample using a graduated cylinder or volumetric flask. (If 100 ml is not available, record volume and continue.) Place sample into a 250 ml beaker, set on stirrer plate and switch on magnetic stirrer. Measure the pH of the sample using a pH probe. Record on the data sheet.

4. If pH is above 8.3, titrate with 0.02 N H_2SO_4 to 8.3 to estimate phenolphthalein alkalinity. The sample should be continually stirred during titration. Record the volume of titrant used. Then titrate the sample with 0.02 N H_2SO_4 to a pH of 4.5 to estimate total alkalinity. (If pH is less than 8.3, the only titration is to 4.5.) Record the total volume used to reach a pH of 4.5. Calculate alkalinity using the following equations:

Phen. Alkalinity as mg CaCO3 per liter=

(ml. titration to 8.3) x 100 (if 100 ml of sample are used)

Total Alkalinity as mg CaCO3 per liter=

(ml. titration to 4.5) x 100 (if 100 ml of sample are used).

Record alkalinity on the data sheet.

If 100 ml of sample is not used, consult Lind text for equations (1979).

Comprehensive Cation and Anion Analysis:

Special equipment: Whirl-pacs, cooler and ice, 8 oz plastic water bottles, 30 ml plastic syringe and filter holder, Gelman filters, forceps, dropper bottle of HNO_3.

1. Collect one extra water sample at each location (as described above) for comprehensive analysis in the laboratory.

2. Within 12 hours of sample collection, divide the water sample into two subsamples (one for anion analysis, another for cation). Prepare the anion subsample by filtering 20 ml of sample through a filter holder attached to a syringe. (A Gelman Sciences Super 450 25 mm 0.45 um membrane filter is required and a forceps should be used to place the filter into the holder to avoid touching the paper.) Gently expel the water sample from the syringe with the plunger into a plastic sample bottle. (Do not use glass bottles because they adversely affect the chemical analysis.) Change the filter paper when it becomes noticeably harder to push the plunger down. (More than one filter may be necessary for some samples.) Label the bottle with the following information:

SAMPLE FOR ANION ANALYSIS
Susan Galatowitsch
Horticultural Sciences
305 Alderman Hall
624-3242, galat001@maroon.tc.umn.edu

Site Name: ______________ _ _________
Date: ________________________________
Sample Location: ____________________
Observer: ___________________________

3. Prepare the cation subsample by filtering 20 ml of sample into a new plastic bottle as described above. Acidify this sample by slowly adding HNO_3 to the filtered sample until the pH is 2 or lower. Label the bottle with the following information:

SAMPLE FOR CATION ANALYSIS
Susan Galatowitsch
Horticultural Sciences
305 Alderman Hall
624-3242, galat001@maroon.tc.umn.edu

Site Name: __________________________
Date: ________________________________
Sample Location: ____________________
Observer: ___________________________

4. Samples should be refrigerated until delivery to:
Rick Knurr, Senior Scientist
Department of Geology and Geophysics, University of Minnesota
310 Pillsbury Drive SE, Room 4, Minneapolis, MN 55455
(612) 624-8084 knurr001@maroon.tc.umn.edu

Filtered anion samples must be delivered within 1-2 weeks; acidified cation samples can be refrigerated up to 5 months. The anion subsamples should be measured for F, Cl, NO_2-nitrogen, NO_3-nitrogen, Br, sulfate, and PO_4-phosphorus using a DIONEX GP40/CD20 ion chromatograph. The cation subsample should be measured for major and minor cations, Ca, Mg, Na, K, Al, Fe, Mn, P, Sr, Ba, and Si, using a Perkin Elmer Elan 5000 ICP-MS.

Samples can be dropped off M-F between 7:30 and 4:00. Fill out a work request and leave with samples on aluminum cart

Data Entry:

Water chemistry data is entered in an EXCEL spreadsheet titled waterchemistry.xls. Each site is on a separate sheet in the main file and recordings are made in the appropriate columns with any pertinent comments also recorded.

References:

Lind, O.T. 1979. Handbook of common methods in limnology. 2nd ed. C.V. Mosby Co., St. Louis, MO.

Soils

Restored wetland soils typically have very different physical and chemical characteristics than natural wetlands (Galatowitsch and van der Valk, 1996). Some of these, such as low carbon and nitrogen concentrations, will likely have long-term affects on site productivity. Other chemical characteristics and physical characteristics, such as temperature, may affect seed germination.

In this study, soil temperature is measured every month during the field season. Also, every fifth year, soil texture and chemistry are characterized.

Activity:	*Frequency:*
Collect wetland soils for analysis of soil texture, bulk density, organic carbon, nitrogen, and phosphorus.	Every five years, once in the first two weeks of June.
Measure temperature of wetland soil at depths 2 and 20 cm.	Every year, once a month from April to August, during the last two weeks of the month and between 3 and 6 hours after sunrise.

Location of sampling stations:

Soil temperatures are measured at the station closest to the water line on each end of each transect and the next station above and below that station, thus providing data from stations at corresponding elevations on each side of a basin gradient. To prevent discrepancies to due to solar warming, readings should be taken between 3 and 6 hours after sunrise. Sampling stations for soil characteristics are to be located at a point 50 cm away from transect on the same elevational gradient.

Field Procedure for Soil Temperature:

Special equipment: temperature meter or soil temperature probe, meter stick.

1. Grasp temperature probe and insert into soil. Use a meter stick positioned beside the probe to determine when you are at a 2 cm depth. (Push firmly until ground provides resistance as there may be compression of vegetation above soil surface.) Wait until

temperature stabilizes and record on data sheet. (Note: Soil temperatures are recorded on the same sheet as hydrology and water chemistry data.)

2. Insert the probe 18 cm further for the 20 cm measure and determine temperature as described above. Move to next sampling location.

Field Procedures for Physical and Chemical Soil Properties:

Special equipment: soil core (wet tip), Macauley peat auger or bucket auger, tulip bulb planter, measuring stick, plastic bags, flagging, permanent marker, strong adhesive tape, cooler and ice.

1. Collect soil cores to a depth of 5 cm using a tulip bulb planter. Mark the planter at 5 cm with tape, then firmly press into the ground. Sample may remain in the end of the planter or fall out. (Holding a hand under the planter or auger after boring will ensure that no part of the sample is lost.) Place core in plastic bag. Measure hole depth to verify proper sample depth. Label each sample with the following information: site name, date; transect ID, pole ID, sample depth, collector name(s). (This information should be written in permanent marker on plastic flagging tape and tied to the outside of the plastic bag and is best done before the site visit.) Place sample in cooler and rinse planter.

2. Insert auger in hole, noting height of tool with measuring stick. Slowly turn or press auger in 10 cm. Remove auger, being careful not to lose sample, and place core in plastic bag as previous. Measure hole to ensure that a depth of 15 cm has been reached. Rinse auger.

3. Repeat the above procedure for sample depths of 15-25 cm and 25-35 cm, rinsing auger after each coring to prevent contamination of samples. It may be difficult to obtain samples in wet soils or those under water and field workers are advised to experiment with techniques, such as using PVC to prevent holes from collapsing or using two augers, inserting the second in the hole immediately after measuring depth. Working with a partner is strongly recommended.

4. Freeze samples as soon as possible.

Laboratory Procedures for Physical and Chemical Soil Properties:

Special equipment: 500 ml hydrometer jars, hydrometer, sodium hexametaphosphate, 30 % hydrogen peroxide, 1 % acetic acid, metal ointment cans, drying oven, 400 ml or larger beakers, large watch glasses, soil shaker, tall glass jars and textural triangle. (Soil texturing techniques follow Gee and Bauder, 1986.)

1. Deliver the 0-5 cm and 25-35 cm samples to the Research Analytical Laboratory for pH, N, P, and C analysis. The following tests should be performed: pH with 0.01 M $CaCl_2$, phosphate-P (extractable, Olsen's sodium bicarbonate), total nitrogen (Kjeldah with nitrate reduction) and organic carbon ((with bicarbonates) (modified Mebius method)).

   Research Analytical Laboratory
   University of Minnesota
   135 Crops Building
   1903 Hendon Avenue
   St. Paul, MN 55108
   (612) 625-3101 (office) (612) 625-6704 (soil lab, for test status)

   Keep a record of which samples have been delivered, giving one to the analytical laboratory. Sample remains are collected from the lab after analysis.

2. Use the 5-25 cm sample to determine texture. Mix sample by hand to homogenize. Fill an ointment tin with soil, labeling it with site, transect and pole number (these labels should follow the sample through the entire process). Place in 100 °C drying oven (uncovered) for 24-48 hours until dry.

3. For each sample weigh approximately 20 g of soil, record exact weight on data sheet (Appendix A-2) and place in labeled 400 ml beaker. Digest carbon with 100 ml of distilled water, 10 ml of 1 % acetic acid, and 20 ml of 30 % hydrogen peroxide. Very

organic-rich samples will have a tendency to "foam," so be sure to monitor samples in case it is necessary to place a sample in secondary containment. Cover with watch glass and place in 100 °C oven for at least 24 hours.

4. For samples with a clear supernatant when removed from oven, proceed with texture analysis. Repeat the digestion for samples with green to brown supernatant. Decant excess supernatant as necessary, being careful not to lose any of the sample.

5. Place sample in tall, labeled, glass jars and fill with 50 ml of 5 % sodium hexametaphosphate solution. Rinse any sample left in beaker into jars with distilled water. Place in soil shaker overnight.

6. Pour contents of glass jars into labeled hydrometer jar and bring each to a total volume of 500 ml with distilled water. Record the temperature of the solution. Also, set up a blank run using 450 ml of distilled water and 50 ml of metaphosphate solution. Take a temperature and hydrometer reading of the blank immediately.

7. Using a plunger, thoroughly stir the soil mixture for one minute before each run so the soil particles will be uniformly distributed. Use long, steady strokes with the plunger while holding the cylinder base to prevent spillage.

8. Take a hydrometer reading at 40 seconds after stirring stops, when all sand has settled beneath the effective depth of the hydrometer. The hydrometer can be inserted carefully into the cylinder 20-30 seconds before taking the reading. Wipe the hydrometer carefully after each use. Record reading on data sheet. The density of this first reading corresponds to the silt and clay fraction of the soil.

9. Take a second hydrometer reading after sample has settled for 7 hours. The second reading corresponds to the clay fraction of the soil. Record reading on data sheet.

10. Subtract the hydrometer reading of the blank from each soil reading. This is an absolute reading of soil density. Then divide both the 40 second and 7 hour readings by 20 (appx. sample weight in grams) and multiple by 100 for percentages of silt

and clay and clay. Subtract the percentage of clay from the percentage of silt and clay to get the percentage of silt. The remainder is sand. Record these values and key out the soil type using a textural triangle. If analysis appears unreliable, corrections may have to be made for differences between sample temperatures and/or the calibration temperature of the hydrometer.

Data Entry:

Soil temperatures are recorded in a separate workbook from other soil parameters. Temperature records for each site are maintained on an individual sheet in the EXCEL worksheet soiltemps.xls. All temperature readings are recorded, along with comments about stations used and any instability of thermometers.

Soil chemistry data is recorded in the EXCEL worksheet soilchemistry.xls. Each site has an individual sheet and data is simply recorded in the corresponding columns, along with any pertinent comments.

References:

Galatowitsch, S.M. and A.G. van der Valk. 1996. Vegetation and environmental conditions in recently restored wetlands in the prairie pothole region of the U.S. Vegetatio 126: 89-99.

Gee, G.W. and J.W. Bauder. 1986. Particle-size analysis. P.383-411. *In* A. Klute (ed.) Methods of soil analysis part 1-physical and mineralogical methods 2nd ed. American Society of Agronomy Inc. & Soil Science Society of America, Madison, WI.

Vegetation

Plant communities are surveyed to document the recovery of wetland vegetation diversity. Two techniques are used to obtain a complete picture of vegetation recovery: small plots along an elevational gradient and floristic lists. Small plots (1 X 1 m) are surveyed annually at each station along a transect. All species present in the plot are identified and percent cover is estimated. These plots will be used to monitor the reformation of plant zonation and to detect changes in the distribution of dominant species due to hydrology. A complete floristic list is compiled every five years, by zone, to consider how diversity changes over time. These lists are compiled in late May, early July, and late August every five years. Nomenclature follows Great Plains Flora (1991).

Activity:	*Frequency:*
Estimate cover of species along an elevational gradient and detect changes in dominant species distributions.	Annually during the last two weeks of July.
Develop a complete floristic list for each vegetation zone.	Every five years, three times during the year: (1) late May, early June; (2) late July; (3) late August, early September.

Location of sampling stations:

One meter plots are to be located beside each station on a transect. Orient plot frames to the north of the pole, with the center of the southern edge of the frame abutting the pole. There are from 11 to 40 small plots per wetland.

Field Procedure for Annual Vegetation Plots Along Elevational Transect:

Special equipment: plot frame, ocular cover guide, plastic bags, newpaper, wax paper and plant press with blotter paper and cardboard.

1. Place plot frame over vegetation in proper orientation, keeping one edge against station pole. Identify all species present in the plot and list them on the data sheet (Appendix A-3).

2. Estimate the percent cover for each plant species, as well as the amount of standing water, litter and bare ground (no vegetation) in the plot. Use the following cover classes: r=single individual, very insignificant cover, +=few individuals, insignificant cover, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%. Refer to the guide on ocular cover estimates as necessary in the field (Appendix A-4). Determine the cover class and record on data sheet data, listing appropriate transect and pole.

3. Voucher specimens should be collected when identification is uncertain or if there is not already a voucher for a particular species at that site. To collect voucher specimens, select healthy, intact plants (with flowers and/or fruits), preferably from outside the established plots. If you are uncertain if the plant from outside the plot is the same as what was identified within the plot, choose your voucher from inside the plot. Vouchers should be placed in individual bags and labeled with a site code, date, plot ID and species ID (if known).

4. Press voucher specimens within 24 hours. Place plant between single sheets of newspaper and arrange to maximize display of flowers, fruits, and leaves. Press submersed and floating aquatics between waxed paper within a newspaper so that mucilage does not cause the plants to be tightly adhered to the paper. Transfer label information from bag to newspaper. Press newspaper between blotter sheets and cardboard. Place all specimens in plant press and cinch tight. Place plant press in dryer immediately upon return to campus. Remove from dryer in approximately 3 days.

Field Procedure for Comprehensive Floristic List:

Special equipment: ocular cover guide, plastic bags, newspaper, wax paper and plant press with blotter paper and cardboard.

1. Walk each distinctive vegetative area, typically the following zones: wet prairie, sedge meadow, shallow emergent, deep emergent, and open water. Some sites may have mudflat on the periphery or in place of open water in drought years. Make sure that each area corresponds to a zone number on the data sheet (Appendix A-5).

2. Estimate percent cover for each plant species using the ocular guide for estimating percent cover. Record cover on data sheet (Appendix 6) using cover classes as described for transect sampling.

3. Estimate the height classes for each woody species and record on the data sheet. Some species may be found in more than one height class. When this occurs, record height class as a range (i.e., height classes 1-3).

Height classes

1. <0.1 m	4. 2-5 m	7. 20-35 m
2. 0.1-0.5 m	5. 5-10 m	8. >35 m
3. 0.5-2 m	6. 10-20 m	

4. Collect voucher specimens as described for transect sampling.

Data Entry:

Vegetative data is entered on EXCEL spreadsheets that correspond to field data sheets. Each site had a separate sheet within the workbook.

References:

Almendinger, J. C. 1988. A handbook for collecting releve data in Minnesota. Minnesota Natural Heritage Program. St. Paul, MN 55148.

Gleason, H.A., and A. Cronquist. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. 2nd ed. The New York Botanical Garden, Bronx, New York.

McGregor, R.T and T.M. Barkley. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence Kansas.

Mueller-Dumbois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York.

Amphibians

Amphibian populations are monitored because they are thought to be good ecological indicators due to their need for both terrestrial and aquatic habitats, their trophic roles as carnivores, herbivores, and prey, and their thin, sensitive skin. The amphibian assemblages present at the wetland study sites are sampled using three different methodologies. Multiple methods are used because research has shown that using a single method can generate biased and misleading data (Vogt and Hine, 1982). All three methods are done yearly at five site visits during April 6-June 30.

At each wetland chorusing surveys are to be conducted. These surveys involve timed periods of listening for the distinctive advertisement calls of frog and toad species and are carried out late at night, the time period within which calling activity is thought to be the greatest. Visual encounter surveys are also conducted to detect adult amphibians. These opportunistic searches are carried out for 30 minutes both at night and during the day and all amphibian species encountered are recorded._Finally, larval amphibians are collected using aquatic activity traps and minnow traps. These traps are placed in an alternating pattern every 20 meters, along a water-depth gradient (30-90 cm) at each basin. This sampling technique documents successful reproduction of frog and toad species and is the only method of reliably detecting salamanders and newts.

Activity:	*Frequency:*
Obtain a species list of the amphibians present at the site using chorusing surveys and obtain an estimate of relative abundance.	Every year; twice a month from April through June.
Obtain a species list of the amphibians present at the site using visual encounter surveys and obtain an estimate of relative abundance.	Every year; twice a month from April through June.
Obtain a species list of those amphibians that have successfully bred in the wetland using larval sampling and estimate the abundance of breeding amphibian species.	Every year; twice a month from April through June.

Field Procedure for Chorusing surveys:

Special equipment: thermohygrometer, anemometer and stopwatch

Note: Take care not to make noise when approaching the wetland area. It often will take some time for the males to begin calling again if they are disturbed. If necessary, park the vehicle a distance away and approach on foot. Do not conduct the chorusing survey if the air temperature is below 4 °C. Those with hearing difficulties should not conduct this survey.

1. Chorusing surveys are conducted by listening for the distinctive breeding calls of frogs and toads. Once you have arrived at the listening point, record all environmental data (Appendix A-7), start the stopwatch, be quiet, and listen. Record those species that you hear calling and estimate the abundance of each species by using the following scale:

    0 = No individuals of this species detected.

    1 = Individual calls can be distinguished; space between calls.

    2 = Individual calls can be distinguished, but are overlapping.

    3 = Calls are cannot be distinguished individually. Chorus is constant and overlapping.

2. Often when many individuals are chorusing it is difficult to estimate abundance. If this is the case, do not hesitate to enter 3 on the data sheet. However, during a full chorus listen carefully for other, less numerous species calling in the background. Also, you may hear the calls of some secretive wetland birds such as rails or bitterns. There is a place on the data sheet to record these as well. Chorusing surveys will begin two hours after dusk, so the exact time of the survey will vary depending on the time of year. Chorusing surveys will last exactly ten minutes. Be sure you have listened to the training tape and are familiar with the calls of breeding frogs and toads.

Field Procedure for Visual Encounter Surveys (VES):

Special equipment: thermohygrometer, anemometer, stopwatch and headlamp.

1. This methodology is an active search for amphibians in and around the wetland. Two VES will take place on each site visit, one at night and one during the day. The day

VES will occur between 0700 and 1000 hours and the night VES will occur after the chorusing survey, approximately two hours after dusk. When conducting the night VES, a headlamp with a powerful light is used. One can often find where amphibians are hiding by seeing the reflection of their eyes. Also, turning over any downed wood or looking through leaf litter will often turn up salamanders or newts.

2. First, record all environmental data on data sheet (temperature, humidity, wind speed, etc.). Do not conduct the visual encounter search unless the air temperature is above 4 °C.

3. Visual encounter surveys (VES) should take place within 10 meters of the wetland edge. The walking pace should be slow and constant. Search as much of the wetland area as possible in the time allotted. Each VES will continue for exactly 30 minutes. Amphibians can be identified visually from a distance or captured by hand, identified and then released. Record the species and keep track of the number caught on the data sheet. Caution: Be careful not to search an area more than once, to avoid recounting individuals.

4. If a reference specimen is on record for every species of amphibian that was seen during a sampling effort, then it is not necessary to take a reference specimen. However, if a new species is detected or the identity of a specimen is uncertain, a reference specimen must be taken. Reference specimens are taken by placing the amphibian in a plastic whirl-pac bag with some water. Add approximately one gram of MS-222 (an anesthetic). Wait several minutes and then add formalin (a fixitive) to the container until diluted to approximately 7 %. (Caution: Always wear protective gear when working with formalin and try to avoid any spillage.) Seal container tightly and prominently label with a permanent marker. The following information should be included: site name, date, trap type and number, and the name of collector. Later, more detailed information can be added in the laboratory (Appendix A-9). Store specimen in a safe place away from heat and direct sunlight.

Location of Sampling Stations:

Ten traps (5 aquatic activity traps, 5 minnow traps), placed in an alternating pattern every 20 meters in 30 to 90 cm. of water. Visual encounter surveys are done within 10 meters of the wetland edge. If complete coverage of a site is not possible, trap placement and visual surveys should occur in different regions of the wetland on each site visit.

Field Procedure for Larval Sampling:

Special equipment: 5 aquatic activity traps and 10 bottles, 5 minnow traps, large duffel bag (for carrying traps through the wetland during set-up and collection), site map with trap locations, amphibian larvae key, plastic bags and labels (for reference specimens, if applicable).

1. The larval amphibian sampling technique involves using aquatic activity traps and minnow traps to capture amphibian larvae. Set-up occurs around 1500 hrs and involves setting the aquatic activity and minnow traps at specified locations in the wetland.

   Minnow traps are clamped shut and submerged and should not be placed at a depth of greater than one meter. Make sure the float is attached, so you can find the trap again later. Aquatic activity traps are assembled by inserting inverted tops into cut-away plastic bottles and attaching the unit to PVC clamps mounted on. The bottom bottle should be oriented vertically, the top one horizontally. The pointed end of the stake should be inserted into the substrate until the apparatus is firmly in place. The clamps on the traps are adjustable and can be moved up and down. Make sure the top of the pole is flagged with marker to tape so you can find the trap later. IMPORTANT: You must leave some air bubbles in each of the bottles, otherwise the larvae that are trapped will not be able to breathe.

2. Collect traps around 0900 hrs the following day. Count and identify the amphibian larvae that were captured in a minnow trap using the Key to Tadpoles of Minnesota (Appendix C-1). Record the number caught of each species on the data sheet (Appendix A-8). As the larvae are counted and identified and all data has been recorded, return the larvae to the wetland. Next, identify, count, record, and release the contents of an aquatic activity trap. Repeat this procedure until all traps have been emptied and all data has been recorded. Remember, it is important to record the

data from each trap separately. Also, aquatic activity traps may tip over during heavy weather. It should be noted on the data sheet when this occurs.

3. If a reference specimen is on record for every species of larvae that was collected during a sampling effort, then it is not necessary to take a reference specimen. However, if a new species is detected or the identity of a specimen is uncertain, a reference specimen must be taken. Reference specimens are taken by placing the larvae in a plastic whirl-pac bag with some water. Add approximately one gram of MS-222 (an anesthetic). Wait several minutes and then add formalin (a fixitive) to the container until diluted to approximately 7 %. (Caution: Always wear protective gear when working with formalin and try to avoid any spillage.) Seal container tightly and prominently label with a permanent marker. The following information should be included: site name, date, trap type and number, and the name of collector. Later, more detailed information can be added back in the laboratory. Store specimen in a safe place away from heat and direct sunlight.

4. Other organisms are likely to be found in the traps besides amphibians, including fish. Fish should be identified, counted, and released (see Fish Sampling). Adult amphibians are also sometimes found in aquatic activity traps. These should be identified (Appendices C-2 & C-3), recorded, and released or vouchered.

5. In recent years there has been great concern over the amphibian declines and the discovery of widespread deformities in amphibians. If any of the amphibian species encountered during these surveys have deformities it should be recorded and a reference specimen collected. The occurrence of deformities should be reported to the Minnesota Pollution Control Agency.

Data Entry:

The amphibian database is comprised of six sheets within an EXCEL workbook. The beginning and end of each survey and climatic conditions are recorded on the "Environment" sheet. Total organisms detected for each visit are recorded (by species) for each of the sampling techniques on a separate sheet (i.e., VES-Day, VES-Night, Larval, Chorusing). Survey results are summarized on a presence-absence sheet.

References:

Vogt, R. C. and R. L. Hine. 1982. Evaluation of techniques for assessment of amphibian and reptile populations in Wisconsin. *In* N. J. Scott Jr. (Ed.) Herpetological Communities. Wildl. Res. Rep. 13. United States Department of the Interior, Fish and Wildlife Service, Washington, D. C.

Fish

While fish communities in seasonal to semi-permanent wetlands are often depauperate, they can be important consumers in wetland food webs (Peterka, 1989). Based on results of a previous study (Galatowitsch et al., 1997), fish assemblages in wetlands will be effectively sampled by the methods already in place for sampling larval amphibians (minnow traps and aquatic activity traps).

Activity:	*Frequency:*
Obtain a species list of the fish (if any) that are present.	Two times every month (April through June).
Estimate the abundance of fish species (if any).	Two times every month (April through June).

Location of Sampling Stations:

Ten traps (5 aquatic activity traps, 5 minnow traps) placed every 20 meters in 30 to 90 cm of water.

Field Procedure for Fish Sampling:

Special equipment: 5 aquatic activity traps, including 10 bottles and tops, 5 minnow traps, large duffel bag (for carrying traps through the wetland during set-up and collection), site map with trap locations, fish key, plastic bags, and labels (for reference specimens, if applicable).

Note: This procedure is exactly the same as larval sampling for amphibians.

1. Set-up occurs around 1500 hrs and involves setting the aquatic activity and minnow traps in an alternating pattern throughout the wetland. Traps are to be placed every 20 meters in 30 to 90 cm of water.

   Minnow traps are clamped shut and submerged in the water and should not be placed at a depth of greater than one meter. Make sure a float is attached to the traps, so you can find them again later. Aquatic activity traps are assembled by inserting inverted tops into cut-away plastic bottles and attaching the unit to PVC clamps mounted on stakes. The bottom bottle should be oriented vertically, the top one horizontally. The pointed end of the stake should be inserted into the substrate until the apparatus is firmly in place. The clamps on the traps are adjustable and can be moved up and down. Make sure the top of the pole is easily visible so you can find the trap later (flag it or paint it bright orange). IMPORTANT: You must leave some air bubbles in each of the bottles, otherwise the fish that are trapped will not be able to breathe.

2. Collect traps around 0900 hrs the following day. Count and identify the fish captured in minnow traps using the Key to Selected Minnesota Fish (Appendix B-1). Record the number caught of each species from each trap on the data sheet (Appendix A-8). As fish are counted and identified and data recorded, return the fish to the wetland. Next, count, record, and release the contents of the aquatic activity traps. Repeat this procedure until all traps have been emptied and all data has been recorded. (Remember, it is important to record the data from each trap separately.) Other organisms are likely to be found in the traps besides fish, including amphibians. Amphibians (larval and adult) should also be identified (Appendices C-1, C-2 & C-3), counted, and released. Aquatic activity traps occasionally tip over during heavy weather. These occurrences should be noted on the data sheet when recording trap contents.

3. If a reference specimen is on record for every species of fish that was collected during a sampling effort, then it is not necessary to take a reference specimen. However, if a new species is detected or the identity of a specimen is uncertain, a reference specimen must be taken. Reference specimens are taken by placing the fish in a plastic whirl-pac bag with some water. Add approximately one gram of MS-222 (an anesthetic). Wait several minutes and then add formalin (a fixitive) to the container until diluted to approximately 7 %. (Caution: Always wear protective gear when working with formalin and try to avoid any spillage.) Seal container tightly and prominently label with a permanent marker. The following information should be included: site name, date, trap type and number, and the name of collector. Later, further information can be added back in the lab. Store specimen in a safe place away from heat and direct sunlight.

Data Entry:

The fish database is maintained as a sheet within the amphibian database. The total number of fish caught is recorded by species for each site visit.

References:

Galatowitsch, S.M., J. Tester, D. Whited, and S. Moe. 1997. Assessing wetland quality with ecological indicators. CD-ROM.

Peterka, J. J. 1989. Fishes of northern prairie wetlands. *In* van der Valk, A. (Ed.). Northern Prairie Wetlands. Iowa State University Press. Ames, Iowa.

Birds

Breeding bird populations are monitored because they provide an indication that the plant community is adequately diverse and structurally complicated enough to support breeding birds. Bird communities on study wetlands are sampled using the point count method (Bibby et al., 1992).

Activities:	*Frequency of Sampling*:
Obtain a species list of the bird species present at the site.	Bird communities are sampled yearly on three separate occasions between May 8 and June 30.
Obtain an estimate of the abundance of each species.	Bird communities are sampled yearly on three separate occasions between May 8 and June 30.
Assess the birds breeding at each site.	Bird communities are sampled yearly on three separate occasions between May 8 and June 30.

Sampling Stations:

Basins in the East Metro Triplet have a single point, all other sites have three points per basin. Points are to be set-up along transects and should encompass a variety of potential habitat.

Field Procedure:

Special equipment: survey flagging, thermohygrometer, anemometer, stopwatch, binoculars, cassette player and secretive bird tape, bird field guide, nest and egg field guide

Note: Observers should be familiar with common wetland bird species and their calls before conducting these surveys. Those with hearing difficulties should not conduct this survey.

1. To survey birds at wetland study sites we will use the point count method. Wetlands will have three observation points (circles of radius of 25 m/diameter 50m). Boundaries of each point are to be designated by four prominent flags in the four compass directions, laid out in conjunction with a transect (i.e. a marked and numbered transect pole will designate the center of each bird point). Set-up occurs the night before the initial survey and involves establishing and marking observation

points that encompass a variety of potential habitat. These points will then be used for all surveys conducted in a given season and changed the following year. Exception: East Phalen, West Phalen, and Lake Elmo have only one observation point. At these sites, the observation point will be the entire wetland.

2. Bird censuses will start at dawn. Bird calls are easily obscured by wind and rain noise, so if it is raining heavily or the wind speed exceeds 20 mph, the census maybe delayed until 0900 hours. If at that time the weather is still unfavorable, delay the bird census until another site visit. When you arrive at the site in the morning to conduct the survey, first measure all environmental data (i.e., temperature, precipitation, wind speed) and record it.

2. Next, the observer(s) should stand at the center of the first observation point, noting the point on the data sheet, and immediately begin recording all bird species and their abundance within the 25 m radius of that point (Appendix A-10). Each point is sampled for a six-minute period. Any bird encountered, excluding high flyovers, within the radius is recorded. All species detected by sight or call should be recorded along with their abundance using standard ornithological abbreviations (Appendix D-1). Also, flight paths and information about the gender and reproductive status of the bird should be noted using the following codes and symbols: Arrows and rough diagrams to trace flight paths, triangles to represent males, squares to represent females and circles to represent birds of unknown gender. A triangle and square together represent a potentially breeding pair. Breeding confirmation is obtained by noting the breeding status of individual birds and by conducting nest searches within each point. Only record those species that are in the wetland itself or appear to be using it. Do not record species that are in other habitats (i.e. forest, grassland) adjacent to the wetland.

3. After the six-minute period, the tape with secretive bird species calls should be played from the tape recorder. The species calls on this tape are, in order: American bittern, least bittern, American coot, common moorhen, pied-billed grebe, sora (two different calls), Virginia rail (2 different calls), and yellow rail. Record any responses to the calls separately on the data sheet (Appendix A-11). Any birds of

questionable identity can be pursued after the survey period. Proceed to the next point and repeat the above procedure until all points have been surveyed. All birds seen or heard outside the sampling period should be recorded separately.

4. Nest searches should be performed at each site visit after the point counts have been completed. To detect active nests, each point (circle of 25 m radius) will be searched for 10 minutes. At the East Metro sites, the entire basin will be searched for 30 minutes. Nests found outside the searching period should be noted as such on the data sheet. Nests are considered active if there are eggs present and/or a brood is present.

5. Record the species and the number of eggs and/or chicks. Be careful not to disturb the nest or its occupants. See Baicich and Harrison, 1997, for help identifying nests and eggs. For identifying adults, we recommend Petersen's Field Guide to Eastern Birds (Petersen, 1980) or the National Geographic Field Guide to North American Birds.

Data Entry:

There are seven sheets for bird data within an EXCEL workbook that contains data for a single year. The "Environment" sheet includes information on beginning and ending times for each survey, as well as climatic data. A complete bird list for all sites with scientific name, common name and four-letter abbreviation (used on other sheets) is compiled in the "abbreviation" sheet. The results of the censuses are included in the remaining five sheets: surveys, breeding evidence, upland species, secretive species, and nest searches. The "survey" sheet is a tally of the total number of wetland birds (by species) detected at each site visit. Wetland birds detected by using tapes are also tallied on the "secretive bird" sheet. For each species detected at a visit, "evidence of breeding" is coded: 1= species present, 2= male singing, 3=male and female seen together, 4=nesting activity, and 5=young produced. The numbers of upland birds are entered on a separate sheet ("upland birds"). The numbers of nests found are compiled in the sheet "nest search".

References:

Baicich, P. J and C. J. O. Harrison. 1997. A guide to the nests, eggs, and nestlings of North American birds. 2nd ed. Academic Press, New York.

Bibby, C. J., N. D. Burgess, and D. A. Hill. 1992. Bird Census Techniques. Academic Press, New York.

Petersen, R.T. 1980. A field guide to the birds of North America, 4th ed. Houghton Mifflin Co., Boston Mass.

Scott, Shirley L., (Ed.). 1987. A field guide to the birds of North America, 2nd ed. National Geographic Society, Washington D.C.

Development of Community Metrics to Evaluate Recovery of Minnesota Wetlands

Susan M. Galatowitsch, Diane C. Whited,
John R. Tester
University of Minnesota, St. Paul, MN, 55108

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Contents

Abstract

Monitoring wetland recovery requires assessment tools that efficiently and reliably discern ecosystem changes in response to changes in land use. The biological indicator approach pioneered for rivers and streams that uses changes in species assemblages to interpret degradation levels may be a promising monitoring approach for wetlands. We explored how well metrics based on species assemblages related to land use patterns for eight kinds of wetlands in Minnesota. We evaluated land use on site and within 500 m, 1000 m, 2500 m and 5000 m of riverine, littoral, and depressional wetlands (n=116) in three ecoregions. Proportion of agriculture, urban, grassland, forest, and water were correlated with metrics developed from plant, bird, fish, invertebrate, and amphibian community data collected from field surveys. We found 79 metrics that relate to land use, including five that may be useful for many wetlands: proportion of wetland birds, wetland bird richness, proportion of insectivorous birds, importance of *Carex*, importance of invasive perennials. Since very few metrics were significant for even one-half of the wetland types surveyed, our data suggest that monitoring recovery in wetlands with community indicators will likely require different metrics, depending on type and ecoregion. In addition, wetlands within extensively degraded ecoregions may be most problematic for indicator development because biotic degradation is historic and severe.

Introduction

Over the past 25 years of restoration efforts, the failure of restored wetlands to resemble their natural counterparts have precipitated attempts to monitor their recovery (e.g., Zedler, 1993; Galatowitsch and van der Valk, 1996). Wetland recovery has been monitored for two purposes: to study the factors that limit recovery and to determine whether a restoration should be considered a success. The monitoring approaches used by scientists to study a few restored wetlands are generally too time-intensive to be feasibly applied by practitioners making restoration determinations. Protocols commonly used to assess natural wetlands in the US (i.e., WET) are inappropriate for monitoring restoration recovery because they estimate the probability that a wetland performs certain functions (Adamus et al., 1987). These functions include some socially valuable uses such as trapping sediment, floodflow attenuation or processing of excess nutrients, that may eventually impair ecosystem recovery (Galatowitsch et al., 1998). There is growing interest in monitoring wetland recovery by using approaches developed for stream assessment which focus on species assemblages.

Biological monitoring of rivers and lakes to enable water resource decision-making expanded from a historic focus on protection of human health to include a broader array of environmental concerns (Karr, 1991). Work in rivers and lakes suggests that changes in species assemblages (i.e., phytoplankton, invertebrates, fish) are more sensitive indicators of stress than measures of ecosystem function (e.g., nutrient cycling, productivity, decomposition) or chemical and physical composition (e.g., contaminant levels) (Schindler, 1987; Karr, 1991). Karr (1981) devised an approach to use changes in species assemblage to interpret the degree of river and stream degradation. Karr's Index of Biotic Integrity (IBI) relies on multiple community attributes with known relationships to environmental degradation. The IBI approach to biological monitoring has been widely applied to rivers and streams throughout the United States (Davis, 1995). IBIs for fish, invertebrates, and periphyton have been modified for use in different regions, and others have been commonly used across regions (Davis, 1995). Whether the IBI approach will be an effective way to monitor wetland stress and/or recovery is currently being tested in several regions of the U.S., including the Pacific Northwest (Karr, personal communication), Pennsylvania (Croonquist and Brooks, 1991) and Minnesota (this study).

Wetlands differ, however, from lakes and rivers in several important ways that may influence the effectiveness of the IBI approach for monitoring them. First, many animals that occur in wetlands rely on the surrounding upland for some of their life cycle (e.g., hylid frogs hibernate in upland forests). So, changes in species composition may reflect either changes in the wetland, some portion of the surrounding upland, or both (e.g., Findlay and Houlahan, 1997). Habitat isolation, matrix conditions in the landscape, and barriers to movement are important determinants of animal population status and consequently community composition in fragmented habitats (Merriam et al.,1989; Verboom et al., 1991; Fahrig and Merriam, 1994; Bolger et al., 1997). In addition, the portion of the surrounding upland that potentially affects some wetland animal communities (e.g., birds, amphibians) is not necessarily the catchment, but an unknown area. Second, wetlands are dominated by clonal perennial plants rather than algae. The lag time between environmental change and plant response is much greater for clonal perennial vegetation than for algae. This inertia by plant communities will, in turn, likely affect some animal communities. Third, the hydrodynamics of wetlands in some regions have strong annual variation in addition to seasonal variation. For example, wetlands in the North American mid-continent exhibit wet-dry cycles over 5-15 years that result in major shifts in species assemblages (Kantrud et al., 1989). These climatically driven shifts may confound the interpretation of changes due to anthropogenic stress. Finally, because wetlands occupy many different hydrogeomorphic settings, the way in which land use affects species assemblages may vary among different kinds of wetlands (Brinson, 1993). For example, the degree of wetland isolation due to agricultural drainage likely has a direct effect on bird communities of upland depressional wetlands but not those of riparian wetlands.

In order to assess the potential of the IBI approach for wetland assessment, we undertook a study to explore the effectiveness of plant and animal metrics to explain land use differences among eight kinds of wetlands (i.e., series) in Minnesota. The Wetland Conservation Act (1991) of Minnesota requires that the recovery of restored wetlands be monitored in part to ensure that they contribute to sustaining biodiversity in the landscape. Full implementation of wetland conservation policy is not possible until adequate monitoring strategies are developed. Three ecoregion provinces (Prairie Parkland, Laurentian Mixed Forest, Eastern Broadleaf Forest) occur in Minnesota, corresponding to historic differences in landform, climate, and vegetation and to current differences in extent of wetland drainage and land use (MN DNR, 1996). We sampled plants, birds, amphibians, fish and invertebrates in floodplain and littoral wetlands of the Laurentian Mixed Forest ecoregion, glacial depression, floodplain, and littoral wetlands in the Eastern Broadleaf Forest ecoregion, and floodplain, glacial depression, and upland flat wetlands of the Prairie Parkland ecoregion. The objectives of our study were to: (1) evaluate which organismal groups are suitable for development of community metrics, (2) determine the extent to which metrics are scale-sensitive, (3) identify metrics that may be suitable across different kinds of wetlands and different ecoregions, and to (4) identify limitations to use of the community indicator approach for monitoring recovery in Minnesota wetlands.

Methods

Study Sites

For each of the eight series of wetlands considered in this study (Figure 2.1, Table 2.1), from 13 to15 wetlands were chosen to represent a land use gradient from least impacted to most impacted, based on preliminary assessments of land use and accessibility. The pool of sites that could be used was limited by land ownership and uncertain land use history. Therefore, randomly selecting study sites was not feasible. Three hundred forty-four potential sites were identified in June 1995 from an extensive mail survey to natural resource professionals followed by telephone inquiries. A preliminary field analysis of land use impacts of all potential sites conducted in July and August 1995 was used to select 116 wetlands with a range of land use impacts (Table 2.1). Those sites considered most impacted had both on-site degradation (e.g., draining, cultivation) and landscape alteration (high percentage of surrounding urban or agricultural land); least disturbed wetlands had minimal site and landscape alteration. Galatowitsch et al. (1997) provides detailed descriptions of each site, including land use.

Biological Surveys

The vegetation of each site was characterized within one or two large plots (100 m^2-400 m^2) during August-Sepember 1995 and May-June 1996 (Table 2.2). The size, configuration, and number of plots for each wetland series depended on the number of distinctive habitats typically present and whether the vegetation was woody or herbaceous (Mueller-Dumbois and Ellenberg, 1974). One of seven cover/abundance codes was noted for each species: r) one individual - insignificant cover, +) few individuals - insignificant cover, 1) scattered individuals - 1-5% cover, 2) 5-25%, 3) 25-50%, 4) 50-75%, 5) 75-100%. Nomenclature follows Gleason and Cronquist (1991). A set of voucher specimens (with at least one collection per species per series) has been deposited at the University of Minnesota Herbarium, St. Paul, MN.

Animals were surveyed twice from mid-May to mid-July 1996. Breeding birds were surveyed from points or along transects, depending on whether the typical form of wetlands within a series were linear or not (Table 2.2). Observers recorded all birds seen or heard and any evidence of breeding. Tapes also were played (total of three minutes) to elicit responses from secretive species (e.g., pied-billed grebe (*Podilymbus podiceps* (L.), sora (*Porzana carolina* (L.), common moorhen (*Gallinula chloropus* (L.)) (Delphey and Dinsmore, 1993). Low fly-overs (height less than 25 meters) were counted in the survey,

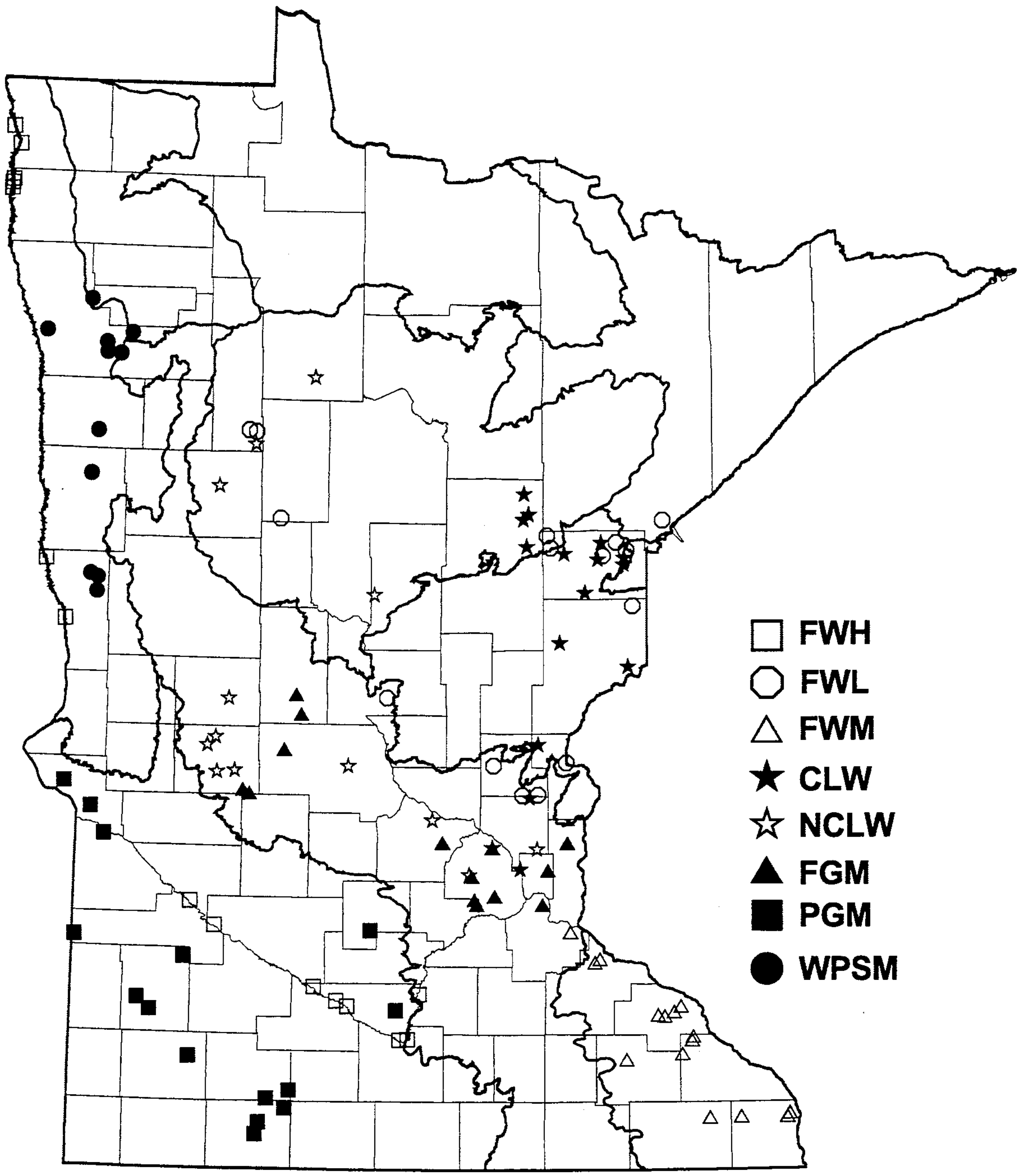

Figure 2.1. Study sites are shown along with ecoregion province boundaries (MN DNR, 1996). See Table 2.1 for ecosystem abbreviations.

Table 2.1. Description of each wetland series. Individual sites and ecoregion boundaries shown in Figure 2.1.

Series	Abbreviation	Description	No. of Sites	Primary Land Use Impacts
Non Calcareous Littoral Wetlands	NCLW	Wetlands associated with non-calcareous lakes (<500uS/sec) between 20 and 200 ha occurring within the Mille Lacs Uplands, Tamarack Lowlands, or Anoka Sandplain ecoregion subsections.	15	Shoreline homesite development, watershed urbanization
Calcareous Littoral Wetlands	CLW	Wetlands associated with calcareous lakes (>500uS/sec) beteen 20 and 200 ha occurring within the Laurentian Mixed Forest or Eastern Broadleaf forest ecological provinces.	14	Agricultural and urban use in watersheds
Wet Prairies and Sedge Meadows	WPSM	Wetlands in upland depressions or on flats that are (or historically were) seasonally flooded, occurring within the Red River Valley ecoregion section	15	Agricultural drainage, grazing by domestic stock, agricultural use in watershed
Forest Glacial Marshes	FGM	Wetlands in upland depressions on glacial till with a semipermanent flooding regime, between 0.4 and 8 ha, not partially or fully drained with ditches and tile, occurring within the Northern Hardwoods ecoregion.	14	Stormwater runoff, road encroachment, watershed urbanization
Prairie Glacial Marshes	PGM	Wetlands in upland depressions on glacial till with a semipermanent flooding regime, between 0.4 and 8 ha, not partially or fully drained with ditches and tile, occurring within the North Central Glaciated Plains ecoregion section.	15	Agricultural drainage, agricultural use in watershed
Floodplain Wetlands of High-Order Rivers	FWH	Floodplains associated with the Minnesota or Red Rivers, within the North Central Glaciated Plains or Red River Valley.	15	Levee construction and rip-rapping, logging, agricultural and urban use in watersheds
Floodplain Wetlands of Mid-Order Rivers	FWM	Floodplains of major tributary rivers of the Mississippi River, with wetland habitat extending for more than 0.5 mi.	13	Channel diversions, straightening, ditching, filling, logging, agricultural and urban use in watersheds
Floodplain Wetlands of Low-Order Streams	FWL	Floodplains associated with first to third order streams, within the Laurentian Mixed Forest ecological province, having a continuous riparian wetland area greater than 0.5 mi.	15	Channelization, ditching, flow constrictions (bridges, culverts), agricultural use in watershed

but recorded separately from other occurrences, whereas high fly-overs were not. Surveys were conducted between dawn and 9:00 AM. Bird surveys were not done when raining or when wind speeds exceeded 13-km hr $^{-1}$. Taxonomy follows Sibley and Monroe (1990).

Aquatic animals (fish, invertebrates, and amphibians) were sampled during each site visit (Table 2.2). Minnow traps, horizontal activity traps, leech traps, and vertical activity traps (16 hr, set overnight) were used for most surveys, except when standing water was minimal. In those cases, timed dip net samples were used instead of trap sets. All samples were preserved in the field. Samples were decanted through a 1 mm sieve; all organisms not passing through the sieve were collected and covered with 10% formalin. On several occasions, collected organisms exceeded a 1 liter volume. In these instances, one quarter of the sample was selected randomly using a divided tray. Subsampling was accounted for in abundance measures.

Fish collected were identified to species (Hatch, 1996) and counted. J. Hatch (University of Minnesota) identified difficult taxa. Fish taxonomy follows Eddy and Underhill (1974). Invertebrates from leach traps, vertical activity traps, and dip nets were identified and counted. Insects and leeches were identified to family; snails were identified to species (Burch, 1982; Klemm, 1972; Merritt and Cummins, 1996). Only data from the second sampling visit were used for invertebrate analysis. All amphibians were identified (Lehtinen, 1996) and counted. Fish and amphibian collections have been deposited at the Bell Museum of Natural History (UM, Minneapolis).

Land Use Characterization

Land use/land cover data were collected in the field to document characteristics of the site. Pertinent features were mapped such as type, number, size, and impacts associated with roads, bridges, buildings, culverts, drain tile, ditches, feedlots, disturbed areas, etc. Each site was assigned a site alteration score from one to five (1=least impacted).

Land use cover in the surrounding landscape was characterized using a geographic information system (GIS) land use/land cover database developed in Arc/INFO 7.12 (ESRI, 1996) at a 100 meter resolution to characterize landscape condition. Existing digital land use data were obtained from the State of Minnesota Land Management Information Center (late 1980's) and the Twin Cities Metropolitan Council (1991). Land use was classified into 18 categories including: urban (industrial/urban, rural residential complex, rural residential other, and farmsteads), forest (deciduous, coniferous, and mixed), grassland (grassland, grassland-forest), agriculture (cultivated, and tree farms and nurseries), water bodies, wetlands, gravel pits and open mines, bare rock, exposed soil and sand, and other. The Twin

Table 2.2. Summary of data collected.

	Plants	Birds	Fish, Amphibians, Invertebrates
NCLW	Species composition and cover estimated in spring and fall from a10 m x 10 m releve located along shoreline at 25 cm mininum water depth (late summer).	600 m transects on edge of open water and emergent zone. Observations lasted 50 min. total. Surveys conducted twice during breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 vertical activity traps. Ten groups of traps were set at 60 m intervals in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
CLW	Species composition and cover estimated in spring and fall from a 10 m x 10 m releve located along shoreline at 25 cm mininum water depth (late summer).	600 m transects on edge of open water and emergent zone. Observations lasted 50 min. total. Surveys conducted twice during breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 vertical activity traps. Ten groups of traps were set at 60 m intervals in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
WPSM	Species composition and cover estimated in spring and fall from a 10 m x 10 m releve located in a saturated area (mid summer).	4 to 5-50 m radius points (10 min. each) placed equidistant around wetland. Surveys conducted twice during breeding season at dawn.	10 timed dip-net sweeps were used for aquatic sampling when water was present on the site.
FGM	Species composition and cover estimated in spring and fall from a 10 m x 10 m releve located along shoreline at 25 cm mininum water depth (late summer).	4 to 5-25 m radius points (10 min.each) placed equidistant around wetland. Surveys conducted twice during breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 vertical activity traps. Ten groups of traps were set at equal distance arround wetland in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
PGM	Species composition and cover estimated in spring and fall from two 10 m x 10 m releves, one located in the emergent zone at mean water depth of 25 cm (late summer) and one in saturated wet meadow zone. Species composition and cover estimated in spring and fall.	4 to 5-25 m radius points (10 min. each) placed equidistant around wetland. Surveys conducted twice during breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 timed dip-net sweeps. Ten groups of traps were set at equal distance arround wetland in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
FWH	Speciés composition and cover estimated in spring in fall from one 20 m x 20 m releve located on the level floodplain and another 10 m x 20 m plot positioned lengthwise on the riverbank.	600 m x 200 m transect centered on the stream corridor. Observations lasted 50 min. total. Surveys conducted twice during the breeding season at dawn.	5 minnow traps, 5 leech traps, 10 timed dip-net sweeps and 5-10 horizontal activity traps (depending on water availability). Ten groups of traps were set at equal distance arround wetland in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
FWM	Species composition and cover estimated in spring and fall from one 20 m x 20 m releve located on the level floodplain and another 10 m x 20 m plot located lengthwise on the riverbank.	600 m x 200 m transect centered on the stream corridor. Observations lasted 50 min. total. Surveys conducted twice during the breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 timed dip-net sweeps. Ten groups of traps were set at equal distance arround wetland in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.
FWL	Species composition and cover estimated in spring and fall from one 10 m x 10 m releve located in the shrub zone and another plot (10 m x 10 m) located in the wet meadow adjacent to the stream.	600 m x 200 m transect centered on the stream corridor. Observations lasted 50 min. total. Surveys conducted twice during the breeding season at dawn.	5 minnow traps, 10 horizontal activity traps, 5 leech traps, and 10 timed dip-net sweeps. Ten groups of traps were set at equal distance arround wetland in 30 cm of water overnight for 16 hours. Traps set twice, during breeding bird surveys.

Cities Metropolitan Council data were updated with 1994 color infrared aerial photography (1:15840) to delineate new urban development and to distinguish differences in forest and grassland cover type. Changes were identified on plots and digitized into the GIS database. National Wetland Inventory (USFWS 1981-1994, 1:24,000) data were unioned with the land use data to improve the accuracy of wetland classification within the land use database. A statewide Conservation Reserve Program (CRP) coverage was obtained from the Minnesota Department of Agriculture to define newly established grassland areas that were previously cultivated. Additional infrastructure data (roads, railroads, utility lines, etc.) were obtained from the Minnesota Department of Transportation and managed as separate coverages.

Landscape pattern for each wetland was described by the following variables developed from the GIS database: proportion of land as urban, agriculture, forest, grassland, or water (includes wetlands). These proportions were examined at different radii surrounding the site: 500 m (79 ha), 1000 m (314 ha), 2500 m (1963 ha), and 5000 m (7854 ha) (Figure 2.2). The 5000 m radius was excluded from analysis of forest glacial marshes because urban coverages required extensive updating, exceeding available resources. Circles were used rather than catchments because some of the biotic groups (i.e., plants, birds, amphibians) are not strictly aquatic organisms and their distributions are likely affected by land use surrounding a site. In addition, three of the series under study are in upland depressions in glacial terrain where watersheds are difficult or impossible to define (Omernik and Bailey, 1997), and many wetlands of the large river floodplain series have nearly identical lands included in their catchments.

Analysis

Biota-land use relationships were considered for taxonomic groups (i.e., genera and families) and guilds. Plant species were grouped into guilds based on growth habit (i.e., woody vs. herbaceous), life span (annual vs. perennial), origin (native or introduced) following Galatowitsch and McAdams (1994) and Galatowitsch and van der Valk (1994). Birds were grouped into guilds based on wetland dependency (Croonquist and Brooks, 1991), trophic level, feeding substrate and feeding technique (DeGraaf et al., 1985), nesting behavior, and wintering location (Thompson et al., 1992). Fish guilds were based on trophic level (Plafkin et al., 1989; Scott and Crossman, 1973; Becker, 1983) and origin (Plafkin et al.,1989). Based on preliminary analysis, invertebrate or amphibian guilds were not used. Databases for all species observed with their taxonomic and guild assignments are found in Galatowitsch et al. (1997).

To identify patterns in biological communities that may relate to land use differences, each organismal data set (i.e., five for each series) was explored with TWINSPAN output tables (Hill, 1979).

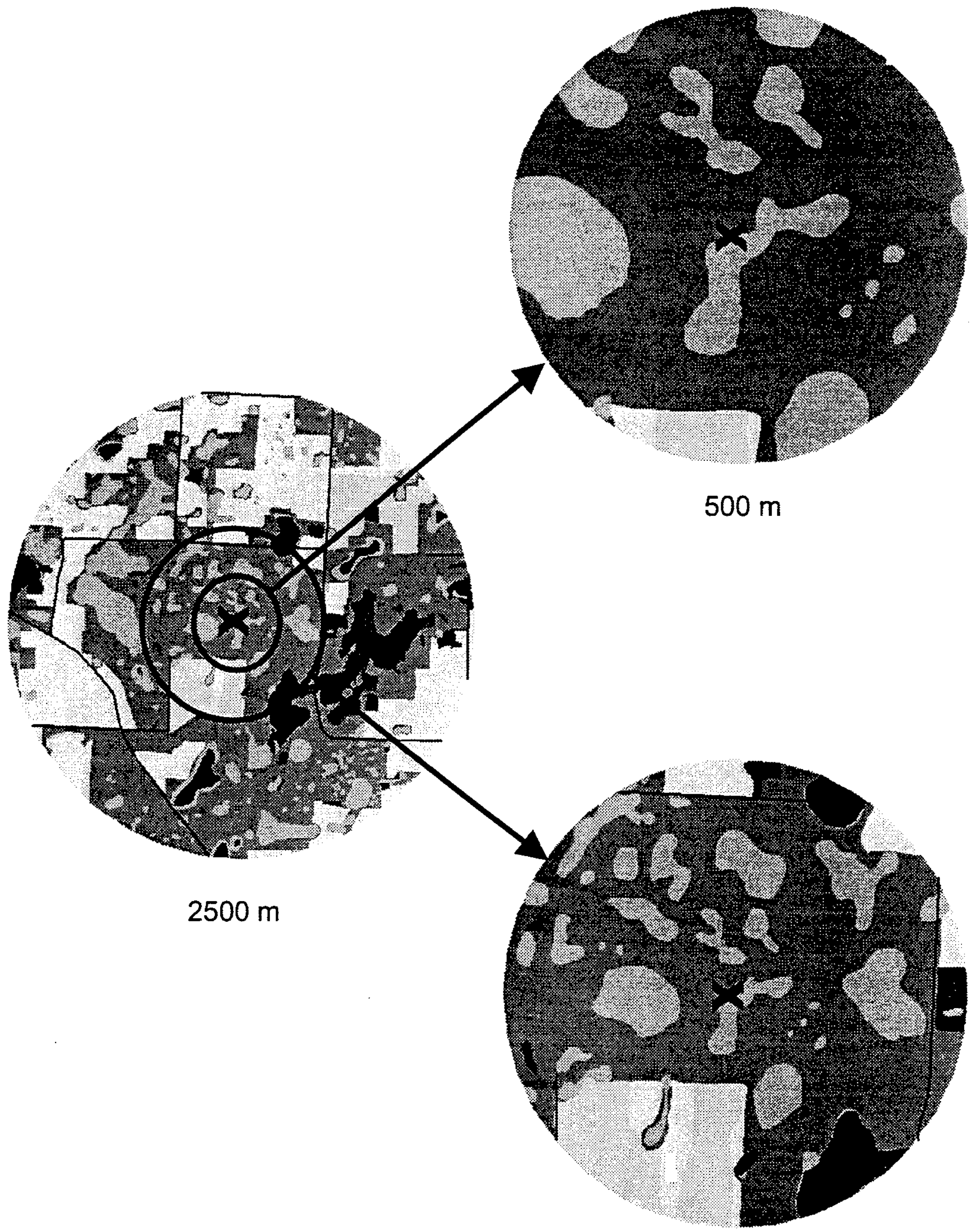

Figure 2.2. An example of three of the four scales used in the landscape analysis. Land use analysis area were delineated as circles with radii of 500, 1000, 2500, and 5000 m (not shown), centered on study sites.

These tables are organized so that the most similar sites (as described by the abundance their species) are grouped together as columns on a table; and so the species with similar habitat affinities (as described by sites where they occur) are grouped together as rows. The TWINSPAN tables were used to generate a list of potential indicators for analysis with land use data. Taxonomic groups or guilds (or occasionally individual taxa) that appeared more frequently at sites with similar land use characteristics in any series were deemed to be potential indicators. Animal abundances were considered as absolute numbers and relative proportions. Plant abundances were considered as cover, relative cover, or importance values. Importance values, an approximate measure of abundance, was calculated by summing cover class scores (r=0.1 and + =0.5). Other potential indicators, such as species richness, also were considered (Table 2.3).

Values for each potential indicator were calculated for each site in the series. Potential indicator values were correlated with site alteration score and land use cover in the watershed. Six correlations were calculated, one for each land cover category (agriculture, urban, disturbed, forest, water/wetland and grassland). A total of 11,856 relationships were tested. Relationships with Pearson correlation coefficients greater than 0.53 ($p<0.1$) are considered worthy of further considerations as indicators of wetland quality. Each of these relationships was plotted to identify high coefficients based on outliers. Those with outliers were not considered significant.

Results

A total of 572 plant, 171 bird, 103 invertebrate, 44 fish, and 10 amphibian taxa were observed in the 116 wetlands sampled in the study. Based on pattern detection from TWINSPAN tables, 106 potential indicators were identified: 45 plant, 28 bird, 16 invertebrate, 13 fish, and 4 amphibian metrics. A total of 79 of these metrics were significantly correlated to land use: 32 plant, 23 bird, 14 invertebrate, 8 fish, and 2 amphibian metrics. Calcareous littoral wetlands had the greatest number of significant community metrics (33), followed by high-order river floodplains (30). Low-order river floodplains had 25 metrics, forest glacial marshes had 23 metrics, and mid-order river floodplains had 22 metrics. The fewest metrics were identified from wet prairies and sedge meadows (18), non-calcareous littoral wetlands (15) and prairie glacial marshes (8).

Plants

Of the 32 plant metrics, none correlated to land use in more than half of the series; 25 correlated to land use in one or two series (Table 2.4). Importance of *Carex* (CAI), *Carex* richness (CAR), importance of

Table 2.3. Potential indicators identified from plant and animal community data. Proportional indicators for animals are calculated as a total of all organisms observed (not a proportion of taxa) unless noted. Absolute abundances for plant species cannot be reliably estimated from cover class data. Importance values, an approximate measure of abundance, was calculated by summing cover class scores (r=0.1 and + =0.5).

Abbreviation	Definition	Abbreviation	Definition	Abbreviation	Definition
Birds		***Invertebrates***		***Plants***	
ABHC	Abundance of brown-headed cowbirds	CORI	Abundance of Corixidae	ACI	Importance of Asteraceae
ANR	Number of dabbling duck species	CRR	Number of crustacean taxa	AST	Importance of Aster
ASSP	Abundance of sedge wrens, marsh wrens, swamp sparrows	DYTI	Abundance of Dytiscidae	CACC	Importance of Carex and Calamagrostis
AYW	Abundance of yellow warblers	GASR	Number of snail species	CAI	Importance of Carex
BABU	Total abundance of all birds	HIRR	Number of leech taxa	CAR	Carex richness
BFR	Number of forest-nesting species	IABU	Total invertebrate abundance	GPNI	Importance of native perennial graminoids
BITR	Number of bitterns and rails	INSR	Number of insect taxa	GPNR	Number of native perennial graminoids
BLTR	Number of species with large territories	ISR	Invertebrate taxa richness	HPNI	Importance of native herbaceous perennials
BOGR	Number of open ground nesting birds	PCR	Proportion of crustaceans	HPNR	Number of native herbaceous perennials
BSR	Bird species richness	PDIP	Proportion of Dipterans	INI	Importance of introduced species
BWR	Number of wetland species	PEPH	Proportion of Ephemeroptera	INR	Number of introduced species
CIS	Abundance of marsh and sedge wrens	PET	Proportion of Ephemeroptera and Trichoptera	IPI	Importance of invasive perennials
HALE	Presence of bald eagles	PGAS	Proportion of snails	PFGR	Proportion of graminoid species
PAN	Proportion of dabbling ducks	PHIR	Proportion of leeches	PGPNR	Proportion of native perennial graminoid species
PBHC	Proportion of brown-headed cowbirds	PINS	Proportion of insects	PGR	Proportion of graminoid species
PBIN	Proportion of insectivorous birds	POA	Proportion of Oligochaetes and Annelids	PHCC	Ratio of importance of Phalaris to Carex and Calamagrostis
PBOG	Proportion of open ground nesting birds			PIR	Proportion of richness as introduced species
PBPI	Proportion of piscivorous birds	***Fish***		POI	Importance of Polygonum
PCIS	Proportion of wrens	CENR	Number of sunfish	POTI	Importance of Potamogeton species
PFB	Proportion of forest-nesting birds	CYPR	Number of cyprinid species	POTR	Number of Potamogeton species
PFBR	Proportion of forest-nesting species	FABU	Total abundance of all fish	PWOR	Number of tree species
PPIC	Proportion of woodpeckers	FSR	Fish species richness	SAI	Importance of submersed macrophytes
PTYR	Proportion of flycatchers	PCAT	Proportion of Catostomidae	SAI	Salix importance
PWB	Proportion of wetland birds	PCEN	Proportion of sunfish	SAR	Number of submersed macrophyte species
PYW	Proportion of yellow warblers	PCYP	Proportion of Cyprinids	SSAR	Salix richness
RWB	Abundance of red-winged blackbirds	PERC	Abundance of Perca flavescens	SEI	Importance of spring ephemerals
SSYT	Abundance of yellowthroats,swamp sparrows, LeConte's sparrows	PFIN	Proportion of insectivorous fish	SER	Number of spring ephemerals
YHB	Abundance of yellow headed blackbirds	PFPI	Proportion of piscivores	TYPI	Importance of Typha species
		PFOM	Proportion of omnivores	TYEM	Ratio of importance of Typha to all
Amphibians		PFPI	Proportion of piscivorous fish	ULI	Importance of Ulmus
AABU	Total abundance	UMLI	Abundance of Umbra limi	VAP	Ratio of annuals to perennials
AHYL	Abundance of Hylids			VAR	Number of annual species
ASRI	Amphibian species richness			VCYI	Importance of Cyperaceae
RAPI	Abundance of Rana pipiens			VCYR	Number of Cyperaceae species
				VGH	Ratio of graminoids to herbaceous perennials
				VGR	Number of graminoid species
				VHR	Number of herbaceous species
				VIR	Number of introduced species
				VPA	Proportion of annual species
				VPI	Proportion of introduced species
				VSR	Plant species richness
				WDR	Number of tree species with >5% cover
				WDR	Number of trees species with cover
				WOI	Importance of woody species
				WOR	Number of woody species

Table 2.4. Correlations (p<0.1) between land use and plant metrics are shown for site impacts and proportions of land use at four radii (m) surrounding sites. Upper case letters indicate a positive relationship, lower case letters indicate an inverse relationship. A=Agriculture, G=Grassland, F=Fortest, U=Urban, W=Wetland, S=Site Index.

	NCLW					CLW					WPSM				
	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500	5000
CAI								g			s				
IPI			U	gA	fAU		fU	f		AfGw					
GPNR	s	G	G											G	
INR											S				
GNPI	s	G													
VSR															
PIR															
ACI															
CAR	s	G	G								s				
ULI															
VAR															
PGR															
POI															
SAI															
TYEM															
VGH												G			gW
VGR															
WOI															
WOR															
SAR								g	u	ag					
TYPI								f	a		S				
VCYI							F		u	u					
VHR															
WDR															
HPNR		G													
SSAR															
VAP	S														
VHNPI															
CACC															
INI											S				
POTI								W							
POTR							W								

	FGM				PGM				
	Site	500	1000	2500	Site	500	1000	2500	5000
CAI	s	F	F	F					
IPI									
GPNR									
INR									
GNPI									
VSR									
PIR									
ACI									
CAR	s	F	F						
ULI									
VAR									
PGR									
POI									
SAI									
TYEM						G^2	G^2	G^2	G^2
VGH									
VGR									
WOI									
WOR									
SAR									
TYPI									
VCYI									
VHR									
WDR									
HPNR									
SSAR									
VAP			W		S^2				
VHNPI									
CACC				F					
INI									
POTI									
POTR									

	FWH					FWM					FWL				
	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500	5000
CAI		U^2	aFG^2	aFG^2	aFG^2						s^2	G^2	G^2		
IPI							aF^2		FU^2	$a GU^2$	S^2				
GPNR							U^1	U^1	f^1	fU^1		U^1			w^1
INR		aU^2	aU^2	a^2	aG2			g^2				A^2	Af^2		
GNPI							u^2	u^2	Fu^2	Fu^2			G^2		U^1
VSR		a^2	aG^2	aG^2	aFG^2				a^2	u^2			G^2		
PIR		U^2	a^2	U^2	aFG^2 f^1				w^2						G^2
ACI	s^1	U^2	W^2	FW^2	FW^2										
CAR													Af^2		
ULI	s^2	F^2 w^1	F^2	FG^2	FG^2										
VAR		a^2 W^1	aG^2	aG^2	aG^2							A^2			
PGR		aUW^2	aGU^2	aU^2	aU^2										
POI		W^1	W^1	FW^1	W^1										
SAI											S^1		A^1		g^1
TYEM															
VGH	S^1														
VGR		aW^1	aW^1	a^1	aG^2										
WOI											S^1	W^1		U^1	f^1
WOR	s^2		u^2	FG^2											
SAR															
TYPI															
VCYI															
VHR		a^2		G^2	G^2										
WDR			F^2	FG^2											
HPNR									u^2						
SSAR											S^1				
VAP															
VHNPI									G^1						
CACC															
INI															
POTI															
POTR															

PGM: 1=meadow, 2=emergent
FWH: 1=floodplain, 2=streambank
FWM: 1=floodplain, 2=streambank
FWL: 1=shrub, 2=meadow

invasive perennials (IPI), and number of introduced species (INR) each had significant land use relationships in four of the eight series. Three metrics have significant land relationships in three series: importance of native perennial graminoids (GPNI), species richness (VSR), and the ratio of annuals to perennials (VAP).

The greatest number of plant metrics was detected for the high-order river floodplain series (15). Most are negatively correlated to the proportion of agriculture in the surrounding landscape (at multiple scales): Importance of *Carex* (CAI), number of introduced species (INR), species richness (VSR), proportion of introduced species (PIR), number of annual species (VAR), proportion of graminoid species (PGR), number of graminoid species (VGR). Generally, these metrics are also positively related to either proportion grassland or forest, and less frequently, urban land. Some of these same metrics have a different relationship to land use in the low-order river floodplain series, which has the second greatest number of plant metrics (12). Number of introduced species (INR) and number of annual species were higher with more agricultural use, as were *Carex* richness (CAR) and *Salix* importance (SAI). Greater proportion of grassland corresponded to higher importance of *Carex* (CAI), importance of native perennial graminoids (GPNR), species richness, and proportion of introduced species. Importance of introduced species (INI), importance of *Salix* (SAI), importance of woody species (WOI), and *Salix* richness (SSAR) was higher with greater disturbance, while importance of *Carex* was less. Urban uses were most consistently related to plant metrics for the mid-order river floodplains (8 total). Number of native perennial graminoids, importance of native perennial graminoids (GPNI), species richness, and number of native herbaceous perennials (HPNR) were less with greater urban use, while importance of invasive perennials (IPI) was greater. These relationships were often specific to certain scales.

For calcareous littoral wetlands (7 metrics), importance of *Carex* (CAI), importance of Cyperaceae (VCYI), submersed aquatic richness (SAR), and importance of *Typha* (TYPI) were lower with more agriculture, grassland, or urban use, while the importance of invasive species (IPI) was higher. Likewise, increased importance of invasive species corresponded to increased urban land and agriculture in the non-calcareous littoral wetland series (6 metrics). This metric was negatively related to grassland proportion. Proportion of grassland was positively related to number of native perennial graminoids (GPNR), importance of native perennial graminoids perennials (GPNI), *Carex* richness (CAR), and number of native herbaceous perennials (HPNR).

Site disturbances are related to five of the seven plant metrics for the wet prairie-sedge meadow series. Greater site disturbance corresponded to higher importance of introduced species (INI), importance of *Typha* (TYPI), and invasive species richness (INR) and decreased importance of *Carex* (CAI) and *Carex* richness (CAR). Three of four plant metrics for the forest glacial marsh series correspond to a greater proportion of forest: *Carex* importance and richness and importance of *Carex* and

Calamagrostis (CACC). For prairie glacial marshes, one metric, the ratio of *Typha* to all emergents (TYEM), was higher with grassland proportion, and another, ratio of annuals to perennials (VAP), was higher with more site disturbance.

Birds

Four bird metrics corresponded to land use in more than half of the eight series: proportion of wetland birds (PWB) (7), proportion of insectivorous birds (PBIN) (6), total abundance (BABU) (5), number of species with large territories (BLTR) (5) (Table 2.5). Three other metrics were significant for four series: species richness (BSR), number of wetland species (BWR), proportion of forest-nesting species (PFBR), and another, proportion of forest-nesting birds (PFB), was significant for three series. The remaining 15 bird metrics corresponded to land use in one or two series. Compared to plants, relatively few metrics were related to site disturbances in the surrounding area.

Each of the floodplain wetland series had six bird metrics. For the high-order river floodplain series, four metrics were positively related to agriculture and/or negatively related to grassland: proportion of insectivorous birds (PIN), proportion of forest-nesting species (PFBR), proportion of yellow warblers (PYW), and abundance of yellow warblers (AYW). For low-order river floodplains, a greater proportion of agriculture corresponded to higher bird abundance (BABU) and number of species with large territories (BLTR) and a lower proportion of insectivorous birds (PBIN), proportion of forest-nesting species (PFBR), and abundance of sedge wrens, marsh wrens, and swamp sparrows (ASSP). Four of the metrics for the mid-order river floodplain wetlands were related to proportion of forest. Greater forest proportion corresponded to a higher proportion of wetland birds (PWB), proportion of insectivorous birds (PBIN), proportion of forest-nesting species (PFBR), and lower species richness (BSR).

Ten of 12 bird metrics for calcareous littoral wetlands were related to proportion of agriculture and/or grassland. Increased species richness (BSR), number of wetland birds (BWR), bird abundance (BABU), number of open ground nesting species (BOGR) (within 1000 m) and abundance of red winged blackbirds (RWB) was associated with increased proportion of grassland. Red-winged blackbird abundance was also positively correlated with agriculture, as were the number of open ground-nesting species. Proportion of water birds (PWB), number of forest-nesting species (PFBR), proportion of forest birds (PFB), and presence of bald eagles (HALE) decreased with increased proportion of agriculture.

Table 2.5. Correlations (p<0.1) between land use and animal metrics are shown for site impacts and proportions of land use at four radii (m) surrounding sites. Upper case letters indicate a positive relationship, lower case letters indicate an inverse relationship. A=Agriculture, G=Grassland, F=Fortest,U=Urban, W=Wetland, S=Site Impact Index.

	NCLW					CLW					WPSM					FGM			
	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500
Birds																			
PWB			w	w	w					a		F		u					G
PBIN		Au		u								gu	g					u	
BSR								G	G	fG		uW		u			W	G	G
BWR								f	G	G		F	F	FuW	u				G
PFBR									a	a									
BABU								f	fG	fGU		u		u	u		W		G
BLTR									G			F			a		W	G	G
PFB		a	a	a					aU	aU									
SSYT						s	F	F	F	F									
BOGR							G	G	guA			F		u					
RWB							fAG	fAG	fAG	GF							fU		
HALE							gf	ag	ag	aF									
PPIC			F	aF	agF														
PYW																			
AYW																			
PBPI			G	G	G														
PTYR				F	a														
ABHC																			
ASSP																			
CIS																			
PAN																			
BFR										U									
BITR																			G
Fish																			
FSR										u							fW	G	G
FABU			G													S		a	a
PFPI																			
CYPR										F									
CENR									agF	aFG									
PCAT																			
PCEN							agF												
PCYP							W												
Invertebrates																			
ISR								f	f							S	A	w	f
PGAS							a							U		S	f	fU	fU
CRR							a												fW
PET			W	W			a												
GASR												F	W	W	a	S		U	G
IABU							A	fA		w			A						
PCR							A	w	w	w									U
PDIP				a	ag														
POA									U							s			
DYTI																			
HIRR							fG	f	Af	AfGw									
PHIR							fG	A		A									
INSR												F							A
PEPH																			
Amphibians																			
ASRI																			w
RAPI																		W	

	PGM					FWH					FWM					FWL				
	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500	5000	Site	500	1000	2500	5000
Birds																				
PWB	s	G	G	G				GW				G	GW	aG	aF					
PBIN							A	Ag	Agu	Agu		uwF	uF	Fw		s		a		
BSR												g	f	G	W					
BWR													W	W						
PFBR							Ag	Agu	Agu	Afu		F	F	F				a		
BABU															W		A			
BLTR					W														A	A
PFB											S									
SSYT					W															
BOGR																				
RWB																				
HALE																				
PPIC						s	f													
PYW							A	gA	fgA	fgwA										
AYW								gu		fg										
PBPI																				
PTYR																				
ABHC																	W			
ASSP																s		a		
CIS		G			W															
PAN			G																	
BFR																				
BITR																				
Fish																				
FSR											S	u		GU					a	a
FABU	S		g				W													
PFPI							A	A	F	Fa										
CYPR																			a	a
CENR																				
PCAT										aF										
PCEN																				
PCYP																				
Invertebrates																				
ISR							W	f	fUW	U			W		F					
PGAS							fu	Af										U	U	
CRR								W	W	W	s									
PET							aF	aF	aFU	aF							U			
GASR																				
IABU													W							
PCR												f								
PDIP													W				w	w		
POA												A								
DYTI							A	gA	gA	gA										
HIRR																				
PHIR																				
INSR																				
PEPH							W										fU			
Amphibians																				
ASRI												f								
RAPI																		F		

Six of eight bird metrics for forest glacial marshes were positively correlated with grassland: proportion of wetland birds (PWB), species richness (BSR), number of wetland birds (BWR), bird abundance (BABU), number of species with large territories (BLTR), and number of bitterns and rails (BITR). The proportion of insectivorous birds (PBIN) was less with more urban land while the abundance of red winged blackbirds (RWB) was greater. Likewise, three of five bird metrics for prairie glacial marshes were positively correlated to grassland: proportion of wetland birds, proportion of dabbling ducks (PAN), and abundance of marsh and sedge wrens (ASSP). This last metric, as well as number of species with large territories and abundance of yellowthroats, swamp sparrows, and LeConte's sparrows (SSYT) were higher with greater proportion of wetlands at 5000 m. Urban use was significantly related to six of seven bird metrics for the wet prairie-sedge meadow series. More urban land corresponded to a lower proportion of insectivorous birds, species richness, number of wetland birds, proportion of wetland birds, bird abundance, and number of open ground nesting birds. These last three metrics, as well as number of species with large territories, were higher when the proportion of forest was greater.

Invertebrates

Only the proportion of gastropods (PGAS) was a significant metric for more than half the series (5 of 8); three others, taxa richness (ISR), number of crustacean species (CRR), and proportion of ephemeropterans and trichopterans (PET), were significant for four of the series (Table 2.1). Three others, invertebrate abundance (IABU), proportion of crustacean species (PCR), and proportion of dipterans (PDIP) were significant in three series. Compared to other organismal groups, relatively few (6) were only significant in one or two series.

Higher taxa richness (ISR), crustacean richness (CRR), and proportion of ephemeropterans (PEPH) corresponded to a greater proportion of wetlands in the surrounding area in high-order river floodplains. Fewer invertebrate taxa, lower proportion of gastropods (PGAS), and greater proportion of ephemeropterans were associated with more forest. Agriculture was positively correlated with proportion of gastropods, abundance of dytiscids (DYTI), and negatively correlated with proportion of ephemeropterans. Three of six invertebrate metrics were positively correlated with proportion of wetland: invertebrate taxa richness, invertebrate abundance (IABU), proportion of dipterans (PDIP). Most significant correlations for this series only occurred at one scale. Proportion urban land was related to three of four invertebrate metrics for low-order river floodplains. A higher proportion of gastropods, ephemeropterans, and ephemeropterans and trichopterans (PET) corresponded to more urban land.

Nine invertebrate metrics were significantly related to land use for calcareous littoral wetlands whereas only two were found for non-calcareous littoral wetlands. Seven of the nine were related to agriculture. A lower proportion of gastropods, fewer crustacean species (CRR), lower proportion of ephemeropterans (PEPH), greater invertebrate abundance (IABU), higher proportion of crustacean species (PCR), a greater number of leech taxa (HIRR), and a higher proportion of leeches (PHIR) corresponded to a higher proportion of agriculture. For non-calcareous wetlands, the proportion of dipterans (PDIP) was negatively correlated with agriculture and grazing while the proportion of ephmeropterans was positively correlated to proportion of water.

For forest glacial marshes, site disturbances were related to 4 of 7 invertebrate metrics. A greater number of taxa (ISR), higher proportion of gastropods (PGAS), more gastropod taxa (GASR), and fewer oligochaetes and annelids (POA) corresponded to higher site disturbance. Those metrics related to higher site disturbance were also directly relational to urban or agricultural use. Three of the four significant metrics for the wet prairie-sedge meadow series were only significant for one land use at one scale. The number of gastropod taxa was related to forest, water, or agriculture at different scales. No invertebrate metrics were significantly related to land use for prairie glacial marshes.

Fish

Total number of fish species and fish abundance were significantly related to land use for four of eight series, the other six metrics were important for only one or two series. Forest and agriculture were related to two of three fish metrics for high-order river floodplains. More forest corresponded to a higher proportion of castostomids (PCAT) and piscivores (PFPI). Proportion of piscivores was inconsistently related to agriculture, depending on scale. Likewise, species richness (FSR) was inconsistently related to land use (urban) for mid-order river floodplains. No other fish metrics were significant for this series. In contrast, total fish richness and cyprinid richness (CYPR) were less with a greater proportion of agriculture.

Higher cyprinid richness (CYPR), sunfish richness (CENR), and proportion of sunfish (PCEN) was associated with more forest for calcareous littoral wetlands. The two sunfish metrics are also negatively related to agriculture. Only one metric (at one scale) was significantly related to land use for non-calcareous littoral wetlands: fish abundance (FABU) was directly related to grassland at 1000 m. Greater fish abundance was associated with more site disturbance in both forest glacial marshes and prairie glacial marshes. For forest glacial marshes, greater fish abundance corresponded to less agriculture whereas for prairie glacial marshes, greater fish abundance corresponded to less grassland. Fish richness (FSR) was positively related to more grassland in forest glacial marshes. Not surprisingly, no significant metric-land use relationships were detected for wet prairies-sedge meadows, a series where flooding is ephemeral.

Amphibians

Significant relationships between land use and amphibian metrics were only detected in three series: forest glacial marshes, mid-order river floodplains, and low-order river floodplains. In these cases, the relationships were confined to one scale or were not consistent between scales.

Discussion

Monitoring recovery in wetlands with community indicators will likely require very different metrics, depending on type of wetland and ecoregion. In this study, 61 of the 79 metrics showed significant relationships to land use in less than one-half of the series. Only five metrics were consistently related to specific land uses across several series (i.e., PWB, PBIN, BWR, CAI, IPI). The number of metrics identified varied considerably among different kinds of wetlands, from more than 30 in calcareous littoral wetlands and high-order floodplains to only eight in prairie glacial marshes. The organismal groups most effective for monitoring change also vary considerably among series. For example, plants yielded more metrics for floodplain series than for other wetlands. Several fish metrics were predictors of land use for many different wetlands but fish are not present in most ephemeral wetlands. Birds appear to be the most universally useful organismal group for monitoring changes in wetlands related to land use and amphibians the least useful.

We identified five metrics in this study that are useful in many kinds of wetlands (at least half of the series), were relatively insensitive to the scale of land use analysis, and showed a consistent relationship to a land cover type. Three are bird metrics (proportion of wetland birds, wetland bird richness, proportion of insectivorous species) and two are plant metrics (importance of *Carex*, importance of invasive perennials).

The proportion of insectivorous birds was lower with more urban land surrounding non-calcareous littoral wetlands, wet prairies-sedge meadows, forest glacial marshes, high-order river floodplains, and mid-order river floodplains. The effects of habitat alteration on reducing diversity and abundance of insectivores have been previously reported for riverine wetlands in Pennsylvania (warblers and vireos) (Croonquist and Brooks, 1991) and on the Upper Mississippi River (bark-gleaners) (Knutson, 1995).

The second metric, proportion of wetland birds, was consistently higher with greater proportion of grassland in the surrounding landscape. This relationship was significant for prairie glacial marshes, forest glacial marshes, high-order river floodplains, and mid-order river floodplains. Many wetland birds rely on grasslands for nesting habitat (Swanson and Deubbert, 1989). In addition, the conversion of grasslands to agriculture favors avian predators such as red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), weasel (*Mustela* spp.) and crows (*Crovus brachyrhynchos*) (Fleskes and Klaas, 1991).

Wetland bird richness was higher with more extensive wetland cover in the surrounding landscape for wet prairie-sedge meadows, forest glacial marshes, and mid-order river floodplains. In Iowa wetlands, Brown and Dinsmore (1986) observed more bird species in complex marshes than isolated marshes. The importance of wetland complexes to wetland birds has been extensively documented across midcontinental North America (e.g.,Swanson and Deubbert, 1989).

The importance of *Carex* spp. was lower in wet prairies-sedge meadows, forest glacial marshes and low-order river floodplains with more site impacts. An in-depth analysis of land use impacts to plant communities based on the same data set used here (for three series) showed that *Carex* and other native perennials was reduced by cultivation, ditching, and stormwater inputs (Galatowitsch et al., in press).

This same analysis showed that invasive perennials (e.g., *Phalaris arundinacea, Typha angustifolia*) increased in wetlands with stormwater inputs. In a controlled greenhouse experiment, Green and Galatowitsch (in preparation) found *Carex* and other native perennials to be outcompeted by *Phalaris arundinacea* with nitrate additions. We found the importance of invasive perennials to be greater with more urban land surrounding non-calcareous littoral wetlands, calcareous littoral wetlands, and mid-order river floodplains.

In addition to these metrics that have potential for widespread use, we identified others that will likely be reliable for specific series, based on finding interpretable land use relationships across many scales. For example, the proportion of forest birds consistently showed an inverse relationship to proportion of agriculture surrounding non-calcareous littoral wetlands, while, for this same series, the proportion of woodpeckers was directly related to proportion of forest. Cyprinid richness is inversely related to proportion of agriculture in low-order river floodplains. Declines in native cyprinid communities in degraded streams also have been been described by Fausch et al. (1984), Karr (1991), Lenat and Crawford (1994), and Mensing et al. (1998)

For most types of wetlands included in our study, several metrics were identified that should be effective for monitoring recovery. For prairie glacial marshes, however, few metrics were identified that effectively relate biota to land use. It seems more likely that lack of detection resulted from minimal land cover diversity than from insensitivity of biota to land use changes. Prairie glacial marshes are situated in the intensively agricultural southwest prairie. Agricultural land comprises 78% of the counties in this ecoregion (USDOC, 1992). Many birds, including sandhill cranes (*Grus canadensis*), marbled godwits

(*Limosa fedoa*) and common loons (*Gavia immer*) were extirpated from this ecoregion at the turn of the century by habitat fragmentation and market hunting (Weller, 1979; Dinsmore, 1981; Roberts, 1932). Likewise, a number of wetland plant species such as *Cypripedium candidum, Parnassia glauca, Lilium michiganense*, and *Carex lasiocarpa* are much less common than they were reported to have been historically (Galatowitsch and van der Valk, 1995). Wetlands within extensively degraded ecoregions seem to be a special circumstance for planning and monitoring recovery. Unless extensive landscape-scale restoration is undertaken, the opportunity for the biota to respond may be very limited. It is unknown, however, whether species that have been reduced or extirpated will recolonize newly restored habitats.

The inertia and associated persistence of species to respond to changes in land use may influence the effectiveness of community metrics even in ecoregions that are not extensively degraded. Significant lags in plant responses to climate have been widely documented (e.g., Davis, 1989). Plant communities dominated by clonal species and long-lived species, typical of most northern temperate wetlands, likely experience the greatest inertia. In particular, perennials that invade wetlands stressed by agricultural runoff and stormwater inputs will not necessarily be outcompeted by less aggressive species after these stresses are alleviated. Many aggressive wetland plants that invade in response to disturbance have broad tolerances to environmental conditions (Galatowitsch et al., in press). If diagnostic community shifts are not reversible, these plant metrics may be of limited use in monitoring. Croonquist and Brooks (1991) also raised the concern over whether sensitive or more specialized bird species can outcompete generalists during wetland recovery.

The effectiveness of different organismal groups for wetland monitoring also depends on their diversity and abundance in a particular kind of system and whether adequate sampling is feasible. In our study, the number of metrics identified for each organismal group corresponded to its overall diversity. For example, only a few metrics could be constructed and tested for the 10 species of amphibians we observed in this study. In addition, an inability to detect significant relationships among potential indicators probably stems from incomplete community characterization. Lehtinen et al. (1998) used two survey methods, chorusing and visual encounter surveys, in addition to larval sampling, to census amphibians in the forest glacial marshes included in this study. They were able to detect a strong relationship between amphibian richness and proportion of urban land ($R^2 = 0.91$). The findings by Lehtinen et al. (1988) also suggest that sampling effort needs to be carefully controlled throughout long-term monitoring efforts to avoid misinterpretation of metric results.

Our results clearly show that use of many metrics should not be extended from one kind of wetland to another without verification. In 12 instances, the relationship between a community metric and a land cover type was positive in at least one series and negative in another. For example, invertebrate species richness increased with forest cover surrounding some kinds of wetlands and decreased in others. This may not be surprising because species richness often peaks at intermediate levels of disturbance (Connell, 1983). So, whether the relation of species richness to disturbance is positive or negative may depend on the range or level of disturbance on the site or in the surrounding landscape.

We were unable to show that land use relationships at certain scales (within 5000 m) are more critical for determining plant and animal community composition. Land use patterns across larger areas than we sampled may determine community composition. In some cases, community metrics were relatively insensitive to scale, but in other cases significant relationships were detected at only one scale. To some extent, we believe scale insensitivity is the result of the noise that exists in large observational data sets, where none of the land cover features are independent of each other. For this reason, community metrics identified from studies such as this should be further evaluated with controlled experiments (e.g., Green and Galatowitsch in preparation) or with observational studies intended for validation. In addition, other land use parameters also may be more sensitive than simple proportional cover estimates. For example, wetland birds and amphibian distributions have been documented to correspond to other measures, i.e., connectedness and road density (Whited et al. in review, Lehtinen et al. in press).

Based on the results of this study, with interpretations supported by more detailed investigations, community metrics appear to have potential as a recovery monitoring strategy. There are, however, some important aspects to their use that must be investigated before these metrics are used for decision-making. First, we need to determine if organisms sensitive to land use changes can outcompete generalists after stressors have been removed. We have initiated a long-term monitoring program for several restored glacial wetlands in Minnesota to assess which indicators can reverse their response. Second, the metrics we evaluated need to be tested for inter-annual variability. We are concerned that the profound effects of wet-dry cycles will alter which metrics are significant or how they should be interpreted. It may be most logical to conduct these studies on many existing wetlands crossing a range of degradation, so that the changes in metrics due to recovery do not confound the results. Finally, additional work needs to be done to consider how many sets of metrics are needed to adequately evaluate wetlands in a region. Metrics need to be validated across a greater range of wetland sizes and hydroperiods than we considered here.

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Wetland Ecosystem Monitoring Research Program: Study Site Descriptions

Susan M. Galatowitsch, Rachel Budelsky, Richard M. Lehtinen, John Mulhouse and Anne M. Capistrant
University of Minnesota, St. Paul, MN 55108

Contents

Introduction

Four groups of wetlands in the south-central portion of Minnesota were chosen to systematically compare the long-term development of planted and unplanted wetland restorations. Each group of wetlands, with one exception, includes a native reference wetland, a wetland restoration in which native plants were deliberately introduced, and an unplanted wetland in which only the water regime has been restored. This third wetland type typifies the approach taken in most wetland restorations in the region.

Whereas there is much debate regarding the ultimate success of unplanted and planted restorations, there are no prior long-term studies to provide support for one type of restoration implementation over another.

In the present study, data on soil, hydrological, and water chemistry characteristics, animal diversity and abundance, and vegetation diversity and abundance were collected from each of the sites during the first growing season after restoration for comparison between sites and as a baseline for comparison over time. The wetlands in each group were chosen on the basis of similarity of size, soil type, parent material (e.g., glacial till, outwash), proximity, and anticipated hydrology. Potential sites were visited by field crews to assess the condition of the site and suitability for inclusion in the study. Aerial photographs, National Wetland Inventory maps, soil surveys, and topographic maps were collected, where available, for each of the sites. The planted wetlands were chosen first. In all cases they represented an attempt to go beyond the typical wetland restoration with additional initial investment in planting materials. These demonstration wetlands were then paired with a typical restoration and a reference wetland based upon the criteria described above. The location of the demonstration wetlands ultimately determined the location of each of the four wetland groups in the state (Figure 3.1). In the case of the western group, the demonstration wetland was never restored, but the other two wetlands remained in the study.

Data collected from wetlands in the study are presented in this chapter. For ease of comparison, results are presented by wetland group. The wetland groups are referred to as the West Metropolitan Group, the East Metropolitan Group, the Southern Group, and the Western Group. Sites within each group are briefly introduced and characteristics of wetlands within the group are described. A detailed description of each site follows the group characteristics section, accompanied by supporting tables and figures.

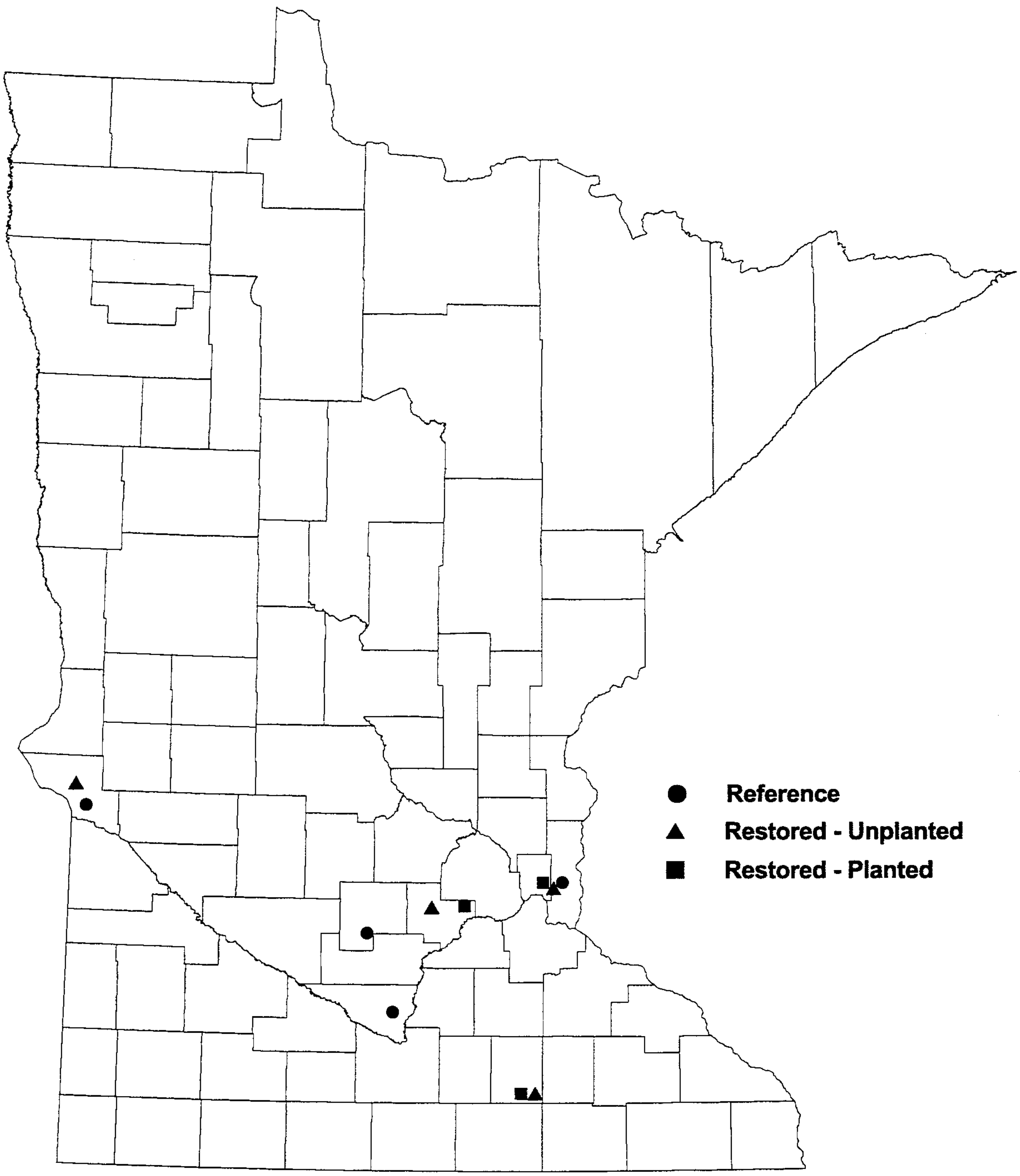


Figure 3.1. Long term wetland monitoring sites in Minnesota.

West Metropolitan Group

The location and size of the three sites in the west metropolitan group are presented below. The location of the three wetlands relative to one another is also shown in Figure 3.2.

	Site	Size (ha)	Location	Ownership
Planted	Spring Peeper	2.48	Carver Co., T116 R23 S16	MNLA
Unplanted	Carpenter	8.61	Carver Co., T116 R25 S16	W. Carpenter
Reference	Schaefer Prairie	3.3	McCleod Co., T115 R29 S34	TNC

Characteristics of the Wetlands in the Group

Soils: Soil texture at the Spring Peeper Meadow restoration (silty clay and silty clay loam) and Schaefer Prairie (silty clay loams) were most similar while the Carpenter restoration had a heavier clay loam soil (Table 3.1). Total N and total P were relatively similar across all three sites at the surface. At the 25-35 cm depth, total N and total P (below the water line) was lower at the reference site (Schaefer) than at the restoration sites. Total organic carbon was slightly higher at Carpenter than the other two wetlands. Soil temperatures (mean, maximum, and minimum) were consistently higher at the restored wetlands than at the reference wetland (Table 3.2).

Water: None of the three wetlands showed strong directional water movement (recharge or discharge) (Table 3.3). Surface water levels changed by 31 vertical cm at Spring Peeper, 27 cm at Schaefer, and 15 cm at Carpenter. The mean water temperature was slightly higher at the restoration sites than the reference wetland, but the maximum temperature recorded was the same for all wetlands (Table 3.4). Dissolved oxygen did not vary greatly between sites. Total alkalinity was highest at Carpenter, lowest at Spring Peeper, and intermediate at Schaefer Prairie. The Spring Peeper restoration had the greatest range of conductivities (87.9 - 892.0 uS/cm), but the means were comparable among the sites. The lowest minimum pH values were recorded at Spring Peeper, although maximum pH values were similar for all three wetlands. Chlorine levels were two orders of magnitude higher at Spring Peeper than at the other sites (Table 3.5). Sulfate and sodium were also higher at Spring Peeper. The proximity of the site to roads where salt is used in the winter may result in chlorine and sodium contaminated runoff entering the Spring Peeper restoration.

Fauna: The Carpenter restoration had the greatest total number of avian species, the greatest number of breeding birds, and the greatest total bird abundance (Table 3.6). Most of the species observed are associated with open water (i.e. migratory waterfowl, swallows, egrets). Carpenter was the only site of the three with an open water area. No fish were observed at any of the wetlands. All three sites had roughly the same number of amphibian species (Table 3.7). The northern leopard frog was most commonly encountered at Schaefer Prairie, the American toad was seen most often at Carpenter, and the western chorus frog was observed most often at Spring Peeper. Schaefer was the only wetland where a salamander species was found.

Flora: In total, the Spring Peeper Meadow planted restoration had 173 species (Table 3.8), the Carpenter unplanted restoration had 77 species (Table 3.9), and the Schaefer Prairie reference site had 127 species (Table 3.10).

Site	Upland	Wet Prairie	Sedge Meadow	Wet Edge	Emergent	Open Water
Spring Peeper	x	108	83	x	30	x
Carpenter	25	x	x	57	x	7
Schaefer	x	75	42	x	25	19

The restorations differed greatly in the type of species found above the emergent zone. Whereas the Spring Peeper restoration had a high percentage of native species, the Carpenter restoration was sparsely populated with primarily weedy annuals (*Cirsium arvense, Conyza canadensis, Crepis tectorum, Taraxacum officinale*, etc.). It is not unusual to observe weedy annuals in an unplanted wetland soon after restoration. However, the rapid establishment of the planted materials at the Spring Peeper restoration is encouraging. Of the 115 seeded or planted native species installed at the Spring Peeper restoration, 74 species (64%) were observed after the first growing season. Water availability after planting and aggressive weed control at the Spring Peeper restoration are likely to have contributed to the establishment of the planted native wetland plants.

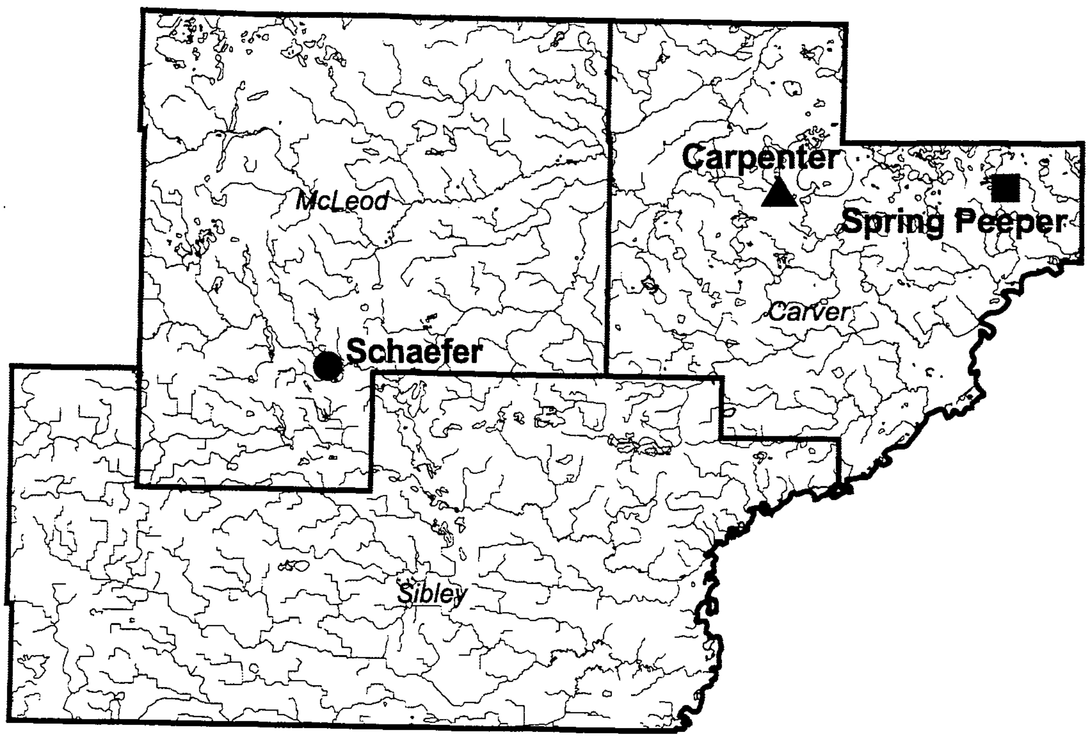


Figure 3.2. Regional map showing the location of the west metropolitan triplet of wetlands.

Table 3.1. Averages of soil characteristics from four stations at each elevation (above, at, and below the water line).

		Spring Peeper			Carpenter			Schaefer		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth										
0-5 cm	Total N (%)	0.57	0.99	1.22	0.94	1.74	1.81	0.89	1.39	1.44
	Total P (ppm)	936	1073	1188	1036	1311	1236	971	985	779
	Total Org. C (%)	5.4	8.24	8.4	10.33	11.79	12.48	5.64	7.76	11.09
5-25 cm	Texture	Silty clay, Silty clay loam			Clay loam			Silty clay loam		
25-35 cm	Total N (%)	0.44	0.98	1.4	0.6	1.15	1.93	0.19	0.32	0.24
	Total P (ppm)	620	855	1068	579	827	956	579	624	407

Table 3.2. Summary of soil temperature data taken at 2 and 20 cm, 7 times between April and October, 1998. Four sampling stations per site were used to record temperatures at the stationd nearest to the water line, the stations closest to 30 cm above the water line, and the stations closest to 30 cm below the water line.

		Spring Peeper			Carpenter			Schaefer		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth	Temperature (C)									
2 cm	Mean	20	18	17.5	20	19.8	17.5	14.3	13.8	12.8
	Minimum	12	10	12	8	14	9	7	4	6
	Maximum	27	22	22	32	27	25	21	22	17
20 cm	Mean	16.3	15.8	16.5	15.3	15.5	16	12.3	11.5	11.3
	Minimum	9	9	11	6	6	8	4	3	6
	Maximum	21	20	21	22	21	21	18	19	17

Table 3.3. Total head gradients for piezometers (cm). A negative number indicates upward movement of water. A positive number indicates downward movement.

Spring Peeper

Depth Interval (cm):	Nest 1 69-91	Nest 1 91-152	Nest 2 69-91	Nest 2 91-152	Nest 3 69-91	Nest 3 91-152
4/6/98	0	2.5	1	0	0	-1
4/27/98	-2.5	5	1	0	-1	-2
5/26/98	0	2	1	0	1	-1
6/25/98	0	-2	-1	2	-1	2
7/17/98	1	-1	2	1	1	-1
8/12/98	10	-1	7	1	3	-1
9/8/98	8	-1	10	1	3	-2
10/1/98	18	-2	15	1	5	-3
11/10/98	13	-7	2	4	2	2

Depth Interval (cm):	Nest 4 69-91	Nest 4 91-152	Nest 5 69-91	Nest 5 91-152	Nest 6 69-91	Nest 6 91-152
4/6/98	0	1	0	-1	0	1
4/27/98	-1	1	0	0	-1	1
5/26/98	2	1	0	0	0	0
6/25/98	-1	5	-1	0	2	0
7/17/98	1	1	-2	2	0	0
8/12/98	7	0	1	0	-1	2
9/8/98	4	1	8	-7	-1	1
10/1/98	2	2	8	-7	-1	0
11/10/98	2	6	8	-8	1	4

Carpenter

Depth Interval (cm):	Nest 1* 30-61	Nest 1* 61-152	Nest 2 30-61	Nest 2 61-122	Nest 2 122-152	Nest 3 30-61	Nest 3 61-122	Nest 3 122-152
4/18/98	2	-3	2	-2.5	2			
5/6/98	5.5	-8	-0.5	-0.5	2.5	-1.5	-3	25.5
5/25/98	0	1	0.5	-2	7	2	-2	4
6/10/98	0	6	-2.5	1	2	9	-6	1
6/24/98	14	-19	1.5	-2	2	4	-12	0
8/21/98	0.5	-2	0	-3.5	4	3.5	-7.5	3
9/17/98	26.5	-5.5	1	-2.5	3	11.5	-5.5	4

*The 122 cm well malfunctioned.

Schaefer

Depth Interval (cm):	Nest 1 30-61	Nest 1 61-122	Nest 1 122-152	Nest 2 30-61	Nest 2 61-122	Nest 2 122-152	Nest 3 30-61	Nest 3 61-122	Nest 3 122-152
4/16/98	-6	8	13	2	-2	17	9	-4	4
5/1/98	4	1	-2	1	-5	6	6	-1	-5
5/23/98	5	-5	2	1	-13	12	3	-5	0
6/12/98	4	-4	4				5	-3	-1
7/1/98	2	-1	3	2	16	-14	3	-8	2
8/17/98	3	-5	5	16	3	2	4	-6	3
9/24/98	4	-8	4	11	4	3	11	-4	6

Table 3.4. Summary of alkalinity, conductivity, pH, DO, and water temperatures from April to October 1998.

	Spring Peeper			Carpenter			Schaefer		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (C)	17.6	11.0	24.0	18.0	9.0	24.0	14.0	6.0	24.5
Dissolved Oxygen (mg/l)	2.0	0.6	5.9	3.4	0.9	7.8	1.6	0.6	3.8
Total Alkalinity (mg $CaCO_3$)	65.2	13.0	118.0	137.8	111.0	177.0	111.6	88.0	138.0
Conductivity (uS/cm)	441.1	87.9	892.0	390.8	280.0	515.0	342.8	218.0	466.0
pH	7.8	6.9	9.5	9.3	8.1	10.0	8.7	7.3	9.5

Table 3.5. Anion and cation composition of water.
A 'T' indicates trace levels.

	Spring Peeper	Carpenter	Schaefer
Anions (mg/kg)			
F	0.302	0.576	0.28
Cl	142	6.533	1.242
NO2-N	T	T	T
Br	0.111	0.101	T
NO3-N	T	0.008	0.075
PO4-P	T	T	T
SO4	6.109	0.313	1.383
Cations (ug/g)			
Al	0.1911	0.0388	0.0664
Si	1.474	3.3444	5.2311
P	0.2353	0.2747	0.2325
Fe	0.7372	0.8002	0.4096
Mn	0.4687	0.1585	0.0717
Sr	0.1594	0.193	0.1573
Ba	0.0975	0.0561	0.0713
Ca	70.1233	67.2464	75.4511
Mg	27.305	33.6563	25.6462
Na	29.7526	3.2759	2.3844
K	6.0697	5.5698	0.9985

Table 3.6. Number of birds of each species detected during three bird surveys conducted between dawn and 0900 h between 5 May and 10 July. Upland bird species are not included in this listing. This list includes incidental detections.

Coded breeding evidence of birds detected in surveys at each site. 0 = species not present; 1 = species present; 2 = singing male detected; 3 = male and female of species seen together; 4 = nesting activity detected for this species; 5 = young produced for this species. Maximum breeding evidence for each species at each site is found in the Summary column. Upland bird species are not included in this listing. This list includes incidental detections.

	Common Name	Scientific Name	Spring Peeper Total	Spring Peeper Breeding	Carpenter Total	Carpenter Breeding	Schaefer Total	Schaefer Breeding
ALFL	Alder flycatcher	*Empidonax alnorum*	0	0	0	0	4	2
AMCO	American coot	*Fulica americana*	0	0	6	3	0	0
BNKS	Bank swallow	*Riparia riparia*	0	0	0	0	4	1
BARS	Barn swallow	*Hirundo rustica*	2	1	13	1	5	1
BLTE	Black tern	*Chlidonias niger*	0	0	8	1	0	0
BWTE	Blue-winged teal	*Anas discors*	2	3	8	3	0	0
CAGO	Canada goose	*Branta canadensis*	0	0	3	1	0	0
CLSW	Cliff swallow	*Hirundo pyrrhonota*	3	1	5	1	0	0
COGR	Common grackle	*Quiscalus quiscula*	4	1	17	1	7	1
COME	Common merganser	*Mergus merganser*	0	0	1	1	0	0
COYE	Common yellowthroat	*Geothlypis trichas*	0	0	6	2	10	2
DOGO	Domestic goose		0	0	1	1	0	0
GTBH	Great blue heron	*Ardea herodias*	2	1	3	1	1	1
GREG	Great egret	*Casmerodius albus*	0	0	44	1	0	0
KILL	Killdeer	*Charadrius vociferus*	10	1	13	2	5	1
LEYE	Lesser Yellowlegs	*Tringa flavipes*	1	1	0	0	0	0
MALL	Mallard	*Anas platyrhynchos*	10	5	12	3	6	3
MAWR	Marsh wren	*Cistothorus palustris*	0	0	0	0	18	4
NOSH	Northern shoveler	*Anas clypeata*	0	0	2	3	0	0
PBGR	Pied-billed grebe	*Podilymbus podiceps*	0	0	1	1	0	0
REDH	Redhead	*Aythya americana*	0	0	4	3	0	0
RWBL	Red-winged blackbird	*Agelaius phoeniceus*	30	5	24	5	40	5
RUDU	Ruddy duck	*Oxyura jamaicensis*	0	0	2	3	0	0
SORA	Sora	*Porzana carolina*	0	0	4	2	0	0
SPSA	Spotted sandpiper	*Actitis macularia*	1	1	0	0	0	0
SWSP	Swamp sparrow	*Melospiza georgiana*	0	0	0	0	7	2
TRES	Tree swallow	*Tachycineta bicolor*	4	1	9	1	10	1
UNBI	Unknown bird		0	0	1	1	1	1
UNDU	Unknown duck		0	0	4	5	4	1
UNSH	Unknown shorebird		0	0	8	1	0	0
VIRA	Virginia rail	*Rallus limicola*	0	0	1	2	0	0
WODU	Wood duck	*Aix sponsa*	4	3	24	5	0	0
YHBL	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	0	0	3	5	2	2
YWAR	Yellow warbler	*Dendroica petechia*	0	0	0	0	4	2
	Total Number of Species		12		27		16	
	Total Number of Breeding Bird Species			4		10		3
	Total Abundance		73		227		128	

Table 3.7. Amphibians detected in the following surveys: VES-Day - daytime visual encounter search, VES-Night - night time visual encounter search, Larval - minnow traps and aquatic activity traps, Chorus - chorusing sruveys.

Number of adults and/or juveniles detected during 30 min. visual encounter search (VES) conducted between 0800 and 1000 h. Surveys began 4/07/98 and ended 7/10/98.

Total amphibian larvae caught in minnow traps and aquatic activity traps on each site site and overall total. Adults were also occasionally found in these traps as well and these are reported here separately from the larval data and as totals only.

Chorusing surveys were conducted for 10 minutes beginning 2 h after sunset from 4/06/98 to 7/10/98. 0 = no individuals of this species detected 1 = individual calls can be distinguished, no overlap 2 = individual calls can be distinguished but are overlapping 3 = calls cannot be distinguished individually, constant and overlapping. Number given is the highest chorusing designation recorded over all site visits.

		Spring Peeper				Carpenter				Schaefer			
Common Name	Scientific Name	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus
Northern leopard frog	*Rana pipiens*	2	4	5	1	4	7	79	2	58	40	156	2
Wood frog	*Rana sylvatica*	0	0	0	0	14	0	0	0	0	0	0	0
Western chorus frog	*Pseudacris triseriata*	24	48	0	3	7	11	5	3	0	1	39	3
Cope's gray treefrog	*Hyla chrysoscelis*	0	6	0	2	0	6	0	2	0	2	0	2
Gray treefrog	*Hyla versicolor*	0	0	0	0	0	2	0	2	0	5	0	1
Treefrog	*Hyla sp.*	7	4	19	0	1	0	18	0	1	0	0	0
American toad	*Bufo americanus*	17	10	4	2	175	3	229	3	0	0	0	0
Tiger salamander	*Ambystoma tigrinum*	0	0	0	0	0	0	0	0	0	0	61	0

Table 3.8 Floristic list annotated with abundance for each zone and plot at Spring Peeper Meadow. Cover estimates were made on August 5, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WP - Wet Prairie, SM - Sedge Meadow, EM - Emergent. A * indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Total Cover By Zone			Plot Cover																												
Species	Authority	Family	WP	SM	EM	O5W	Y5W	R5W	P5W	B5W	5slvr	B5E	P5E	R5E	Y5E	O5E	O10W	Y10W	R10W	P10W	B10W	B10E	P10E	R10E	Y10E	O10E	O13W	Y13W	R13W	P13W	P13E	R13E	Y13E	O13E
Acer negundo	L.	ACE	0.5	0.5		0.1	0.1																				0.1							
Acorus calamus	L.	ARA			2																													
Alisma plantago-aquatica	L.	ALI		2	3				4	2	3	4	5							3	5	4	5							3				
Sagittaria latifolia	Willd.	ALI		0.5	3					5	2	4									4	5	1							3				
Amaranthus retroflexus	L.	AMA	0.5																									2						
Cicuta bulbifera	L.	API		0.1																														
Sium suave	Walter.	API		0.1																														
Zizia aurea	L.	API	1	0.5		2								2											1								1	
Asclepias incarnata	L.	ASC	0.5	0.5									1											1										
Achillea millefolium (lanulosa)	L. / (Nutt.)	AST	0.1																															
Ambrosia artemisiifolia	L.	AST	1	0.5										1	2									1	3	3	3		2					3
Ambrosia trifida	L.	AST	0.5	0.5																														
Aster drummondii	Lindley.	AST	*																															
Aster lanceolatus (simplex)	Willd.	AST	*																															
Aster puniceus	L.	AST	0.5	0.5				3						3					2												0.5			
Aster sp.		AST																									0.1							
Aster umbellatus	Miller.	AST		0.1																														
Bidens cernua	L.	AST		0.5	1																		1											
Bidens connata	Muhl.	AST		0.5	0.5																													
Bidens sp.		AST						1						0.1															1	3				
Boltonia asteroides	(L.) L'Her	AST	0.5	2	0.5			2											3											2				
Cirsium sp.		AST																																
Conyza canadensis	(L.) Cronq.	AST	1											1				2	1					0.5			1		1					
Crepis tectorum	L.	AST	*																															
Erigeron annuus	(L.) Pers.	AST	*																															
Erigeron sp.		AST																	2										2					
Erigeron strigosus	Muhl.	AST	0.5			2													2															
Eupatorium maculatum	L.	AST	0.5	0.5										1					1													1		
Eupatorium perfoliatum	L.	AST	0.5	0.5																														
Euthamia graminifolia	(L.) Nutt.	AST	0.5																															
Helenium autumnale	L.	AST	0.5															2																
Helianthus giganteus	L.	AST	0.5																															
Helianthus rigidus	(Cass.) Desf.	AST	0.5											1																				
Helianthus strumosus	L.	AST	*																															
Heliopsis helianthoides	(L.) Sweet	AST	1				2																											
Lactuca serriola	L.	AST	*																															
Liatris pycnostachya	Michx.	AST	0.5																															
Liatris ligulistylis	(A. Nels.) K. Schum.	AST	0.5																															
Ratibida pinnata	Vent.	AST	0.5																															
Rudbeckia hirta	L.	AST	1			4	2																				0.1							
Silphium perfoliatum	L.	AST	0.5																															
Solidago canadensis	L.	AST	*	*																														
Solidago nemoralis	Aiton	AST	1																															
Solidago rigida	L.	AST	1																															
Solidago sp.		AST						1																										
Solidago speciosa	Nutt.	AST	1																															
Sonchus arvensis	L.	AST	*																															
Sonchus asper	(L.) Hill	AST	*																						0.5									
Sonchus oleraceus	L.	AST												0.5																				
Sonchus sp.		AST	0.5	0.5			2							1	1																			
Taraxacum officinale	Weber ex. Wigg.	AST	0.5	0.5											0.5										0.5		0.5	0.5						1
Unknown Asteraceae		AST	0.5	0.5									2	0.5	1				1															
Vernonia fasciculata	Michx.	AST	0.1	0.5										0.1																				
Barbarea vulgaris	R. Br.	BRA	*	*																														
Capsella bursa-pastoris	(L.) Medikus.	BRA	0.1																															
Erysimum cheiranthoides	L.	BRA	*																															
Rorippa palustris	(L.) Besser.	BRA	0.5	0.5					0.5					0.5					1				1	1					0.5					
Rorippa sylvestris	(L.) Besser.	BRA	*																															
Thlaspi arvense	L.	BRA		0.5		0.1	0.5							0.5										1		1								
Unknown Brassicaceae		BRA																																
Lobelia siphilitica	L.	CAM	*																															
Cerastium nutans	Raf.	CAR	*																															
Silene latifolia (pratensis)	Poiret./(Raf.) Godr.&Gren.	CAR	0.5	0.5																														
Silene nivea	(Nutt.) Otth.	CAR	*																															
Silene noctiflora	L.	CAR	*																															
Unknown Caryophyllaceae	L.	CAR																																
Chenopodium album	L.	CHE	0.5	0.5														0.5								0.5		0.5						
Hypericum ellipticum	Hook.	CLU	*																															
Convolvulus arvensis	L.	CON	0.5																															0.1
Carex atherodes	Sprengel.	CYP			1																													
Carex bebbii	(L. H. Bailey) Fern.	CYP		2				2	2																					4	4			
Carex buxbaumii	Wahlenb.	CYP		0.5																														
Carex comosa	F. Boott.	CYP			1																													
Carex cristatella	Britton	CYP		3																			2						2			0.5		
Carex hystericina	Muhl.	CYP		*																														
Carex granularis	Muhl.	CYP		0.5																														
Carex lacustris	Willd.	CYP			1																													

Table 3.8. Continued . . .

Species	Authority	Family	Total Cover By Zone			Plot Cover																												
			WP	SM	EM	O5W	Y5W	R5W	P5W	B5W	5silvr	B5E	P5E	R5E	Y5E	O5E	O10W	Y10W	R10W	P10W	B10W	B10E	P10E	R10E	Y10E	O10E	O13W	Y13W	R13W	P13W	P13E	R13E	Y13E	O13E
Carex lasiocarpa	Ehrh.	CYP		1																														
Carex pseudocyperus	L.	CYP		*																														
Carex retrorsa	Schweinitz	CYP		0.1	1																													
Carex rostrata	Stokes	CYP			1																													
Carex scoparia	Schk.	CYP		0.5																				1										
Carex stipata	Muhl.	CYP		2				1																										
Carex stricta	Lam.	CYP			1																													
Carex tenera	Dew.	CYP		0.5																														
Carex vulpinoidea	Michx.	CYP		3	0.5																													
Carex sp.		CYP							1					2					0.1					1	3						1			
Cyperus esculentes	L.	CYP	*	*																														
Cyperus sp.		CYP																		0.5														
Eleocharis ovata (obtusa)	(Roth) Roemer & Schultes. / (Willd.) J	CYP		*																1														
Eleocharis tenuis	(Willd.) Schultes.	CYP			0.5																													
Scirpus atrovirens	Willd.	CYP		0.5	0.5															2														
Scirpus cyperinus	(L.) Kunth.	CYP		*																														
Scirpus validus	Vahl	CYP			2					0.1																								
Scirpus sp.		CYP																	2															
Dalea candida	Michx. ex Willd.	FAB	0.1																															
Dalea purpurea	Vent.	FAB	0.1																															
Lotus corniculatus	L.	FAB	0.5																															
Medicago lupulina	L.	FAB	0.5																							1								1
Melilotus officinalis	(L.) Pallas.	FAB	*																														2	
Trifolium pratense	L.	FAB	*																															1
Trifolium repens	L.	FAB	*																															
Trifolium sp.		FAB																											1					
Vicia villosa	Roth.	FAB	0.5																															
Gentiana andrewsii	Griseb.	GEN	0.5																															
Ribes sp.		GRO																0.5																
Iris versicolor	L.	IRI			0.5																													
Juncus nodosus	L.	JUN	*	0.1																														
Juncus tenuis	Willd.	JUN		*																														
Juncus spp.		JUN		0.1																														
Agastache foeniculum	(Pursh.) Kuntze.	LAM	0.5																															
Dracocephalum parviflorum	Nutt.	LAM		*																														
Lycopus americanus	Muhl.	LAM		1	0.5			2	1					2					1	2			0.5						0.5		2	1		
Mentha arvensis	L.	LAM		0.5																														
Monarda fistulosa	L.	LAM	*			1	2																											
Pycnanthemum virginianum	Dur. & Jackson.	LAM	0.5			0.1																												
Scutellaria lateriflora	L.	LAM	*	*																														
Unknown Lamiaceae		LAM	0.5			0.1								0.5				2																
Lemna minor	L.	LEM		0.5	0.5					5	5	5								0.5		1												
Spirodela polyrhiza	(L.) Scheiden.	LEM			0.1					0.5											0.5													
Zigadenus elegans	Pursh.	LIL	0.5																															
Lobelia siphilitica	L.	LOB		0.5																														
Lythrum alatum	Pursh.	LYT		0.5																														
Lythrum salicaria	L.	LYT		0.5																														
Abutilon theophrasti	Medikus	MAL	0.5												0.5											0.5								
Hibiscus trionum	L.	MAL		0.5																							0.5							
Epilobium ciliatum	Raf.	ONA		1																					2	0.5			0.5					
Oxalis stricta	L.	OXA	*			0.1																					1							1
Plantago major	L.	PLA	0.5	0.5																						0.5	1		1					2
Agrostis stolonifera (alba)	L.	POA	*	*																												1		
Alopecurus aequalis	Sobol.	POA	*																															
Andropogon gerardii	Vitman	POA	1																															
Bromus erectus	Hudson.	POA	*																															
Bromus kalmii	A.Gray.	POA	0.5																															
Bromus sp.	Schrader	POA	*																															
Calamagrostis canadensis	(Michx.) Beauv.	POA		0.5					1					0.5									0.5	0.5							4			
Digitaria sanguinalis	L. (Scop.)	POA	*																								3	1					2	0.1
Echinochloa crusgalli	(L.) P. Beauv.	POA	0.5	0.5	3			1					2														0.5							
Echinochloa muricata	(P.Beauv.) Fern	POA	*	*										0.5														1	0.5	2			0.5	
Elymus canadensis	L.	POA	*	0.5	0.5	0.1																					0.5						0.1	
Elytrigia repens	(L.) Nevski.	POA	*																															
Glyceria grandis	S.Wats.	POA		0.5	0.5										1																			
Hordeum jubatum	L.	POA	*	*																														
Leersia oryzoides	(L.) Swartz	POA		0.5	1													1		2	2		1							3				
Panicum capillare	L.	POA	*	*																									2			0.5		
Panicum dichotomiflorum	Michx.	POA	*																															
Panicum virgatum	L.	POA	0.5																															
Phalaris arundinacea	L.	POA		0.5																														
Poa palustris	L.	POA	*	*																														
Poa pratensis	L.	POA	*	*																														
Setaria faberi	R. Herrm.	POA		2		3	4							2														0.5	1		0.5	1	2	0.5
Setaria glauca	(L.) P. Beauv.	POA		2			1							0.5	3									1	2	4	1	3	1			4	5	1
Setaria sp.		POA																						0.5	0.5									
Polygonum convolvulus	L.	POL	*																															
Polygonum erectum	L.	POL		*											1																			
Polygonum lapathifolium	L.	POL		0.5			0.5	2	1					2	1								0.5						2				0.5	
Polygonum pensylvanicum	L.	POL		0.5		0.5								1				1	0.5	2			0.5	0.5	1	0.5								
Polygonum persicaria	L.	POL		*																														
Polygonum punctatum	Elliott.	POL	*	*										0.5										0.5							0.5			

Table 3.8 Continued . . .

Species	Authority	Family	Total Cover By Zone WP	SM	EM	Plot Cover O5W	Y5W	R5W	P5W	B5W	5slvr	B5E	P5E	R5E	Y5E	O5E	O10W	Y10W	R10W	P10W	B10W	B10E	P10E	R10E	Y10E	O10E	O13W	Y13W	R13W	P13W	P13E	R13E	Y13E	O13E
Rumex crispus	L.	POL	0.5	0.5										1											2				1			1		
Rumex orbiculatus	A. Gray.	POL		0.5																														
Rumex sp.		POL					1							1										2							0.5			1
Sorghastrum nutans	(L.) Nash.	POA	0.5																															
Spartina pectinata	Link.	POA	0.5																															
Unknown Poaceae		POA				1								1				1																
Phlox pilosa	L.	POL	0.5																															
Polygonum aviculare	L.	POL	0.1																															
Portulaca oleracea	L.	POR	•												0.5												1	0.5						
Potamogeton foliosus	Raf.	POT			•																													
Caltha palustris	L.	RAN		0.5																														
Ranunculus pensylvanicus	L.f.	RAN		•																														
Ranunculus sp.		RAN		0.5		2																												
Thalictrum dasycarpum	Fischer & Ave-Lall.	RAN	0.1																															
Rhamnus cathartica	L.	RHA	•																															
Geum aleppicum	Jacq.	ROS	0.5	0.5																													1	
Potentilla norvegica	L.	ROS	•	•																														
Potentilla rivalis	Nutt.	ROS	•																															
Potentilla sp.		ROS					3											1						1	0.5		0.1	1	2					
Ranunculus abortivus	L.	ROS	•																															
Ranunculus pensylvanicus	L.f.	ROS	•											1																				
Salix exigua (interior)	Nutt.	SAL	•																															
Penthorum sedoides	L.	SAX		0.5	0.5																													
Mimulus ringens	L.	SCR		0.5	0.5				0.1														2											
Veronica peregrina	L.	SCR		0.5		2	2	0.5	0.5					0.5					0.5						1	2			0.5			0.5		
Solanum nigrum	L.	SOL	•																										0.1					
Sparganium eurycarpum	Engelm.	SPA			0.5																													
Typha sp.		TYP			0.1																													
Pilea pumila	(L.) A. Gray.	URT	•																															
Urtica dioica	L.	URT			0.1													2	0.5					2										
Verbena cf. urticifolia		VER	•																															
Verbena hastata	L.	VER		3				4						2					3					1							2	2		
Verbena stricta	Vent.	VER	0.5			1									0.1																		0.5	
Vitis riparia	Michx.	VIT	0.1															0.5																

Table 3.9. Floristic list annotated with abundance for each zone and plot at Carpenter Marsh. Cover estimates were made on July 28, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WE - Wet Edge, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Total cover by Zone			Plot Cover																					
Species	Authority	Family	UP	WE	OW	N4	N5	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S8	S9	S10	S11	S12	S13	S14
Acer negundo	L.	ACE		0.5																							
Alisma plantago-aquatica	L.	ALI		0.5	0.5																						
Amaranthus albus	L.	AMA	*																								
Amaranthus retroflexus	L.	AMA	0.1													0.1											
Toxicodendron radicans	(L.) Kuntze.	ANA	0.1																								
Asclepias incarnata	L.	ASC		0.5																			2				
Ambrosia artemisiifolia	L.	AST	0.5																								
Unknown Asteraceae		AST	*									0.5															
Cirsium arvense	(L.)Scop.	AST		0.5																			2	4			
Cirsium sp.		AST	1										3	4													
Conyza canadensis	L.	AST	0.5													1											
Crepis tectorum	L.	AST		*																							
Erigeron philadelphicus	L.	AST		*																							
Erigeron pulchellus	Michx.	AST		*																							
Solidago sp.		AST	0.5												0.1												
Sonchus oleraceus	L.	AST		1		0.5						0.1	0.5	0.5									1				
Taraxacum officinale	Weber ex Wiggers	AST	0.5									0.5	0.1			1	1										
Capsella bursa-pastoris	(L.) Medic	BRA		*																							
Erysimum cheiranthoides	L.	BRA	*																								
Rorippa palustris	(L.) Besser.	BRA	0.5													0.5											
Rorippa sylvestris	(L.) Besser.	BRA		0.1													0.5										
Thlaspi arvense	L.	BRA	0.5									2			0.5	0.5											
Ceratophyllum demersum	L.	CER			*																4						
Chenopodium album	L.	CHE		*												0.1											
Carex bebbii	(L.H. Bailey) Fern.	CYP		1																							
Carex conjuncta	F. Boott.	CYP		*																							
Carex vulpinoidea	Michx.	CYP	0.5	1		1																					
Carex sp.		CYP		*																							
Cyperus sp.		CYP	0.5													0.5											
Eleocharis palustris	L.	CYP		1			2																				
Scirpus atrovirens	Willd.	CYP		0.5																							
Equisetum arvense	L.	EQU		1		3																					
Equisetum hyemale	L.	EQU		*																							
Acalypha rhomboidea	Raf.	EUP	0.5												0.5												
Medicago lupulina	L.	FAB	0.5	0.5								2			1	0.5											
Trifolium pratense	L.	FAB		0.1																							
Trifolium repens	L.	FAB	1	0.5											2												
Juncus tenuis (dudleyi)	Willd. / (Wieg.)	JUN		0.1												0.1											
Glechoma hederacea	L.	LAM		*																							
Lamium amplexicaule	L.	LAM		*																							
Lycopus americanus	Muhl.	LAM	0.5	0.5		0.5											0.5										
Lemna minor	L.	LEM		0.5	2	2	5	1	2	4								4	2	1	2	5					
Lemna trisulca	L.	LEM			2		0.5		2	3								0.5	2	3	4	5					
Epilobium ciliatum	Raf.	ONA		0.5							0.5	0.5					0.1						2				
Erysimum cheiranthoides	L.	ONA		*																							
Oxalis stricta	L.	OXA	0.5												0.5												
Plantago major	L.	PLA		0.5								0.5			3	1							2				
Agropyron repens	(L.) Beauv.	POA		1		0.5					0.5	2	3	5													
Agrostis gigantea	Roth	POA		3							3	3															

Table 3.9. Continued . . .

Species	Authority	Family	Total cover by Zone: UP	WE	OW	Plot Cover: N4	N5	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S8	S9	S10	S11	S12	S13	S14
Alopecurus carolinianus	Walter.	POA		*																							
Beckmannia syzigachne	(Steud.) Fern.	POA		0.5																							
Bromus inermis	Leyss.	POA		1									2														
Bromus tectorum	L.	POA		*																							
Digitaria sanguinalis	(Schreber)Muhl	POA	0.1																								
Echinochloa muricata	(P.Beauv.) Fern	POA		2							2	1				3	5						2				
Elymus trachycaulus	(Link) Gould	POA		*																							
Glyceria grandis	S. Wats.	POA		1																			3				
Hordeum jubatum	L.	POA		0.5																							
Panicum capillare	L.	POA	1	1							2	0.5				1	0.5										
Phalaris arundinacea	L.	POA		3	1			4					4	2										3			
Phleum pratense	L.	POA	0.5																								
Poa interior	Rydb.	POA		*																							
Poa pratensis	L.	POA		1		1																					
Poa sp.		POA		*																							
Setaria glauca	(L.) P. Beauv.	POA	0.5												3												
unknown Poaceae		POA		2		4						0.5											0.5				
Polygonum erectum	L.	POL		1							0.5	2			1	1											
Polygonum lapathifolium	L.	POL		0.5							0.5				0.5	1											
Polygonum persicaria	L.	POL		1													0.5						0.5				
Rumex crispus	L.	POL		1		2									2	0.5	1						1				
Potamogeton pusillus	L.	POT			0.5				2																		
Ranunculus sceleratus	L.	RAN		*																							
Ranunculus sp.		RAN	0.5	0.5								1				0.5	1										
P:ıentilla norvegica	L.	ROS	0.5													1											
Potentilla rivalis	Nutt.	ROS		*																							
Rubus sp.		ROS		*																							
Galium aparine	L.	RUB		*																							
Populus deltoides	Marshall	SAL		*																							
Penthorum sedoides	L.	SAX		0.5		1										0.5											
Mimulus ringens	L.	SCR		0.5																							
Veronica peregrina	L.	SCR	0.5	0.5							0.5	0.5				0.5	0.5										
Typha sp.		TYP		1	2				0.5	2	2	0.5															
Verbena hastata	L.	VER		0.5																							

Table 3.10. Floristic list annotated with abundance for each zone and plot at Schaefer Prairie. Cover estimates were made on July 28, 1998. Taxonomy follows Gleason and Cronquist (1991) an McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WP - Wet Prairie, SM - Sedge Meadow, EM - Emergent, OW - Open Water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded

			Cover by Zone				Plot Cover																											
Species	Authority	Family	WP	SM	EM	OW	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Acer negundo	L.	ACE		1																													
Alisma plantago-aquatica	L.	ALI		0.1	0.5																												
Sagittaria cuneata	Sheldon.	ALI		0.5		1					1	0.1	3																				
Sagittaria sp.		ALI			0.5	0.5																											
Amaranthus rudis	Sauer.	AMA			0.1																												
Toxicodendron radicans	(L.) Kuntze.	ANA	0.5																														0.5
Cicuta bulbifera	L.	API	0.1						0.1																								
Sium suave	Walter.	API			0.5	1																											
Zizia aptera	(A. Gray) Fern.	API	*																														
Zizia aurea	L.	API	1				2	1											1	1	1	0.5	0.5							0.1	1	0.5	
Apocynum cannabinum (sibiricum)	L.	APO	1						0.1																						0.1	0.1	
Asclepias incarnata	L.	ASC	0.5	1													1																
Asclepias speciosa	Torr.	ASC	0.1																														
Asclepias tuberosa	L.	ASC	0.5																														
Achillea millefolium (lanulosa)	L.	AST	0.1				0.5																										
Artemisia ludoviciana	Nutt.	AST	0.5																														
Aster ericoides	L.	AST	0.1																														
Aster novae-angliae	L.	AST	0.1															0.1															
Aster simplex (lanceolatus)	Willd.	AST	0.1															0.1															
Cirsium arvense	(L.)Scop.	AST	*	*																													
Cirsium sp.		AST	0.5																														
Coreopsis palmata	Nutt.	AST	0.5																0.5														2
Euthamia graminifolia	(L.) Nutt.	AST	*	*																													
Helenium autumnale	L.	AST	0.5																	1													
Helianthus rigidus	(Cass.) Desf.	AST	0.5																			0.1	1										
Helianthus x laetiflorus var. rigida	Pers.	AST	0.5						0.5									0.5	0.5														
Heliopsis helianthoides	(L.) Sweet.	AST	*																														
Liatris aspera	Michx.	AST	0.1																														
Liatris pycnostachya	Michx.	AST	0.5																														
Ratibida pinnata	Vent.	AST	1				1												0.1		1												
Rudbeckia hirta	L.	AST	*																														
Senecio pauperculus	Michx.	AST	*																														
Solidago canadensis	L.	AST	2					2										0.5	0.5	2	1	2								1		4	
Solidago gigantea	Ait.	AST		2																			2										
Solidago rigida	L.	AST	1																2														
Solidago sp.		AST	*																														
Sonchus sp.		AST			0.5																												
Taraxacum officinale	Weber ex Wiggers	AST	0.5																														
Unknown Asteraceae		AST		0.1																			1						0.1				
Lithospermum canescens	(Michx.) Lehm.	BOR	*																														
Rorippa palustris	(L.) Besser.	BRA			0.5																												
Campanula aparinoides	Pursh.	CAM		0.5													0.5													0.5			
Lobelia siphilitica	L.	CAM		*																													
Utricularia vulgaris	L.	CAM		1	1	3						4	2		2										1		2						
Ceratophyllum demersum	L.	CER				2																											
Convolvulus arvensis	L.	CON	0.1																														0.1
Cornus racemosa (foemina)	Lam.	COR	0.1																														
Carex haydenii	Dew.	CYP		1																			4										
Carex interior	Bailey.	CYP		0.5																													
Carex lacustris	Willd.	CYP		1	1	0.5				1				2	1		3							0.5				4	1				

Table 3.10. Continued . . .

			Cover by Zone				Plot Cover																										
Species	Authority	Family	WP	SM	EM	OW	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Carex lanuginosa	Michx.	CYP	3	4						4	2			3	2			5		4				4	0.5				2				
Carex utriculata	F. Boott.	CYP		0.5	0.5																												
Carex sp.		CYP	3					3	2								2			1		4		0.5						3	4		
Cyperus strigosus	L.	CYP			0.5																												
Eleocharis palustris	L.	CYP			0.5																												
Eriophorum polystachion	L.	CYP		•																													
Scirpus acutus	Muhl.	CYP			0.5	1																											
Scirpus heterochaetus	Chase.	CYP			•																												
Scirpus validus	Vahl.	CYP		2																													
Equisetum arvense	L.	EQU	0.1	0.5											0.1			0.1		0.5										0.1			
Equisetum hyemale	L.	EQU	0.5		0.5																												
Amorpha canescens	Pursh.	FAB	0.5																														
Amorpha fruticosa	L.	FAB	0.5																													0.1	
Dalea candida	Michx. ex Willd.	FAB	0.5																														
Dalea purpurea	Vent.	FAB	0.5																												0.1		
Desmodium canadense	(L.) DC.	FAB	0.5					0.5										0.5	1												0.5	0.5	0.5
Ribes americanum	P. Mill.	GRO	•																														
Myriophyllum sibiricum	Komarov.	HAL			0.5	5																			5		5	2					
Iris versicolor	L.	IRI		1																													
Lycopus asper	Greene.	LAM		0.5													0.5													0.5			
Pycnanthemum virginianum	Dur. & Jackson.	LAM	1				0.5	0.5									1				0.5		0.5								0.5	0.5	
Scutellaria galericulata	L.	LAM		•																													
Stachys palustris	(Nutt.) Eplin	LAM		0.5																													
Teucrium canadense	L.	LAM	0.5																				0.5										
Lemna minor	L.	LEM			0.5	0.5																						0.5					
Spirodela polyrhiza	(L.) Scheiden.	LEM		0.5	0.5	0.5																						0.5					
Allium canadense	L.	LIL	0.5																														
Zigadenus elegans	Pursh.	LIL		1																													
Smilacina stellata	(L.) Desf.	LIL	•																														
Lobelia siphilitica	L.	LOB		0.1																													
Lythrum alatum	Pursh.	LYT	0.1																														
Epilobium leptophyllum	Raf.	ONA		0.5																													
Cypripedium candidum	Muhl.	ORC	•																														
Agrostis stolonifera (alba)	L.	POA	1															1	1			0.5										0.5	
Andropogon gerardii	Vitman	POA	3				0.5												3	1	1	0.5											5
Bromus inermis	Leyss.	POA	0.5																													2	
Bromus kalmii	A.Gray.	POA	0.5																														
Calamagrostis canadensis	(Michx.) Beauv.	POA	•																														
Calamagrostis stricta (inexpansa)	(Timm.) Koeler.	POA	0.5	0.5					5																					1			
Echinochloa crusgalli	(L.) P. Beauv.	POA			0.5																												
Echinochloa muricata	(P.Beauv.) Fern	POA	•	•																													
Elymus canadensis	L.	POA	1																		2												
Hierchloe odorata	(L.) Beauv.	POA		•																													
Panicum virgatum	L.	POA	0.5															0.5															
Panicum wilcoxianum	Vasey.	POA	0.1															0.1														0.5	0.1
Phalaris arundinacea	L.	POA		0.5																													
Phleum pratense	L.	POA	0.5																1													1	
Phragmites australis	(Cav.) Trin.	POA		1	2	0.5					0.5													2	1			0.1	1				
Poa palustris	L.	POA	•																														
Poa pratensis	L.	POA	4				4	5										2			5	4									4	3	4
Poa sp.		POA	•																3	2										0.5			
Sorghastrum nutans	(L.) Nash	POA	1																1														
Spartina pectinata	Link.	POA	1				1		1								1													2	0.5		0.5
Sporobolus heterolepis	A. Gray	POA	0.5																														

Table 3.10. Continued . . .

			Cover by Zone				Plot Cover																											
Species	Authority	Family	WP	SM	EM	OW	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
Unknown Poaceae		POA	•																	0.5		3								1		3	
Zizania aquatica	L.	POA				1						1																					
Phlox pilosa	L.	POL	0.5					0.1										0.5	0.5														0.5
Polygonum amphibium	L.	POL	0.5	2	0.5	0.5			0.5	2	1			2	1		2							2	3					0.1			
Polygonum lapathifolium	L.	POL			0.5	1																											
Potamogeton foliosus	Raf.	POT				2																											
Lysimachia quadriflora	Sims.	PRI		0.5																										0.5			
Lysimachia quadrifolia	L.	PRI	1	0.5				0.1										0.5					0.5								0.5		
Lysimachia thrysiflora	L.	PRI		0.5																													
Anemone canadensis	L.	RAN	0.5																	2													0.5
Ranunculus scleratus	L.	RAN				2						0.1																					
Thalictrum dasycarpum	Fischer & Ave-Lall.	RAN	0.5				0.5											0.5		0.1	0.5	0.5	0.1									0.5	
Riccia fluitans	L.	RIC				1																						0.5					
Fragaria virginiana	Duchn.	ROS	0.5					0.5										0.5	0.5		0.1									0.5	0.5	0.5	0.1
Rubus ideaus	L.	ROS	•																														
Spiraea alba	Duroi.	ROS		0.5																													
Galium boreale	L.	RUB	0.5				1										1	0.5	0.5	0.5	0.5										0.5	0.5	
Galium sp.		RUB	•																														
Populus tremuloides	Michx.	SAL		1																													
Salix bebbiana	Sarg.	SAL		1													2																
Salix exigua	Nutt.	SAL		•																													
Salix sp.		SAL		2																													
Comandra umbellata	L.	SAN	•																														
Parnassia glauca	Raf.	SAX		0.5																			0.1										
Pedicularis canadensis	L.	SCR	0.5																														
Pedicularis lanceolata	Michx.	SCR	0.5																														
Sparganium chlorocarpum	Rydb.	SPA			0.5	0.5							0.5																				
Sparganium eurycarpum	Engelm.	SPA		0.5	0.5	0.5																			0.5			0.5					
Typha angustifolia	L.	TYP		1																									2				
Typha sp.		TYP			2	0.5					0.5			0.1														0.5					
Urtica dioica	L.	URT			0.5																												
Viola nephrophylla	Greene.	VIO	•																														
Viola palmata (pedatifida)	L.	VIO	•																														

Spring Peeper Site Description

Directions to Site:

Follow State Route 5 West to Highway 41. Turn left (south) and follow 41 over the hill. Apple orchards on the right will soon give way to the wetland, which can be seen below the road. Turn right at the bottom of the hill (by Mammoth Corp.) and park in the gravel lot on the right. (Page 40 in MN Atlas)

Site Description:

The twelve-hectare (thirty-acre) restoration site is located on the grounds of the Minnesota Landscape Arboretum (MNLA) in Chanhassen, MN. The three-hectare (7.5 acre) wetland basin was drained and tiled in 1927 and again in 1957 for agricultural development. Corn and soybean production continued in the basin until 1989, when the main portion was converted to a hay field (reed canary grass). In 1995 the Arboretum acquired the property.

The immediate land use surrounding the site includes portions of the MNLA (wetland, deciduous forest), urban and industrial development and a major highway (to be four lanes by 2000). Predominant land use in the watershed was previously row crop agriculture, now supplanted by industrial and residential development. The soil mapping unit is Glencoe silty clay loam and Houghton and Muskego mucks.

The goal of the restoration is to create a biologically diverse sedge meadow as a model for developers and others who must restore sedge meadow/shallow marsh wetlands. An additional goal is to use the site for wetland restoration research. Funding for the plant materials and plant management was provided by the Minnehaha Creek Watershed District and the Legislative Commission on Minnesota Resources (LCMR). The MnDNR provided funds for the upland oak savanna tree planting scheduled for April/May 1999. A topographic map of the site is shown in Figure 3.3.

Planting Plan for Restoration:

<u>Basin Restoration & Site Preparation</u>

The species to be restored were chosen on the basis of species lists from nearby pristine wetlands and other sources such as the Minnesota Scientific and Natural Areas Program (MnDNR) (Table 3.11). It was predicted that the Spring Peeper site would support a temporary or seasonal wetland. Species were assigned to one of three planting zones: Lower Meadow, Upper Meadow, and Wet Prairie Buffer. A

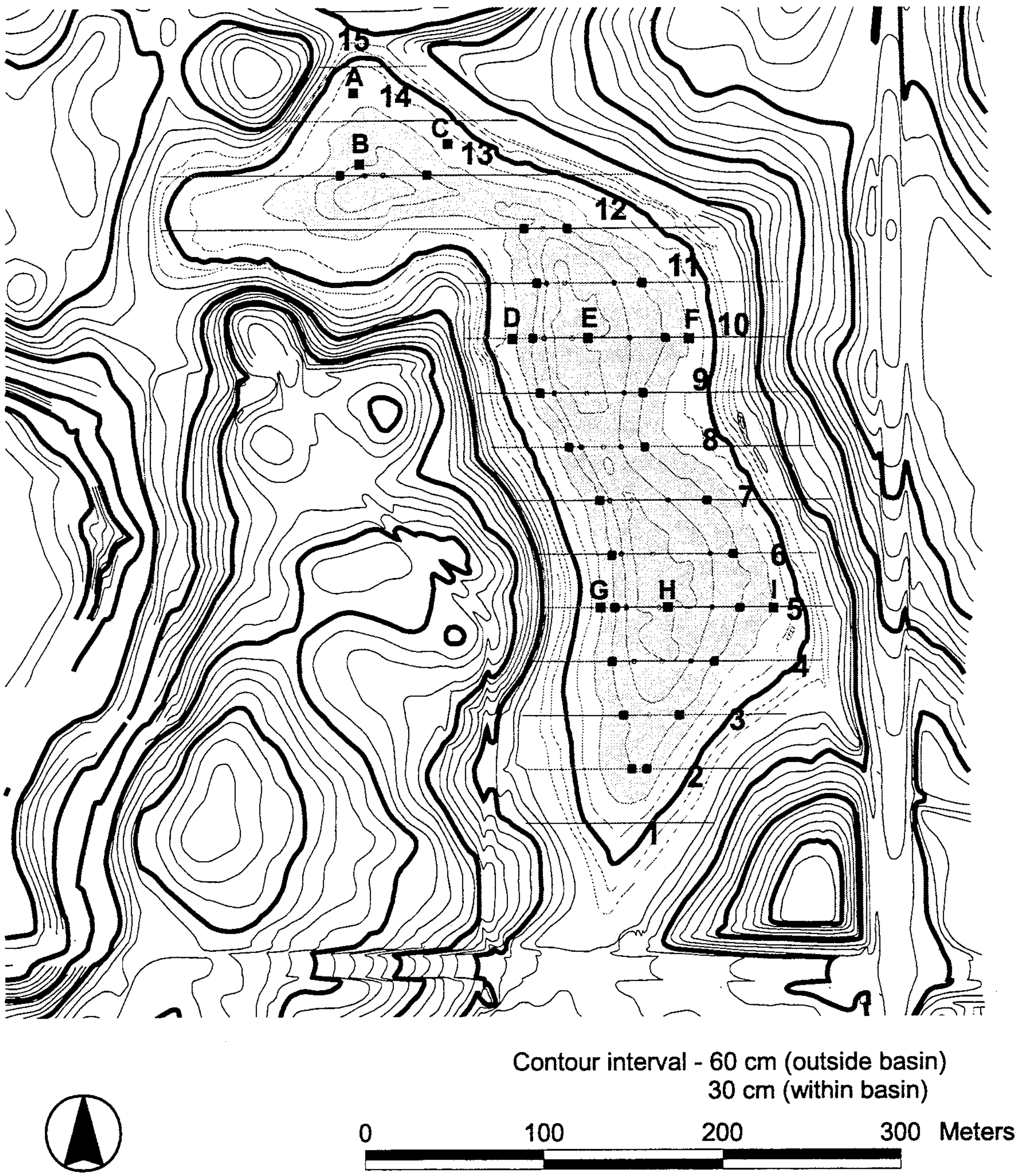


Figure 3.3. Topographic map of the Spring Peeper Meadow planted restoration. Horizontal lines across the wetland represent transect lines for data collection.

hydric cover crop mix (*Polygonum sp.* and *Rumex orbiculatus*) was sown throughout the Upper and Lower Meadows.

Prior to the reintroduction of water, the herbicide RoundUp and prescribed burns were used to control mature stands of reed canary grass (*Phalaris arundinacea*). Existing drainage tile was broken and inline stoplog water control structures were installed in October 1996 to manage water levels. Simultaneous with site preparation, sedges were being propagated for the areas of the wetland that were planted as well as seeded. Nineteen Carices and eight other taxa were propagated from seed or rhizomes.

Species selected for greenhouse propagation were those that were thought to be less likely to successfully germinate in the restoration. In 1996, 15,400 plants were produced to start a wetland nursery in raised beds. In 1997, and additional 35,000 plants were produced to be planted directly into the restoration.

Seed and Plant Installation

The site was seeded in October and November, 1996 using rates and species shown in Table 3.11. Seeds were sown in the fall (i.e. dormant seeding) to allow naturally fluctuating winter temperatures to break seed dormancy. Although the seeds were sown according to Figure 3.3b, a series of storms in November wind-rowed the seeds, primarily along the east side of the basin.

Seedling planting began May 5, 1997 in the Upper Meadow and followed the water level down. Planting began in the Lower Meadow on May 20, 1997. The greenhouse seedlings were used in the Upper Meadow and the larger nursery grown stock was used in the Lower Meadow. Ninety percent of the planting was accomplished by July when heavy rains postponed additional planting. Planting was completed in August. In May, 1998 there was additional planting around the southeast portion of the boardwalk and portions of the Upper Meadow were replanted.

Other

Invasive species were intensively managed using hand-weeding and spot spraying with Rodeo in 1997 and 1998. Water level manipulation was also used to manage weeds, in particular the germination of cattails, by reducing the area of exposed mud.

To encourage visitors, a boardwalk was built across the south end of the restoration (July 1997), a path was created around the east and north sides of the restoration from the parking area (August 1997), twelve interpretive panels were installed along the boardwalk and path, and an overlook shelter (Gallistel Overlook) was built on the northeast side of the wetland.

Table 3.11. Quantities of plants and seeds used in the Spring Peeper revegetation. Seeds were planted in November, 1997. Seedlings and adult divisions were planted summer, 1997.

All seed quantities are bulk.

		Seed Quantities (g)		Plants		
Scientific Name	**Common Name**	**Wetland**	**Upland**	**Wetland**	**Upland**	**Zone**
Acorus calamus	Sweetflag	4191.0		720		Lower meadow
Agastache foeniculum	Hyssop	227.0				Wet prairie
Alisma plantago-aquatic	Broadleaf Plantain	161.0				Lower meadow
Amorpha canescens	Leadplant		170.3			Mesic prairie
Amorpha fruticosa	False Indigo Bush	9.8				Wet prairie
Andropogon gerardii	Big Bluestem		14528.0			Wet prairie, mesic prairie
Anemone canadensis	Canada Anemone	15.9				Wet prairie
Anemone cylindrica	Thimbleweed	20.6				Wet prairie
Asclepias incarnata	Swamp Milkweed	2542.4				Upper meadow
Asclepias tuberosa	Butterflyweed		85.1			Mesic prairie
Aster drummondii	Drummond's Aster	851.0				Wet prairie
Aster lanceolatus	Aster	568.0				Wet prairie
Aster novae-angliae	New England Aster	568.0				Wet prairie
Aster oolentangiensis	Aster		113.5			Mesic prairie
Aster puniceus	Red-Stalked Aster	1857.5				Upper meadow
Aster puniceus	Red Stemmed Aster	1290.0				Wet prairie
Aster umbellatus	Aster	37.1				Wet prairie
Bidens cernua	Nodding Beggar's Ticl	3949.8				Lower meadow, upper meadow
Boltonia asteroides	White Boltonia	283.8				Upper meadow
Bouteloua curtipendula	Sideoats Grama		2270.0			Mesic prairie
Bromus kalmii	Kalm's Brome	2.6				Upper meadow
Calamagrostis canaden	Canada Bluejoint	68100.0				Lower meadow, upper meadow
Caltha palustris	Marsh Marigold	2.2		270		Lower meadow
Campanula aparinoides	Marsh Bellflower	0.2				Lower meadow
Carex atherodes	Slough Sedge	2030.0		360		Lower meadow
Carex bebbii	Bebbs Sedge	234.0		6800		Upper meadow
Carex buxbaumii	Carex	5.4		14		Upper meadow
Carex comosa	Bearded Sedge	9534.0		13680		Lower meadow
Carex cristatella	Crested Sedge	17300.0		7000		Upper meadow
Carex granularis	Meadow Sedge	26.3		804		Upper meadow

Table 3.11. Continued . . .

All seed quantities are bulk.

Scientific Name	Common Name	Seed Quantities (g) Wetland	Seed Quantities (g) Upland	Plants Wetland	Plants Upland	Zone
Carex lacustris	Lake Sedge	12150.0		1458		Lower meadow
Carex lasiocarpa	Needle Sedge	2380.0		1802		Lower meadow
Carex mix	Sedges	919.0		1170		Lower meadow
Carex mix (bebbii,crista	Sedges	5453.5				Upper meadow
Carex pellita (lanuginos	Woolly-Fruit Sedge	980.0		1159		Upper meadow
Carex pseudocyperus	Bottlebrush Sedge			450		Lower meadow
Carex retrorsa	Retrorse Sedge	254.0		1620		Lower meadow
Carex scoparia	Sedges			1080		Upper meadow
Carex stipata	Sedge	390.0		4290		Upper meadow
Carex stricta/haydenii	Tussock Sedge	1210.5		6408		Lower meadow
Carex tenera	Sedge			648		Upper meadow
Carex utriculata (rostrat	Beaked Sedge	5676.0		7920		Lower meadow
Carex vulpinoidea	Fox Sedge	780.0		7700		Upper meadow
Chelone glabra	White Turtlehead			48		Upper meadow
Cicuta bulbifera	Bulblet-Bearing Water	265.0				Lower meadow
Cicuta maculata	Water Hemlock	2.0				Lower meadow
Coreopsis palmata	Prairie Tickseed		56.8			Mesic prairie
Dalea candida	White Prairie Clover	283.8				Wet prairie
Dalea purpurea	Purple Prairie Clover		1362.0			Wet prairie, mesic prairie
Desmodium canadense	Showy-Tick Trefoil	160.4				Wet prairie
Eleocharis spp.	Spike Rush	1690.0				Upper meadow
Elymus canadensis	Nodding Wild-Rye	2271.3				Wet prairie
Epilobium sp.	Willow-herb	43.1				Upper meadow
Eupatorium maculatum	Joe-Pye Weed	4086.0				Upper meadow
Eupatorium perfoliatum	Common boneset	9034.0				Upper meadow
Euthamia graminifolia	Grass Leaved	283.8				Wet prairie
Galium obtusum	Blunt-Leaf Bedstraw	9.6				Lower meadow
Gentiana andrewsii	Bottle Gentian			144		Wet prairie
Geum aleppicum	Yellow Avens	139.0				Upper meadow
Glyceria grandis	Reed Meadowgrass	624.0				Lower meadow
Helenium autumnale	Sneezeweed	58.3				Upper meadow

Table 3.11. Continued . . .

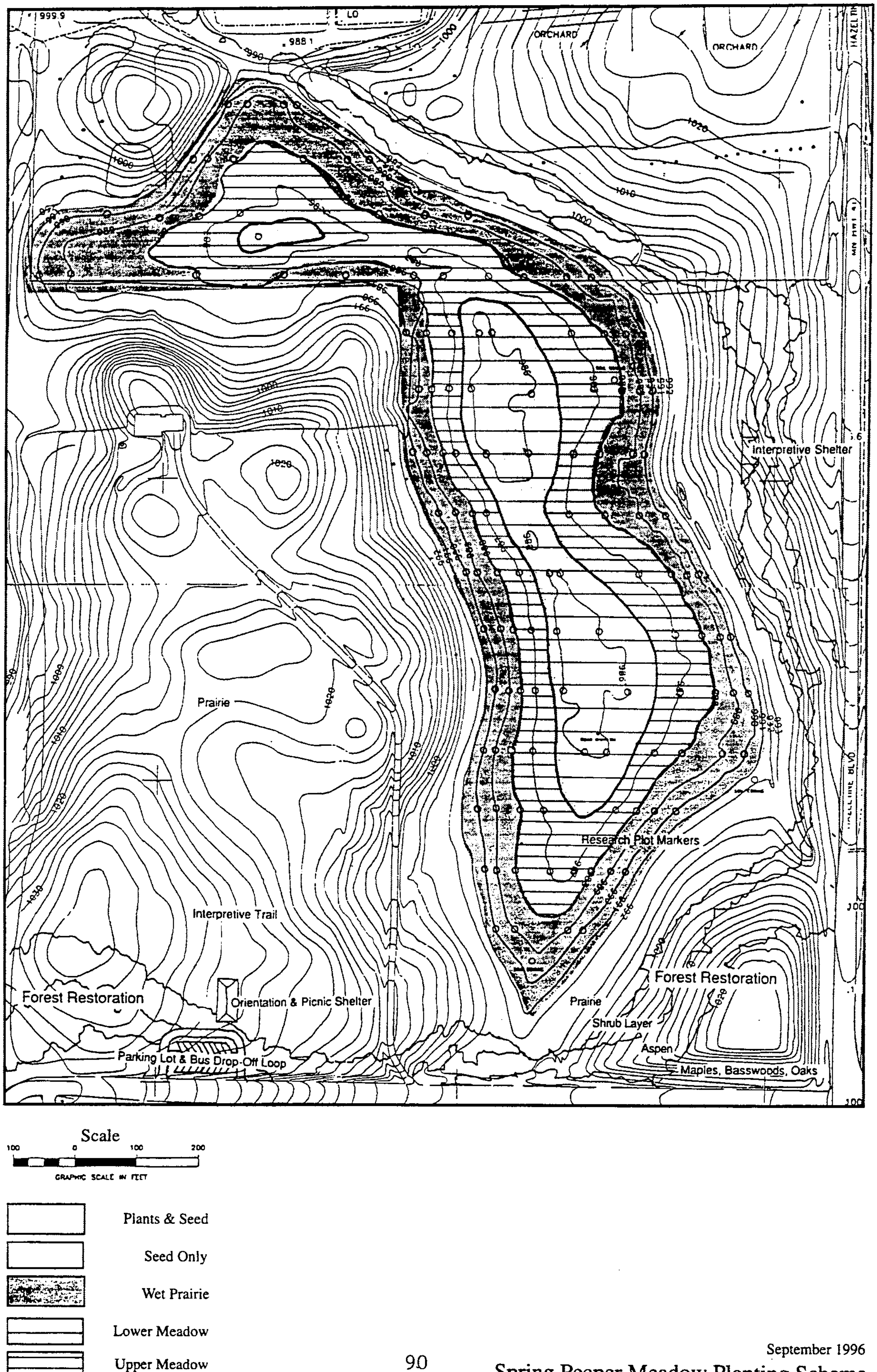
All seed quantities are bulk.

		Seed Quantities (g)		Plants		
Scientific Name	**Common Name**	**Wetland**	**Upland**	**Wetland**	**Upland**	**Zone**
Helianthus giganteus	Tall Sunflower	142.0				Wet prairie
Helianthus rigidus	Sunflower		56.8			Mesic prairie
Heliopsis helianthoides	Ox-Eye	567.5				Wet prairie
Impatiens capensis	Spotted Touch-Me-No	4.2				Upper meadow
Iris versicolor	Blueflag Iris	1642.0		365		Lower meadow
Juncus balticus	Baltic Rush	380.0				Upper meadow
Juncus nodosus	Knotted Rush	574.0				Upper meadow
Lathyrus palustris	Vetchling Peavine	2.0				Lower meadow
Liatris ligulistylis	Blazingstar	5.0		288		Wet prairie
Liatris pycnostachya	Prairie Blazingstar	2270.0				Wet prairie
Lobelia siphilitica	Great Blue Lobelia	10.6				Upper meadow
Lobelia spicata	Pale Spike Lobelia	0.8		648		Wet prairie
Lycopus americanus	American Bugleweed	1572.0				Upper meadow
Lysimachia quadriflora	Four-Flower Loosestri	170.6				Upper meadow
Lysimachia thyrsiflora	Tufted Loosestrife	42.6				Lower meadow
Lythrum alatum	Prairie Loosetrife	8.5				Upper meadow
Mentha arvensis	Field Mint	61.0				Upper meadow
Mimulus ringens	Alleghany Monkey-Flo	19.0		432		Upper meadow
Monarda fistulosa	Bergamot		624.8			Wet prairie, mesic prairie
Muhlenbergia glomerata	Marsh Muhly	76.9				Upper meadow
Onoclea sensibilis	Sensitive Fern			140		Upper meadow
Osmunda cinnamomea	Cinnamon Fern			140		Upper meadow
Panicum virgatum	Switchgrass	1816.0				Wet prairie
Penthorum sedoides	Ditch Stonecrop	5.4				Upper meadow
Phlox pilosa	Downy Phlox	17.1		144		Wet prairie
Physostegia virginiana	Obedient Plant	0.3		5		Upper meadow
Pycnanthemum virginiai	Virginia Mountain Mint	593.3				Wet prairie
Ranunculus spp.	Buttercup	1.0				Upper meadow
Ratibida pinnata	Gray Headed Coneflower		624.3			Wet prairie, mesic prairie
Rudbeckia hirta	Blackeyed Susan		227.0			Mesic prairie
Sagittaria latifolia	Broadleaf Arrowhead	511.0				Lower meadow

Table 3.11. Continued . . .

All seed quantities are bulk.

Scientific Name	Common Name	Seed Quantities (g) Wetland	Seed Quantities (g) Upland	Plants Wetland	Plants Upland	Zone
Schizachyrium scopariu	Little Bluestem		2270.0			Mesic prairie
Scirpus atrovirens	Green bulrush	4551.9				Upper meadow
Scirpus cyperinus	Wool Rush	929.3				Lower meadow
Scirpus fluviatilis	River Bullrush	15.3		3		Lower meadow
Scirpus validus	Soft-Stem Bullrush	250.0				Lower meadow
Scutellaria galericulata	Hooded Skullcap	53.3				Lower meadow
Scutellaria lateriflora	Blue Skullcap	21.4				Upper meadow
Silphium perfoliatum	Cup Plant	49.5				Wet prairie
Sium suave	Hemlock Water-Parsn	4.0				Lower meadow
Solidago nemoralis	Goldenrod		113.5			Mesic prairie
Solidago rigida	Stiff Goldenrod	34.1				Wet prairie
Solidago speciosa	Goldenrod		85.1			Mesic prairie
Sorghastrum nutans	Indaingrass		9307.0			Wet prairie, mesic prairie
Sparganium eurycarpun	Giant Burreed	6062.0				Lower meadow
Spartina pectinata	Prairie Cordgrass	3634.3		1177		Wet prairie
Stachys palustris	Marsh Hedgenettle	126.0				Upper meadow
Teucrium canadense	American Germander	396.0				Upper meadow
Thalictrum dasycarpum	Tall Meadow-Rue	126.0				Wet prairie
Thelypteris palustris	Marsh Fern					Lower meadow
Verbena hastata	Blue Vervain	410.0				Wet prairie
Verbena stricta	Hoary Vervain		170.3			Mesic prairie
Vernonia fasciculata	Prairie Ironweed	4540.0				Upper meadow
Veronicastrum virginicui	Culver's Root	857.3				Wet prairie
Zigadenus elegans	Mountain Death Camu	1.1		48		Wet prairie
Zizia aurea	Golden Alexanders		945.3			Wet prairie, mesic prairie
Total		**195505.2**	**33009.5**	**68935**		
Oats	Wheat/Oats		108960.0			All
Rumex orbiculatus	Great Water Dock	20734.0				Lower meadow, upper meadow
Polygonum penyslvanic	Smartweed	41850.0				Lower meadow, upper meadow
Cover Crop Total		**62584.0**	**108960.0**			



September 1996

Spring Peeper Meadow Planting Scheme

Carpenter Marsh Site Description

Directions to Site:

Follow State Highway 5 West through Waconia. Just beyond Waconia turn right (north) on County Highway 32. Continue on 32 to Paul Avenue Turn right (north) on Paul Avenue and proceed to orchard. Access is on a gravel road on the left, just before the house. The road goes down a small hill and the site is on the right. (Page 40 in MN Atlas)

Site Description and Restoration History:

Originally a wetland, this site was drained in the 1930's for corn production and was cultivated until 1963 (Fig. 3.4). From 1963 to May 1997 the drained basin was used as a sod farm for Kentucky blue grass. In May 1997, the marsh was restored by breaking the tile system and plugging an adjacent ditch. A water control structure was then installed on the southern end of the basin to regulate overflow. No management scheme has been implemented to control undesirable plants

The immediate land use surrounding the site is a commercial tree nursery. Predominant land use in the watershed is row crop agriculture with continued commercial and residential development in the nearby community of Waconia. The soil mapping unit is characterized as peats and mucks.

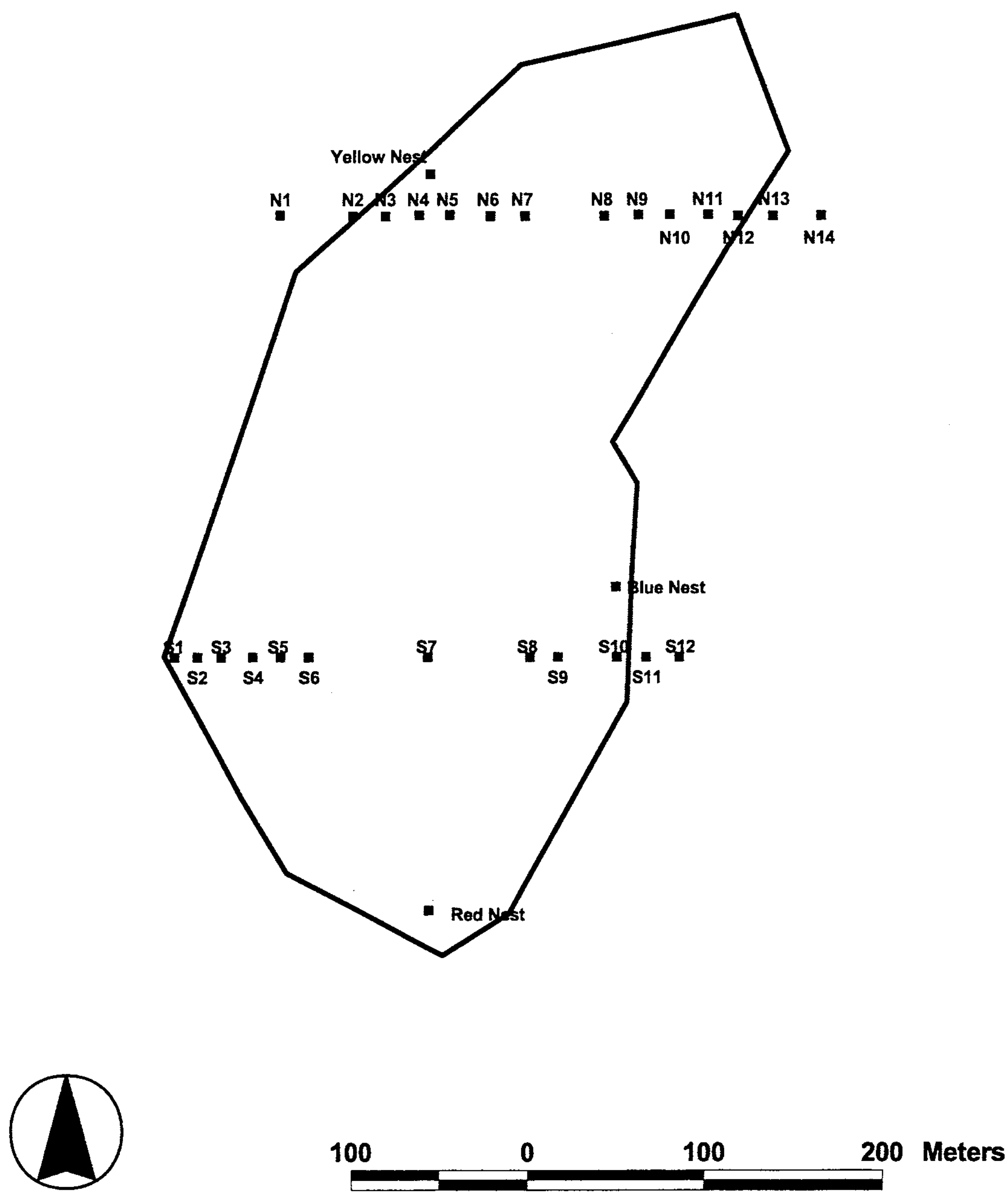


Figure 3.4. Diagram of the Carpenter Marsh unplanted restoration. Numbered points represent data collection plots along north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

Schaefer Prairie Site Description

Directions to Site:

Follow State Route 212 West. 1.5 miles east of Brownton turn left (south) on Nature Ave. (Rt. 4). (The sign for Nature Ave. is small and easily missed--start looking carefully a few miles outside of Brownton.) Nature Conservancy signs are posted at the prairie boundary on the right, about 0.5 mile south. Park on shoulder, beside mailbox. From mailbox follow trail west for approximately 100 m. Wetland is located just to the north of the trail. (Page 31 in MN Atlas)

Site Description:

Originally purchased in 1881, the 160 acres which comprise Schaefer Prairie were mowed annually from 1910 to 1941. However, only 40 acres on the south end of the tract have ever been plowed. Thus, Schaefer Prairie remains a high quality mesic tallgrass prairie community, and, since being obtained by the Nature Conservancy in 1968, has been a designated natural area.

Located in the Minnesota River Prairie subsection of the North Central Glaciated Plains ecoregion, the Schaefer Prairie study site is a depressional wetland within the remnant prairie with wet swales and marshes throughout (Fig. 3.5). Predominant land use in the watershed is row crop agriculture and the soil mapping unit is Glencoe silty clay loam.

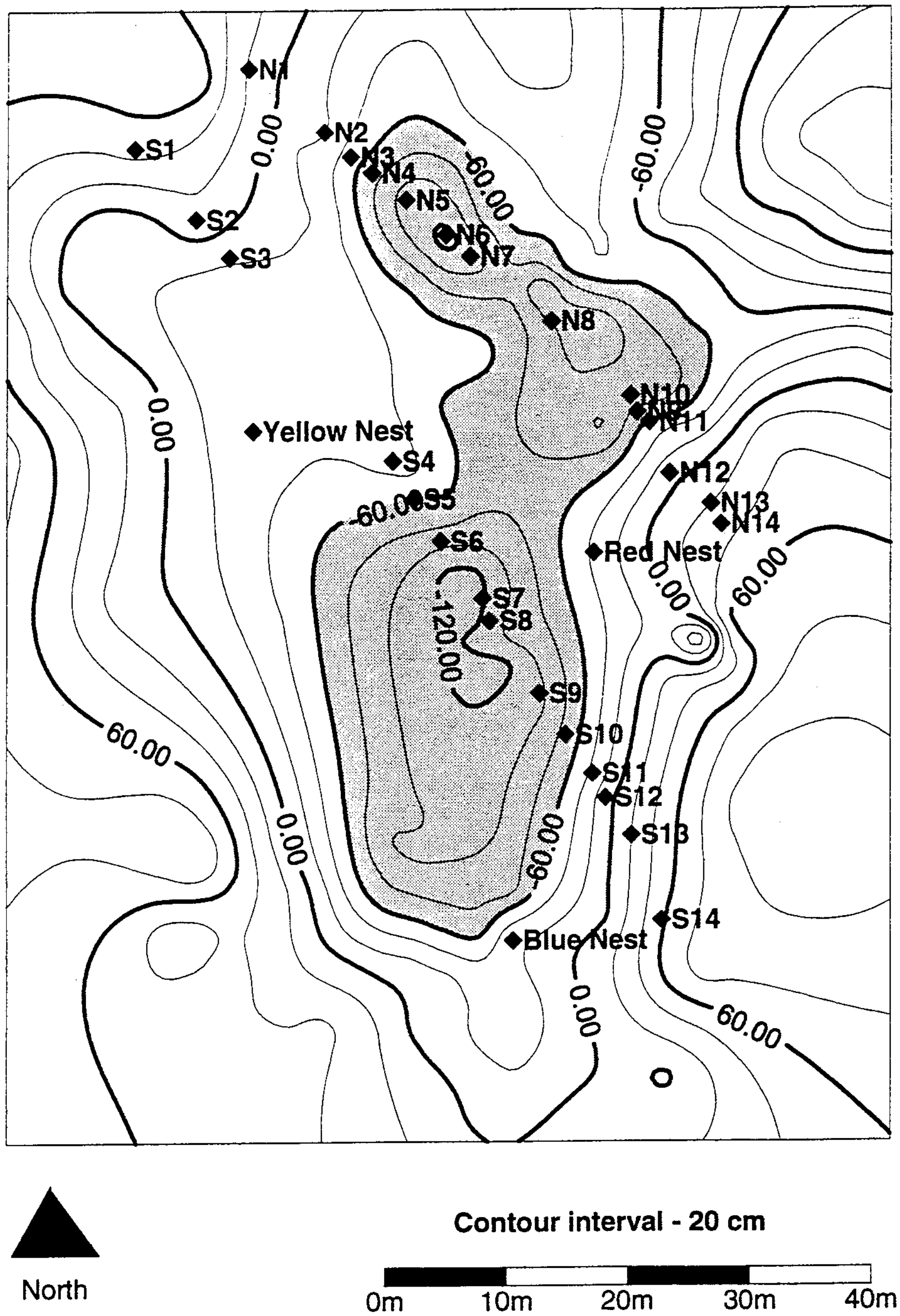


Figure 3.5. Topographic map of the Schaefer Prairie reference wetland for the west metropolitan triplet. Numbered points represent data collection points along north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

East Metropolitan Group

The location of the wetlands in the east metropolitan triplet is shown below. The restored sites were located within an eighth of a mile of each other in St. Paul and the reference site was identified approximately 10 miles further east (Figure 3.6).

	Site	Size (ha)	Location	Ownership
Planted	West Phalen	.34	Ramsey Co., T29 R22 S21	City of St. P.
Unplanted	East Phalen	.09	Ramsey Co., T29 R22 S21	City of St. P.
Reference	Lake Elmo	.75	Washington Co., T30 R21 S22	L.E. Park Res.

Characteristics of Wetlands in the Group

Soils: All three sites had similar soils ranging from Silty Loam and Sandy Loam to Loamy Sand (Table 3.12). In general, the highest values for total organic carbon, total P and total N were observed at the East Phalen wetland at both 0-5 and 25-35 soil depths. The lowest values were observed at the West Phalen restoration. Mean, maximum, and minimum soil temperatures at the surface (2 cm) and at 20 cm were consistently higher at the restored sites than at the reference site (Table 3.13). Exposed soil and lack of trees at West Phalen resulted in surface soil temperatures above the water line that were almost twice as great as temperatures observed at Lake Elmo.

Water: Piezometer nests were vandalized immediately after installation at East Phalen, therefore no data were collected from this site (Table 3.14). Although several piezometers were destroyed at West Phalen, the data collected indicate that West Phalen has strong downward water movement (recharge site). West Phalen also had a large vertical water bounce after rain events due to water entering the wetland from the Lake Phalen inlet. The fluctuation of several vertical feet of water level that occurred repeatedly during the growing season at West Phalen was not observed at any of the other restored wetlands in the study and would rarely, if ever, occur in a native wetland. Surface water fluctuation during the growing season was 148 vertical cm at West Phalen, 28.5 cm at East Phalen, and 56 cm at Lake Elmo. There is no indication of strong directional water movement (discharge or recharge) at Lake Elmo. Water temperature, dissolved oxygen, total alkalinity, conductivity, and pH values were consistently higher at the restoration sites than at the reference wetland (Table 3.15). Water chemistry analysis indicated that chlorine and sulfate levels were one to two orders of magnitude higher at the restoration sites than at Lake Elmo (Table 3.16). In addition, phosporous, calcium. sodium, and potassium were significantly greater at East and West Phalen than at Lake Elmo.

Fauna: Total number of bird species at Lake Elmo (15) as well as the number of breeding species (4) was greater than that seen at the restored sites (Table 3.17). Three species were observed at each of the restoration sites and with mallards and Canada geese representing the two breeding species. No fish were observed in East Phalen (Table 3.18). The site was only recently excavated and does not have a direct connection to another water body. The greatest number of fish species was seen at the West Phalen restoration (7), where fish entered from Lake Phalen through the inlet culvert. Four species were observed at the reference wetland. The greatest number of fish of any one species was the fathead minnow (*Pimephales promelas*) (259) in West Phalen and the central mudminnow (*Umbra limi*) (439) in Lake Elmo. No amphibians were detected in West Phalen (Table 3.19). Amphibian numbers are typically low in wetlands with large numbers of fish. Two amphibian species were observed at East Phalen and five species were noted at Lake Elmo.

Flora: A total of 94 plant species were observed at the West Phalen restoration (Table 3.20), 77 species were noted at East Phalen (Table 3.21), and 71 species were seen at Lake Elmo (Table 3.22).

Site	Upland	Forested Edge	Sedge Meadow	Wet Edge	Open Water
West Phalen	65	x	31	x	9
East Phalen	x	x	x	73	4
Lake Elmo	x	20	48	x	12

Each of the wetlands had at least one unique zone that does not yet occur at the other sites. The sedge meadow and wet edge are the zones of best comparison between the sites. Diversity was highest in the wet edge at East Phalen. The restoration of this site involved the excavation of an existing seasonal wetland, thus many of the species observed in the wet edge zone were native remnants. An equally high number of species would be expected at the reference site, however *Phalaris arundinacea* (reed canary grass) cover was high at Lake Elmo. The presence of this aggressive grass may explain the relatively low species diversity observed in sedge meadow zone. Sixteen (25%) of the 64 species planted as seedlings at the West Phalen restoration were found after the first growing season. Limited water availability after the planting and repeated mowing at the site may have prevented greater establishment of introduced plants.

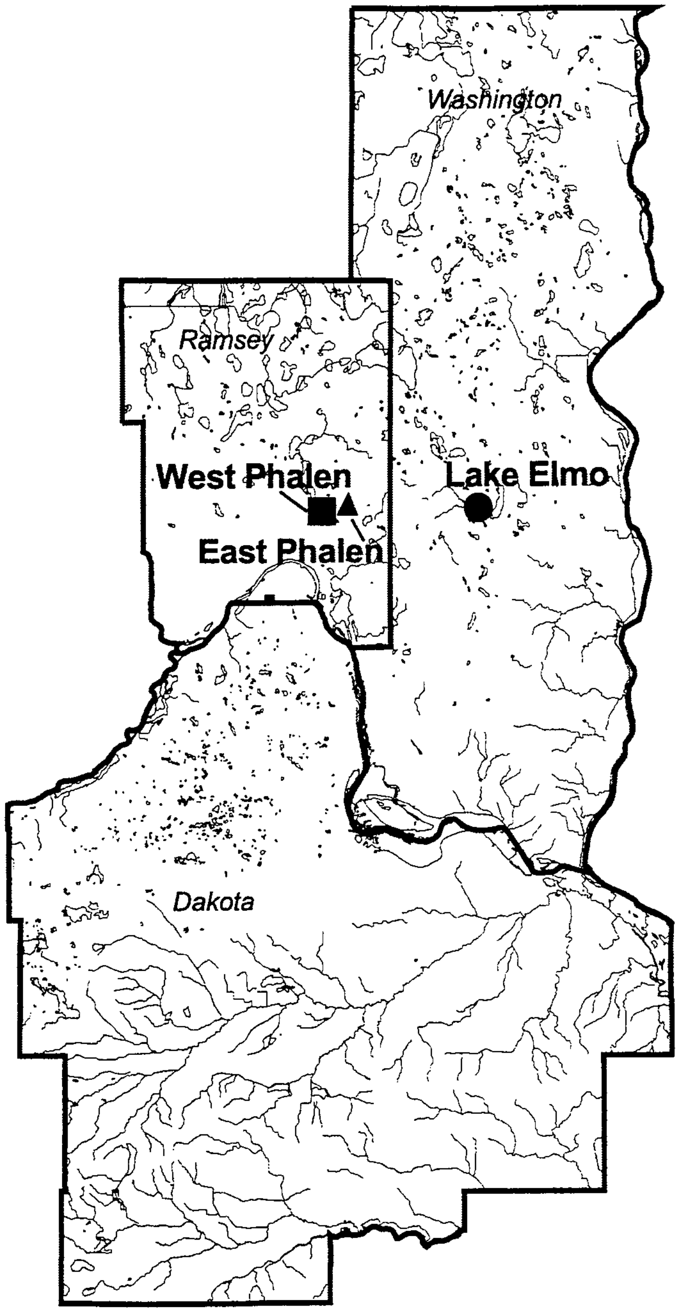


Figure 3.6. Regional map showing the location of the east metropolitan triplet of wetlands.

Table 3.12. Averages of soil characteristics from four stations at each elevation (above, at, and below the water line).

		West Phalen			East Phalen			Lake Elmo		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth										
0-5 cm	Total N (%)	0.17	0.19	0.33	1.12	1.23	0.97	0.28	0.55	0.28
	Total P (ppm)	348	354	364	671	503	335	578	862	609
	Total Org. C (%)	1.4	1.6	2.19	6.9	6.5	5.9	2.63	4.21	2.4
5-25 cm	Texture	Sandy loam to loamy sand			Sandy loam to silty loam			Silty loam to Sandy loam		
25-35 cm	Total N (%)	0.15	0.14	0.12	1.2	1.17	0.24	0.11	0.23	0.3
	Total P (ppm)	275	220	269	432	369	214	427	737	644

Table 3.13. Summary of soil temperature data taken at 2 and 20 cm, 7 times between April and October, 1998. Four sampling stations per site were used to record temperatures at the stationd nearest to the water line, the stations closest to 30 cm above the water line, and the stations closest to 30 cm below the water line.

		West Phalen			East Phalen			Lake Elmo		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth	Temperatures (C)									
2 cm	Mean	25	23.5	22	20	22.3	20	15.3	14.8	14.3
	Minimum	17	17	17	15	18	16	5	2	2
	Maximum	40	34	29	24	36	25	23	27	22
20 cm	Mean	20	21	20.8	15.8	16.8	17.5	13.8	13.3	13
	Minimum	13	14	15	10	11	12	5	4	2
	Maximum	27	26	25	21	22	22	19	20	19

Table 3.14. Total head gradients for piezometers (cm). A negative number indicates upward movement of water.
A positive number indicates downward movement.

East Phalen

Depth Interval	Nest 1			Nest 2			Nest 3		
(cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
				All wells vandalized.					

West Phalen

Depth Interval	Nest 1			Nest 2			Nest 3		
(cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
4/23/98	35	50	9	32	60		22	58	19
5/11/98	32	48	-5	43	10		19	24	16
5/29/98	31	51	-9	43	11		23	34	1
6/15/98	32	50	-8	43	34			5	26
7/3/98	32	52			28			2	21
8/24/98	33	39	-6		0			10	32
9/18/98	33	39	3		21			33	31

152 cm wells vandalized in all nests immediately after installation.
30 cm wells vandalized during midsummer in nests 2 and 3.

Lake Elmo

Depth Interval	Nest 1			Nest 2			Nest 3		
(cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
4/10/98	3	4	-2	6	1	1	1	6	3
5/1/98	8	-4	-6	6	-1	19	2	9	5
5/20/98	4	-4	3	1	-2	2	1	6	-4
6/5/98	2	-4	4	0	-1	1	23	5	-5
7/10/98	1	-3	3	1	-4	3	2	6	-5
8/19/98	4	-4	4	6	3	2	45	9	-5
9/28/98	11	-4	4	14	1	2	42	72	-5

Table 3.15. Summary of alkalinity, conductivity, pH, DO, and water temperatures from April to October 1998.

	West Phalen			East Phalen			Lake Elmo		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (C)	21.3	15.0	25.0	20.1	15.0	23.0	16.1	9.0	20.0
Dissolved Oxygen (mg/l)	8.4	3.3	13.2	6.4	3.8	10.4	1.8	0.6	6.5
Total Alkalinity (mg $CaCO_3$)	36.3	27.0	58.0	64.2	39.0	141.0	14.8	8.0	19.0
Conductivity (uS/cm)	390.5	167.0	482.0	290.6	187.8	381.0	60.8	23.4	84.1
pH	8.9	8.3	9.4	8.5	7.5	9.4	7.3	6.3	8.7

Table 3.16. Anion and cation composition of water. A 'T' indicates trace levels.

Anions (mg/kg)	West Phalen	East Phalen	Lake Elmo Marsh
F	0.185	0.185	0.059
Cl	89.97	27.71	0.663
NO2-N	T	T	T
Br	0.031	0.038	T
NO3-N	T	0.026	0.017
PO4-P	0.036	T	T
SO4	13.71	8.69	0.572
Cations (ug/g)			
Al	0.0448	0.0543	0.1295
Si	0.5868	0.6998	0.8056
P	51.8656	24.6404	0.3716
Fe	0.4017	0.4233	2.996
Mn	0.0091	0.035	0.4308
Sr	0.0607	0.0899	0.0314
Ba	0.0215	0.0665	0.106
Ca	27.0792	55.403	8.2706
Mg	9.5884	10.1548	2.6775
Na	95.8419	39.7855	1.7652
K	113.2843	60.6162	2.969

Table 3.17. Number of birds of each species detected during three bird surveys conducted between dawn and 0900 h between 5 May and 10 July. Upland bird species are not included in this listing. This list includes incidental detections.

Coded breeding evidence of birds detected in surveys at each site. 0 = species not present; 1 = species present; 2 = singing male detected; 3 = male and female of species seen together; 4 = nesting activity detected for this species; 5 = young produced for this species. Maximum breeding evidence for each species at each site is found in the Summary column. Upland bird species are not included in this listing. This list includes incidental detections.

	Common Name	*Scientific Name*	West Phalen Total	West Phalen Breedin	East Phalen Total	East Phalen Breeding	Lake Elmo Total	Lake Elmo Breeding
BARS	Barn swallow	*Hirundo rustica*	0	0	0	0	2	1
BEKI	Belted Kingfisher	*Ceryle alcyon*	0	0	0	0	2	1
BWTE	Blue-winged teal	*Anas discors*	0	0	0	0	2	3
CAGO	Canada goose	*Branta canadensis*	4	3	7	5	8	5
COYE	Common yellowthroat	*Geothlypis trichas*	0	0	0	0	5	2
GTBH	Great blue heron	*Ardea herodias*	0	0	0	0	1	1
GREG	Great egret	*Casmerodius albus*	0	0	0	0	1	1
KILL	Killdeer	*Charadrius vociferus*	3	1	0	0	0	0
MALL	Mallard	*Anas platyrhynchos*	25	5	24	5	3	3
MAWR	Marsh wren	*Cistothorus palustris*	0	0	0	0	2	2
RWBL	Red-winged blackbird	*Agelaius phoeniceus*	0	0	0	0	21	3
SORA	Sora	*Porzana carolina*	0	0	0	0	3	2
SWSP	Swamp sparrow	*Melospiza georgiana*	0	0	0	0	2	2
TRES	Tree swallow	*Tachycineta bicolor*	0	0	0	0	1	1
VIRA	Virginia rail	*Rallus limicola*	0	0	0	0	3	2
WODU	Wood duck	*Aix sponsa*	0	0	1	1	0	0
YWAR	Yellow warbler	*Dendroica petechia*	0	0	0	0	2	2
	Total Number of Species		3		3		15	
	Total Number of Breeding Bird Species			2		2		4
	Total Abundance		32		32		58	

Table 3.18. Total numbers of fish caught in minnow traps and aquatic activity traps at each site visit.

Common Name	Scientific Name	West Phalen	East Phalen	Lake Elmo
	Ameiurus melas	0	0	1
Brook Stickleback	*Culaea inconstans*	7	0	0
Iowa Darter	*Etheostoma exile*	7	0	2
Pumpkinseed	*Lepomis gibbosus*	25	0	0
Bluegill	*Lepomis macrochirus*	28	0	0
Yellow Perch	*Perca flavescens*	7	0	0
Fathead Minnow	*Pimephales promelas*	259	0	2
Central Mudminnow	*Umbra limi*	4	0	439
	Total abundance	337	0	444

Table 3.19. Amphibians detected in the following surveys: VES-Day - daytime visual encounter search, VES-Night - night time visual encounter search, Larval - minnow traps and aquatic activity traps, Chorus - chorusing sruveys.
Number of adults and/or juveniles detected during 30 min. visual encounter search (VES) conducted between 0800 and 1000 h. Surveys began 4/07/98 and ended 7/10/98.
Total amphibian larvae caught in minnow traps and aquatic activity traps on each site site and overall total. Adults were also occasionally found in these traps as well and these are reported here separately from the larval data and as totals only.
Chorusing surveys were conducted for 10 minutes beginning 2 h after sunset from 4/06/98 to 7/10/98. 0 = no individuals of this species detected 1 = individual calls can be distinguished, no overlap 2 = individual calls can be distinguished but are overlapping 3 = calls cannot be distinguished individually, constant and overlapping. Number given is the highest chorusing designation recorded over all site visits.

		West Phalen				East Phalen				Lake Elmo			
Common Name	Scientific Name	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus
Northern leopard frog	*Rana pipiens*	0	0	0	0	0	0	0	0	4	8	15	2
Wood frog	*Rana sylvatica*	0	0	0	0	0	0	0	0	0	1	0	0
Green frog	*Rana clamitans*	0	0	0	0	0	0	0	0	0	0	0	1
Western chorus frog	*Pseudacris triseriata*	0	0	0	0	5	3	2	3	0	0	0	0
Cope's gray treefrog	*Hyla chrysoscelis*	0	0	0	0	0	0	0	0	0	0	0	2
Treefrog	*Hyla sp.*	0	0	0	0	0	0	0	0	0	1	0	0
American toad	*Bufo americanus*	0	0	0	0	20	0	41	2	0	0	0	0

Table 3.20. Floristic list annotated with abundance for each zone and plot at West Phalen Marsh. Cover estimates were made on July 22, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: UP - upland prairie, SM - sedge meadow, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded. Missing numbers indicate transect points which were destroyed prior to surveying, then re-installed later.

			Total Cover By Zone			Plot Cover																								
Species	Authority	Family	UP	SM	OW	N4	N5	N6	N7	N8	N9	N11	N12	N13	N14	N15	N16	N17	S4	S5	S6	S7	S8	S9	S11	S13	S14	S15	S16	S17
Acer negundo	L.	ACE	0.5			0.1																								
Alisma plantago-aquatica	L.	ALI			0.1			1																						
Sagittaria sp.		ALI			0.1											3														
Zizia aurea	L.	API	*																											
Amaranthus sp.		AMA	0.5																											
Asclepias incarnata	L.	ASC		0.5													1			0.1										
Ambrosia artemisiifolia	L.	AST	0.5	0.5		0.5																							0.5	
Arctium minus	Schk.	AST	0.5																											
Aster sp.	L.	AST	0.1			0.1																							1	
Bidens sp.		AST	0.1															0.5												0.5
Cirsium arvense	(L.) Scop.	AST		0.5																										
Conyza canadensis	L.	AST	0.5															1											0.5	1
Liatris pycnostachya	Michx.	AST	0.1			2																								
Matricaria matricarioides	L.	AST	0.5																											
Rudbeckia hirta	L.	AST	3	0.5															0.5	0.5									2	3
Taraxacum officinale	Weber ex Wiggers.	AST	0.5			0.5	0.1										1		2	0.5									2	1
Berteroa incana	(L.) DC.	BRA	0.5																											0.5
Capsella bursa-pastoris	(L.)Medic.	BRA	0.5																											
Lepidium densiflorum	Schrad.	BRA	*																											
Rorippa palustris	(L.) Besser.	BRA	1	1													3			0.1										
Rorippa sylvestris	(L.) Besser.	BRA		0.5																										
Thlaspi arvense	L.	BRA	*																											
Lonicera xylosteum	L.	CAP	*																											
Cerastium nutans	Raf.	CAR	*																											
Cerastium vulgatum	L.	CAR	0.5																											
Silene latifolia	Poiret.	CAR	0.5																											
Stellaria alsine	Grimm.	CAR	2	0.5														0.1											1	0.5
Stellaria media	(L.) Villars.	CAR	0.5																											
Chenopodium album	L.	CHN	2			0.5	0.5										0.5		2	0.5									0.5	
Chenopodium sp.		CHN	*																											
Convolvulus arvensis	L.	CON	1															0.1											2	
Carex sp.		CYP		1			0.1										1		1	2										0.5
Carex stricta	Lam.	CYP		0.5			0.5																							
Carex vulpinoidea	Michx.	CYP		0.5																1										
Cyperus esculentus	L.	CYP		0.5																										
Scirpus validus	Vahl.	CYP			1			1								2					2							1		
Acalypha rhomboidea	Raf.	EUP		0.5														1												
Lotus corniculatus	L.	FAB	*																											
Medicago lupulina	L.	FAB	1				0.5												0.1										2	
Melilotus alba	L.	FAB	0.5			0.1																								1
Trifolium arvense	L.	FAB	*																											
Trifolium pratense	L.	FAB	0.5																											
Trifolium repens	L.	FAB	1			0.5	0.5										2	2	0.5	0.5									1	3
Myriophyllum sibiricum	Komarov.	HAL			1			0.5	0.1	2		4	2	1	1									1	1		3			
Elodea canadensis	Michx.	HYD			5							3	5											4	4	1				
Juncus sp.		JUN		0.5														0.1												
Juncus tenuis	Willd	JUN	0.5	0.5		0.1																							0.1	
Glechoma hederacea	L.	LAM	0.5																											
Lycopus sp.		LAM	0.5			0.5												1												
Monarda fistulosa	L.	LAM		0.1																										
Nepeta cataria	L.	LAM	0.1															0.1												
Lysimachia terrestris	(L.) BSP	LYS		0.5																0.5										
Abutilon theophrasti	Medikus	MAL	0.1																											
Najas flexilis	(Willd.) Rostk.	NAJ			1				2	5	2			2	1	0.5					1	5	5	2	1		2			
Oxalis dillenii	Jacq.	OXA	0.5			0.5											1	0.5	0.5										0.5	0.5
Plantago major	L.	PLA	2			2	0.5										1	1	0.5	1									1	2
Phlox pilosa	L.	PLM	0.5																											
Alopecurus pratensis	L	POA	0.5																											
Andropogon gerardii	Vitman	POA	1			2	1												0.5											
Bromus inermis	Leyss.	POA	*																											
Bromus tectorum	L.	POA	*																											
Calamagrostis canadensis	(Michx.) Peauv.	POA		*																										
Digitaria sanguinalis	(L.) Scop.	POA	3					0.1																						
Echinochloa muricata	(P.Beauv.) Fern.	POA	0.5	2														0.5	2	2										
Panicum capillare	L.	POA	0.5					0.1																					0.5	
Panicum dichotomiflorum	Michx.	POA	0.5	0.5																										
Phalaris arundinacea	L.	POA		0.5																										
Poa annua	L.	POA	*																											

Table 3.20. Continued

Species	Authority	Family	Total Cover By Zone UP	SM	OW	Plot Cover N4	N5	N6	N7	N8	N9	N11	N12	N13	N14	N15	N16	N17	S4	S5	S6	S7	S8	S9	S11	S13	S14	S15	S16	S17
Poa pratensis	L.	POA	*	*																										
Setaria faberi	R. Herm.	POA	0.5															0.5		0.5										
Setaria glauca	(L.) P. Beauv.	POA	*																											
Spartina pectinata	Link	POA		0.5														1												
Unknown Poaceae		POA	2	2			1										0.5	2	2										0.5	
Polygonum sp.		POL		0.5													0.5		0.5											
Polygonum aviculare	L.	POL	2	0.5		0.5		0.5										1	1	2								0.5		1
Polygonum persicaria	L	POL		*																										
Polygonum lapathifolium	L.	POL	1				3									1	1		2	2										
Polygonum pensylvanicum	L.	POL		1																								1	1	
Polygonum punctatum	Elliott	POL	0.5				0.1												0.5	0.5										
Rumex obtusifolia	L.	POL	1																											
Rumex sp.		POL		0.5															2											0.5
Potamogeton crispus	L.	POT			0.5							1	2																	
Potamogeton pusillus	L.	POT			1				2	2	4	1	2	5	2	0.5						4	3	2						
Potamogeton zosteriformis	Fern.	POT			0.5							1																		
Aquilegia canadensis	L.	RAN	0.5																											
Caltha palustris	L.	RAN		0.1																									0.1	
Ranunculus abortivus	L.	RAN	0.5																											
Potentilla argentea	L.	ROS	1			0.5											1	1	0.5										2	2
Populus deltoides	Marshall	SAL	1																											
Lindernia dubia	(L.)Penn.	SCR		0.5																	0.5						0.5	0.5		
Mimulus ringens	L.	SCR		0.5																									1	
Verbascum thapsus	L.	SCR	0.5																											1
Veronia peregrina	L.	SCR		*																										
Veronica serpyllifolia	L.	SCR		*																										
Typha angustifolia	L.	TYP		0.5																										
Urtica dioica	L.	URT	0.5																											
Verbena bracteata	L. & R.	VER	*																											
Verbena hastata	L.	VER	0.5	0.5															0.5											
Viola sororia	Willd.	VIO	0.5														0.5													
Vitis riparia	Michx.	VIT	0.1				0.1																							

Table 3.21. Floristic list annotated with abundance for each zone and plot at East Phalen Marsh. Cover estimates were made on July 24, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WE -Wet Edge, OW - Open water.
A *indicates where a species is presumed to have occurred, although no cover estimate was recorded

			Total Cover By Zone		Plot Cover																
Species	Authority	Family	WE	OW	W2	W3	W4	W5	W6	W7	W8	W9	W10	E1	E2	E3	E4	E5	E6	E7	E8
Acer negundo	L.	ACE	0.5										2								
Alisma plantago-aquatica	L.	ALI	0.5																		
Sagittaria sp.		ALI	0.5								1										
Zizia sp.		API	0.5													2					
Asclepias cf. tuberosa	L.	ASC	0.5																		
Asclepias incarnata	L.	ASC	0.5																		
Ambrosia artemisiifolia		AST	0.5													0.5					
Aster sp.	L.	AST	0.5											0.5							
Cirsium arvense	(L.) Scop.	AST	0.5													1					
Conyza canadensis	L.	AST	0.5																		
Crepis tectorum	L.	AST	*																		
Erigeron philadelphicus	L.	AST	0.5																		
Erigeron strigosus	Muhl	AST	0.5																		
Eupatorium maculatum	L.	AST	0.5																		
Eupatorium perfoliatum	L.	AST	1																		
Matricaria matricarioides	L.	AST	0.5																		
Taraxacum officinale	Weber ex Wiggers	AST	0.5											0.5							
Unknown Forb			0.5																		
Impatiens capensis	Meerb.	BAL	3									4				2					
Cardimine pensylvanica	Muhl.	BRA	*																		
Nuphar microphylla	(Pers.) Fern.	CAB		0.5																	
Lonicera xylosteum	L.	CAP	0.5																		
Silene latifolia	Poiret.	CAR	0.5																		
Echinocystis lobata	(Michx.) T. & G.	CUC	0.5																		
Carex atherodes	Sprengel.	CYP	0.5			0.5															
Carex bebbii	(L.H. Bailey) Fern.	CYP	0.5											1							
Carex conjuncta	F. Boott.	CYP	*																		
Carex crawfordii	Fern.	CYP	*																		
Carex lacustris	Willd.	CYP	0.5		0.5																
Carex vulpinoidea	Michx.	CYP	0.5			0.5										2					
Eleocharis sp.	L.	CYP	0.5																		
Scirpus cyperinus	(L.) Knuth.	CYP	*																		
Scirpus validus	Vahl.	CYP	1																		
Medicago lupulina	L.	FAB	*																		
Melilotus alba	L.	FAB	0.5																		
Trifolium pratense	L.	FAB	0.5																		
Iris versicolor	L.	IRI	0.5																		
Juncus nodosus	L.	JUN	0.5													1					
Juncus tenuis	Willd.	JUN	*																		
Glechoma hederacea	L.	LAM	0.5																		
Lycopus americanus	L.	LAM	0.5																		
Mentha arvensis	L.	LAM	1													1					
Scutellaria lateriflora	L.	LAM	0.5											2							
Lemna minor	L.	LEM		0.5		0.5	0.5	0.5	0.5	0.5	1				0.5	0.5	0.5	0.5	0.5		0.5
Oenothera biennis	L.	ONA	1																		
Plantago major	L.	PLA	0.5																		
Calamagrostis canadensis	(Michx.) Beauv.	POA	*																		
Agrostis capillaris	L.	POA	0.5																		
Agrostis hyemalis	Walter BSP	POA	0.5													0.5					
Echinochloa muricata	(P.Beauv.) Fern	POA	2			1					3					0.5					
Leersia oryzoides	(L.) Swartz	POA	*																		
Lolium perenne	L.	POA	*																		
Panicum villosissimum	Nash.	POA	0.5											0.5							
Phalaris arundinacea	L.	POA	4		5	3					1	3		1							
Poa annua	L.	POA	*											0.5							
Unknown Poaceae		POA	0.5																		
Polygonum lapathifolium	L.	POL	0.5			1					1										

Table 3.21. Continued.

Species	Authority	Family	Total Cover By Zone		Plot Cover																
			WE	OW	W2	W3	W4	W5	W6	W7	W8	W9	W10	E1	E2	E3	E4	E5	E6	E7	E8
Polygonum persicaria	L.	POL	0.5													1					
Polygonum sagittatum	L.	POL	1								0.1			0.5							
Rumex maritimus	L.	POL	0.5																		
Rumex sp.		POL	0.5																		
Potamogeton foliosus	Raf.	POT		0.5				0.5	1								0.5	1	0.5	0.5	
Ranunculus pensylvanicus	L.f.	RAN	0.5																		
Ranunculus sceleratus.	L.	RAN	0.5																		
Rhamnus cathartica	L.	RHA	1									0.1	2								
Rhamnus frangula	L.	RHA	0.5		1																
Geum laciniatum	Murray	ROS	0.5																		
Potentilla norvegica	L.	ROS	0.5																		
Potentilla rivalis	Nutt.	ROS	0.5																		
Salix exigua (interior)	Nutt.	SAL	1													2					
Penthorum sedoides	L.	SAX	0.5																		
Mimulus ringens	L.	SCR	1			0.5										1					
Verbascum thapsus	L.	SCR	0.5																		
Veronica peregrina	L.	SCR	0.5																		
Solanum sp.		SOL	0.5											0.5							
Typha angustifolia	L.	TYP		0.5												0.1					
Urtica dioica	L.	URT	1																		
Verbena hastata	L.	VER	2													0.5					
Verbena urticifolia	L.	VER	0.5																		
Parthenocissus quinquefolia	(L.) Planchon.	VIT	1																		
Parthenocissus sp.		VIT	•										3			2					

Table 3.22. Floristic list annotated with abundance for each zone and plot at Lake Elmo Marsh. Cover estimates were made on July 16, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: FE - Forested Edge, SM - Sedge Meadow, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Cover by Zone			Plot Cover																				
Species	Authority	Family	FE	SM	OW	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Sagittaria sp.		ALI		0.5	0.5							0.5	0.1	0.1								1	0.5	0.5	0.5	
Cicuta bulbifera	L.	API		0.5	0.5																	0.1	0.5			
Asclepias incarnata	L.	ASC		2																						
Aster sp.	L.	AST		1											1											
Bidens sp.		AST		1								0.5	0.1	0.5								0.5	0.5	1		
Cirsium sp.		AST		*		0.1																				
Maianthemum canadense		AST		1											2											
Matricaria matricarioides	L.	AST	0.5																							
Taraxacum officinale	Weber ex Wiggers	AST	0.5																							
Brassica rapa	L.	BRA		*																						
Campanula aparinoides	Pursh	CAM		0.1																						0.1
Lonicera xylosteum	L.	CAP	*																							
Sambucus canadensis	L.	CAP	0.5													2										
Silene latifolia	Poiret.	CAR		1																						
Ceratophyllum demersum	L.	CER			1																					
Echinocystis lobata	(Michx.) T. & G.	CUC		0.5																						
Carex comosa	F. Boott.	CYP		0.5								0.5														
Carex haydenii	Dew.	CYP		1														0.5								
Carex lanuginosa	Michx.	CYP		*																						
Carex scoparia	Schk.	CYP		*																						
Carex stricta	Lam.	CYP		*																						
Carex sp.		CYP		0.5																						
Cyperus strigosus	L.	CYP		*																						
Eleocharis acicularis	(L.) R. & S.	CYP		*																						
Eleocharis obtusa	(Willd) J.A.	CYP		*																						
Eleocharis ovata	(Roth.) Roemer. & Schultes.	CYP		2								1	2	1								1				
Eleocharis palustris	L.	CYP		0.5																						
Eleocharis tenuis	(Willd.) Schultes.	CYP		*																						
Scirpus atrovirens	Willd.	CYP		*																						
Scirpus cyperinus	(L.) Knuth.	CYP		1																						
Scirpus fluviatilis	(Torr.) A. Gray	CYP		0.5																						
Ribes americanum	P. Mill	GRO	0.5													2	1									
Hypericum sp.		HYP		1																		0.1				
Iris versicolor	L.	IRI		0.5									3													
Lycopus uniflorus	Michx.	LAM		1								1	1										0.5	2		
Scutellaria galericulata	L.	LAM		1													1	0.5								
Scutellaria lateriflora	L.	LAM		0.5			0.1						0.5		0.5								0.5	0.5		

Table 3.22. Continued.

Species	Authority	Family	Cover by Zone FE	SM	OW	Plot Cover N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
Lemna minor	L.	LEM		2	1		1	5	5	0.5	1	1	0.5	5			2	4	4	1	1	3	2	1	5	0.5
Spirodela polyrhiza	(L.) Schleid.	LEM			0.5													0.5	1			0.5				
Wolffia columbiana	Karst.	LEM		0.5	0.5		0.5	1	3		0.1							0.5	1	1	1	0.5		0.5		
Najas flexilis	(Willd.)Rostk.	NAJ			0.5															1	1					
Nuphar sp.		NYM			*																					
Circaea lutetiana	L.	ONA		1		0.1																				
Onoclea sensibilis	L.	ONO		0.5																						
Oxalis stricta	L.	OXA	0.1												0.1											
Agrostis hyemalis	(Walter) BSP.	POA		*																						
Bromus inermis	Leyss.	POA		*																						
Leersia oryzoides	(L.) Swartz.	POA		4	0.5				0.5			3	2	2					1			2	2	4		0.5
Phalaris arundinacea	L.	POA	2	4		4	5								3	2	4	2							2	1
Unknown Poaceae		POA		1																						3
Polygonum amphibium	L.	POL	0.5	1		1																				
Polygonum sagittatum	L.	POL		0.5																						1
Potamogeton sp.		POT			5					5	5								4	5	5	2				
Lysimachia terrestris	(L.) BSP.	PRI		1								0.5		0.5									0.5	0.5	0.5	0.5
Lysimachia thyrsiflora	L.	PRI		*																						
Anemone sp.		RAN	0.5												0.5											
Thalictrum dasycarpum	Fischer & Ave-Lall.	RAN	*																							
Rhamnus cathartica	L.	RHA	0.5																							
Riccia fluitans		RIC		0.5	0.5		0.5	3	1					0.5				0.5	1			0.1		0.5	0.5	
Geum canadense	Jacq.	ROS	*																							
Rubus idaeus	L.	ROS	0.5												2											
Rubus occidentalis	L.	ROS	0.5													2										0.5
Galium aparine	L.	RUB		1																						
Galium boreale	L.	RUB		1																						
Galium labradoricum	Wieg.	RUB		0.5																						
Galium sp.		RUB		0.5								0.5											0.5			
Populus deltoides	Marshall	SAL	0.5												0.1											1
Solanum dulcamara	L.	SOL	0.5												0.5											
Sparganium eurycarpum	Engelm.	SPA			0.1																					
Typha latifolia	L.	TYP		4			0.5	1	2			3	0.1	1				2	2				2	0.5		
Urtica dioica	L.	URT	0.5												1											
Verbena hastata	L.	VER	0.5																							
Parthenocissus quinquefolia	(L.) Planchon	VIT	0.5													2	1									1
Vitis riparia	Michx.	VIT	0.5													2										2

West Phalen Site Description

Directions to Site:

Follow I-94 East to 35E North. Continue on 35E to Maryland Ave. Turn right (east) on Maryland Ave. and continue to Johnson Pkwy. Site is visible at intersection, where a large sign indicates the partners involved in the project. (Page 41 in MN Atlas)

Site Description:

The West Phalen wetland restoration is located on the southeast side of Lake Phalen at the corner of Maryland Avenue and Johnson Parkway in St. Paul, MN. Originally a single basin that included the East Phalen site, the wetland was divided by a railroad bed and then filled in. The immediate land use around the site is mostly urban/residential development with some small tracts of degraded forest adjacent. The dominant land use in the area is urban development and Phalen Park, which includes Lake Phalen, recreation area and a nearby golf course. The soil mapping unit is Histsol/Aquoll. A topographic map of the site is shown in Figure 3.7.

Planting Plan for Restoration:

Basin Restoration & Site Preparation

The site was restored in May 1997 by excavating a filled-in basin. An inlet flows from Lake Phalen and a stormwater drain enters from Johnson Parkway. A second drain from Maryland Avenue is blocked. In August 1997, the entire site was spot sprayed with Roundup to kill turf and other weeds, although the use of herbicide was minimal as the St. Paul Parks Department has a policy of not using herbicides in its public parks. A small stand of reed canary grass (*Phalaris arundinacea*) was identified prior to planting which was not sprayed, but may have been hand-pulled. A boardwalk was constructed in August 1998 to facilitate neighborhood interest in the site.

The goal of the restoration was to create a wetland park that would serve as a neighborhood signature amenity. Project planners also anticipated that the site might function to clean stormwater, reduce non-point source pollution into Lake Phalen, enhance wildlife habitat, and provide an educational resource. The project was jointly sponsored by the City of St. Paul, the St. Paul School District, North East Neighborhoods Development Corporation (N.E.N. D.C.), the Ramsey Washington Metro Watershed District, and the University of Minnesota College of Architecture and Landscape Architecture. Funding for landscaping, grading, and planting materials was provided by the Legislative Commission on Minnesota Resources (LCMR).

Plant Installation

Cole Burrell is the landscape architect that developed the planting design for the site. Plugs and bare root seedlings were chosen for the planting because they grow more quickly than seeds. The restoration planners wanted to create obvious and quick results to gain community acceptance for the restoration. Ruth Schumi (651-266-6432) is the St. Paul Parks and Recreation volunteer coordinator who made contact with the college and school groups that installed the plants. Karen Swenson (651-771-6955) is the Executive Director of the North East Neighborhoods Development Corporation (N.E.N.D.C.) that brought in community volunteers and helped coordinate the planting logistics on the planting days.

On September 6, 1997, 400 volunteers from Northwestern College planted the majority of the 25,000 plants to be installed. A list of plants ordered for the planting plan is shown in Table 3.23. No records were kept on the actual numbers and species installed on the day of the planting. Plant materials were color-coded by flats that corresponded with five flagged planting zones: emergent, meadow, wet prairie, mesic prairie, and dry prairie. Plants were removed from their containers, sorted into bushel baskets, and carried to the planting locations. The average planting density for plugs and bare root transplants was 1 plant per square foot. A spacing bar was used to lay out the plugs for planting. Planting began at the end of one zone and progressed along the contour until the end of the zone. After planting, some mulching with clean, weed-free straw occurred, but the effort was inconsistent and sparse. The purpose of the mulching was to hold moisture near the soil and to moderate extreme temperature fluctuations. On September 13, Prosperity Heights elementary school students, their parents, neighborhood activitists, and other volunteers continued the fall planting. Additional volunteer school groups finished the planting over a period of several weeks.

A spring planting was begun May 18 1998, by a firm that had previously contracted work with the city of St. Paul; Woyda and Mortal. The planting occurred over the period of a week.

Other

The ground was hard and dry on the planting days as a result of hot dry weather earlier in the summer. Some plants were lost a few days after the September 6th planting during a rain event that washed the plants out of their holes. Fire Department Station No. 9 came several times after the planting and watered, but with limited coverage. Public Works also brought in water at least once in October 1997. The entire site (down to the water's edge) was mowed to turf length several times during the 1998 growing season to control weeds. A small amount of hand-weeding was done by volunteers on the planting days.

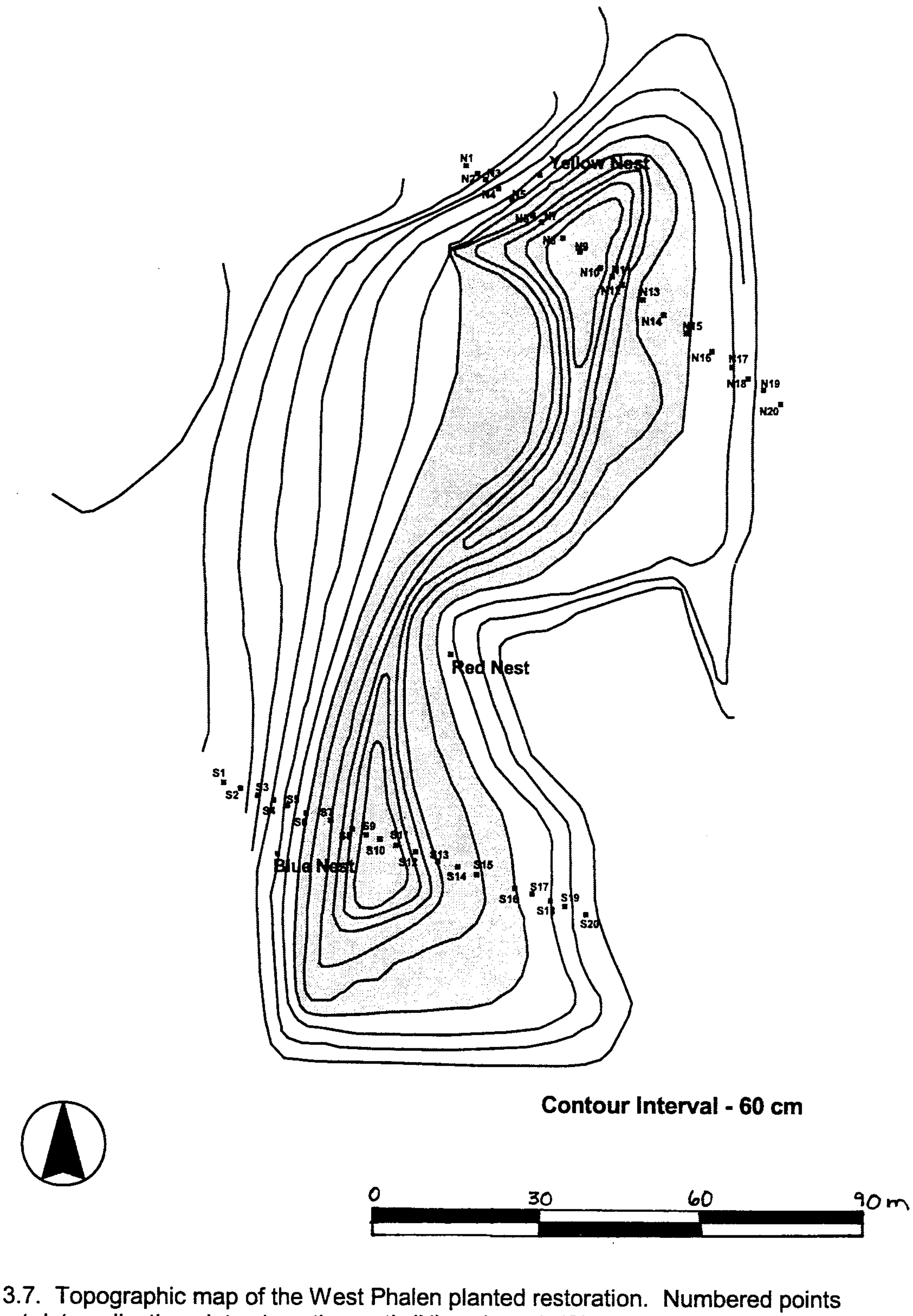


Figure 3.7. Topographic map of the West Phalen planted restoration. Numbered points represent data collection plots along the north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

Table 3.23. Quantities of plants and seeds used in the West Phalen revegetation. Seeds and seedlings were planted in September 1997 and April 1988.

Scientific Name	Common Name	Seed Quantities (g)		Plants		Zone
		Wetland	Upland	Wetland	Upland	
Acorus calamus	Sweetflag			734		Emergent
Alisma plantago-aquatica	Broadleaf water plantain			1785		Emergent
Allium stellatum	Prairie Onion				500	Mesic Prairie
Andropogon gerardii	Big bluestem			93		Wet Prairie
Anemone canadensis	Canada anemone			252		Wet Prairie
Aquilegia canadensis	Columbine				500	Mesic Prairie
Ascelpias tuberosa	Butterfly Weed				1115	Dry Prairie
Asclepias incarnata	Marsh Milkweed			994		Meadow
Aster azureus	Sky Blue Aster				1115	Dry Prairie
Aster ericoides	Heath Aster				876	Mesic Prairie
Aster laevis	Smooth Aster				1456	Mesic Prairie
Aster novae-angliae	New England aster			904		Wet Prairie
Aster oblongifolius	Aromatic Aster				262	Dry Prairie
Aster puniceus	Red-stalked aster			252		Wet Prairie
Aster sericeus	Silky Aster				262	Dry Prairie
Aster simplex	Marsh Aster			610		Meadow
Bouteloua curtipendula	Side-oats Gramma		454		262	Dry Prairie
Calamogrostis canadensis	Canada Blue Joint	454				Meadow
Caltha palustris	Marsh Marigold			490		Meadow
Carex comosa	Bottlebrush sedge			4275		Meadow
Carex stricta	Tussock Sedge			994		Meadow
Carex vulpinoidea	Fox sedge			652		Wet Prairie
Ceonothus americanus	New Jersey Tea				262	Dry Prairie
Eupatorium maculatum	Joe-pye weed			904		Wet Prairie
Eupatorium perfoliatum	Common boneset			252		Wet Prairie
Galium boreale	Northern Bedstraw				570	Mesic Prairie
Gentiana andrewsii	Bottle gentian			114		Wet Prairie
Geum triflorum	Prairie Smoke				262	Dry Prairie
Glyceria grandis	Tall Mana grass			734		Emergent
Helenium autumnale	Sneezeweed			652		Wet Prairie
Helianthus leatiflorus	Showy Sunflower				876	Mesic Prairie
Helianthus maximiliani	Maximillian Sunflower			98		Wet Prairie
Heliopsis helianthoides	Ox-eye				1456	Mesic Prairie

Table 3.23. Continued . . .

Scientific Name	Common Name	Seed Quantities (g) Wetland	Seed Quantities (g) Upland	Plants Wetland	Plants Upland	Zone
Heuchera richardsonii	Prairie Coralbells				262	Dry Prairie
Iris versicolor	Blueflag iris			610		Meadow
Lespedza capitata	Round-headed Bushclover				248	Mesic Prairie
Liatris aspera	Button Gayfeather				1456	Mesic Prairie
Liatris pycnostachya	Prairie blazingstar				733	Wet Prairie
Lobelia siphilitica	Great blue lobelia			154		Wet Prairie
Mimulus ringens	Alleghany monkey flower			540		Meadow
Monarda fistulosa	Wild bergamot				1456	Mesic Prairie
Panicum virgatum	Switchgrass			73		Wet Prairie
Phlox pilosa	Downy phlox				876	Mesic Prairie
Pycnanthemum virginianun	Virginia mountain mint			252		Wet Prairie
Ratibida pinnata	Gray-headed coneflower				147	Mesic Prairie
Rudbeckia hirta	Black-eyed Susan		454			Mesic Prairie
Sagittaria latifolia	Broadleaf arrowhead			5355		Emergent
Schizachyrium scoparium	Little Bluestem		454			Dry Prairie
Scirpus atrovirens	Green bulrush			734		Emergent
Silphium perfoliatum	Cup plant			73		Wet Prairie
Solidago nemoralis	Gary Goldenrod				262	Dry Prairie
Solidago rigida	Stiff goldenrod				1456	Mesic Prairie
Solidago speciosa	Showy Goldenrod				1115	Dry Prairie
Sorghastrum nutans	Indiangrass				1456	Mesic Prairie
Spartina pectinata	Prairie cordgrass			473		Wet Prairie
Sporobolus heterolepis	Prairie Dropseed				1115	Dry Prairie
Thalictrum dasycarpum	Tall meadow-rue			878		Meadow
Tradescantia ohiensis	Spiderwort				570	Mesic Prairie
Verbena hastata	Blue vervain			652		Wet Prairie
Vernonia fasciculata	Prairie ironweed			252		Wet Prairie
Veronicastrum virginicum	Culver's root			652		Wet Prairie
Zizia aptera	Heart leaf alexander			252		Wet Prairie
Zizia aurea	Golden alexanders				724	Wet & Mesic Prairie
TOTAL		**454**	**1362**	**25739**	**21650**	
	Winter Rye (cover crop-upland)		908			

East Phalen Site Description

Directions to Site:

Follow I-94 East to 35E North. Continue on 35E North to Maryland Avenue. Turn right (east) on Maryland Ave. and continue past the West Phalen site. About an eighth of a mile past the West Phalen site, turn left (north) just after the townhouse complex and just before the small strip mall. East Phalen is just past the townhomes, behind the first house on the left. Park on the street and walk to site. (Page 41 in MN Atlas)

Site Description and Restoration History:

Originally a single basin that included the West Phalen site, the wetland was divided by a railroad bed and then filled in. The site was a wet wooded meadow until May 1997, when it was excavated. The basin is thought to be recharged by groundwater and an outflow structure drains overflow.

The immediate land use around the site is mostly urban/residential development with some small tracts of degraded forest adjacent. The dominant land use in the area is urban development and Phalen Park, which includes Lake Phalen, recreation area and a nearby golf course. The soil mapping unit is histsol/aquoll and a topographic map of the restoration site is shown in Figure 3.8.

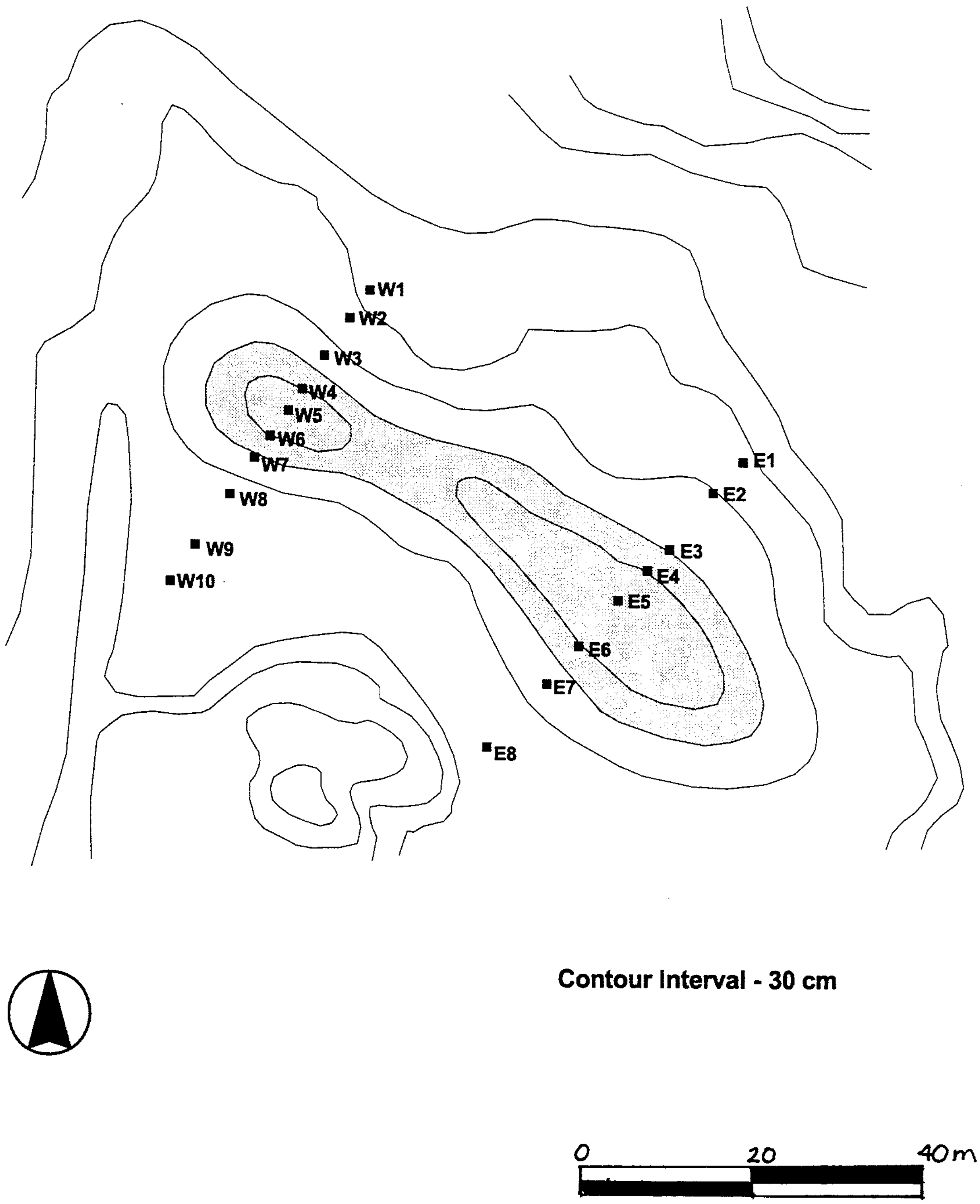


Figure 3.8. Topographic map of the East Phalen unplanted wetland restoration. Numbered points represent data collection plots along west (W) and east (E) transects. All of the piezometers were vandalized after installation.

Lake Elmo Site Description

Directions to Site from the Twin Cities:

Follow I-94 East from Saint Paul. Exit on Radio Drive after I-494 interchange. Turn left at light and proceed north. Turn right at four-way stop and head east on Highway 10. Lake Elmo Park Reserve is approximately one mile up on the left. Go north into park on Keats Ave. (be sure to have a valid vehicle permit for Washington County Parks) and take second left into the Primitive Group Campground. Wetland is on the south edge of the circle loop, near the parking spaces. (Page 42 in MN Atlas)

Site Description:

This intact depressional wetland contains a partial floating mat and has minor seasonal flow into and out of the basin. Historical information indicates that the land surrounding the basin has been cropped and/or grazed frequently in the past, but in the 1970's the area was established as Lake Elmo Park Reserve. The immediate land use around the site is grassland with oak forest and several other nearby wetlands. The dominant land use in the watershed is row crop agriculture and some urban development, with several sizable lakes and wetlands and a grassland/deciduous forest complex inside the park reserve. A topographic map of the wetland is shown in Figure 3.9.

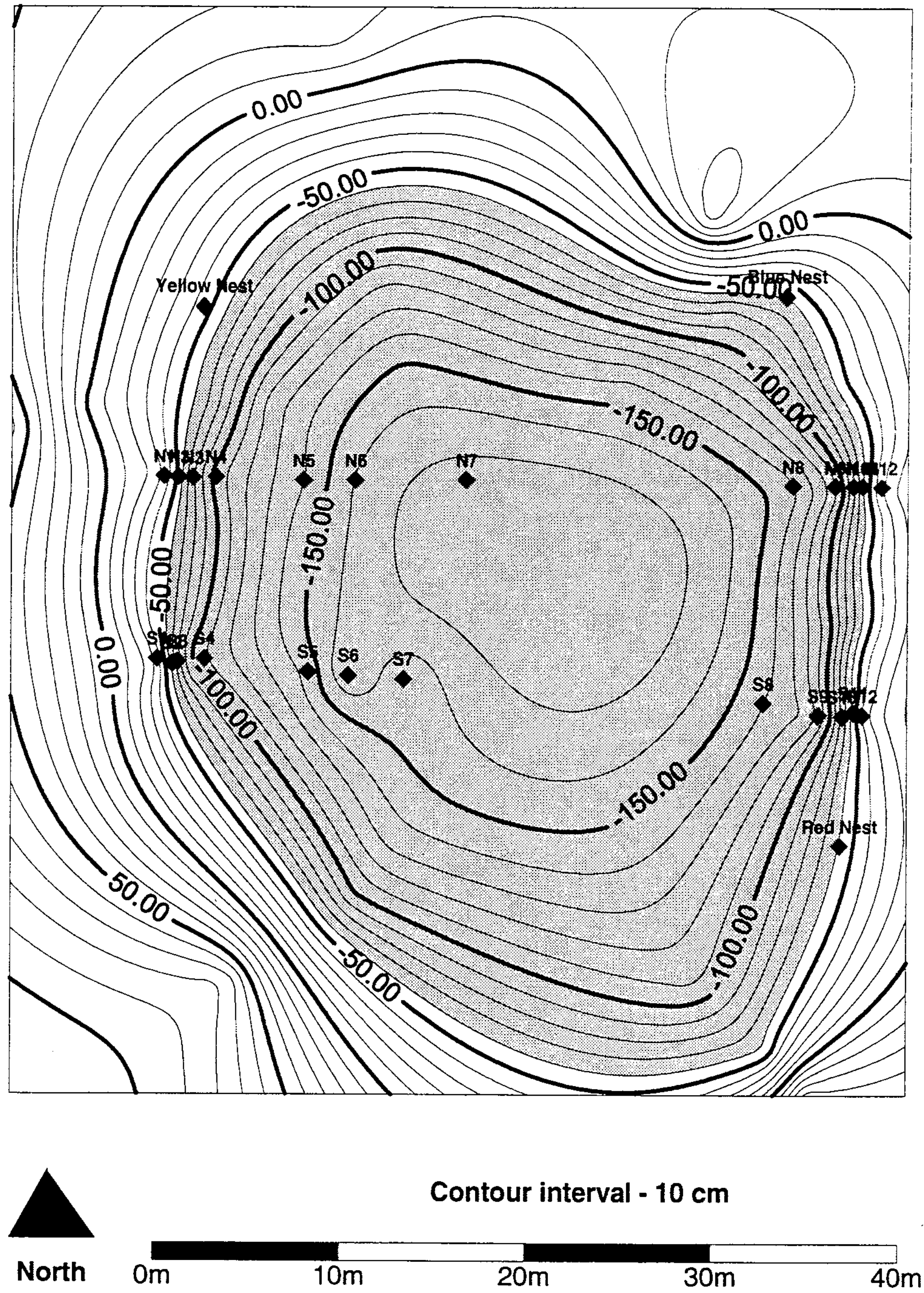


Figure 3.9. Topographic map of the Lake Elmo Marsh reference wetland. Numbered points represent data collection plots along the north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

Southern Central Triplet

The size, location, ownership, and planting status of all three wetlands are shown below. Figure 3.10 indicates the relative location of the sites relative to one another.

	Site	Size (ha)	Location	Ownership
Planted	Big Dog Slough	6.07	Steele Co., T105 R20 S14	MnDOT
Unplanted	Woodcock Marsh	1.39	Steele Co., T105 R20 S13	USFWS
Reference	Swan-Oshawa	1.09	Nicollet Co., T110 R27 S19	DNR

Characteristics of Wetlands in the Group

Soils: Both the reference site and Woodcock have silty clay, silty clay loam, and clay loam soils (Table 3.24). Big Dog Slough has primarily loamy soils with some sandy loam and sandy clay loams. With the exception of Total P, average soil nutrients were highest at the reference site (Swan Oshawa) and lowest at the Big Dog Slough restoration at both soil depths. Total P was highest at the Woodcock restoration and lowest at the reference site, both at the surface and at 25-35 cm below the surface. Minimum and maximum soil temperatures at the surface (2 cm) and at 20 cm were consistently higher for the restoration sites than for the reference site (Table 3.25).

Water: The piezometer nests at Woodcock and Swan Oshawa indicate that both sites are weakly discharge wetlands (Table 3.26). (Big Dog piezometer nests were flooded for nearly the entire season). Surface water fluctuation over the growing season was 39.5 vertical cm at Big Dog, 16.5 cm at Woodcock, and 51 cm at Swan Oshawa. The mean, minimum, and maximum water temperatures were similar for all three sites (Table 3.27). The maximum and mean dissolved oxygen was highest at the two restored sites. Mean, maximum, and minimum total alkalinity and conductivity was greatest at the reference site. The pH was similar at all sites. Water chemistry analysis indicates that chlorine levels were highest at Big Dog and lowest at Swan Oshawa (Table 3.28). Sulfate was highest at Swan Oshawa and lowest at Big Dog. All other anion measures were similar for the three wetlands. Cations were also similar for all sites with the exception of calcium, which was about twice as high at Woodcock than the other two sites.

Fauna: The total number of bird species was highest at the reference site (27), lowest at Woodcock (16), and intermediate at Big Dog Slough (20) (Table 3.29). The number of breeding species followed the same pattern with 11 species observed at Swan Oshawa, four species noted at Woodcock, and eight species observed at Big Dog Slough. A similar number of fish species (either 2 or 3) was seen at all sites (Table 3.30). The total fish abundance was highest at Woodcock. Five amphibian species were seen at each of the wetlands, although the species were not necessarily the same (Table 3.31). Six total species were observed between the three wetlands. The Northern Leopard frog and the American toad had the highest total observations at all sites.

Flora: The number of plant species observed at Big Dog Slough after the first year was 97 (Table 3.32), 65 species at the unplanted Woodcock Marsh (Table 3.33), and 72 at the Swan-Oshawa reference site (Table 3.34). The number of species found in each zone is shown below:

Site	Upland	Wet Prairie	Wet Edge	Sedge Meadow	Emergent Zone	Open Water
Big Dog	51	48	x	28	24	17
Woodcock	32	x	42	x	12	4
Swan Oshawa	x	39	x	31	18	21

(A Sedge Meadow zone was not identified at the Woodcock restoration and the Upland Zone at Swan Oshawa was not assessed.) Of the 89 native species seeded at the Big Dog Slough restoration, 34 (38%) were observed by the end of the first growing season. Half of these were wetland species and half were prairie species. The sedges observed at both restoration sites were primarily (early successional) tussock forming species whereas the sedges at the reference site were spreading mat-formers. Upland species at both restoration sites included a greater number of weedy forb species (*Conyza canadensis, Rorippa palustris, Taraxacum officianale, Trifolium sp.* etc.) than were seen at the reference site. None of these observations is unexpected in the early stages of a restoration.

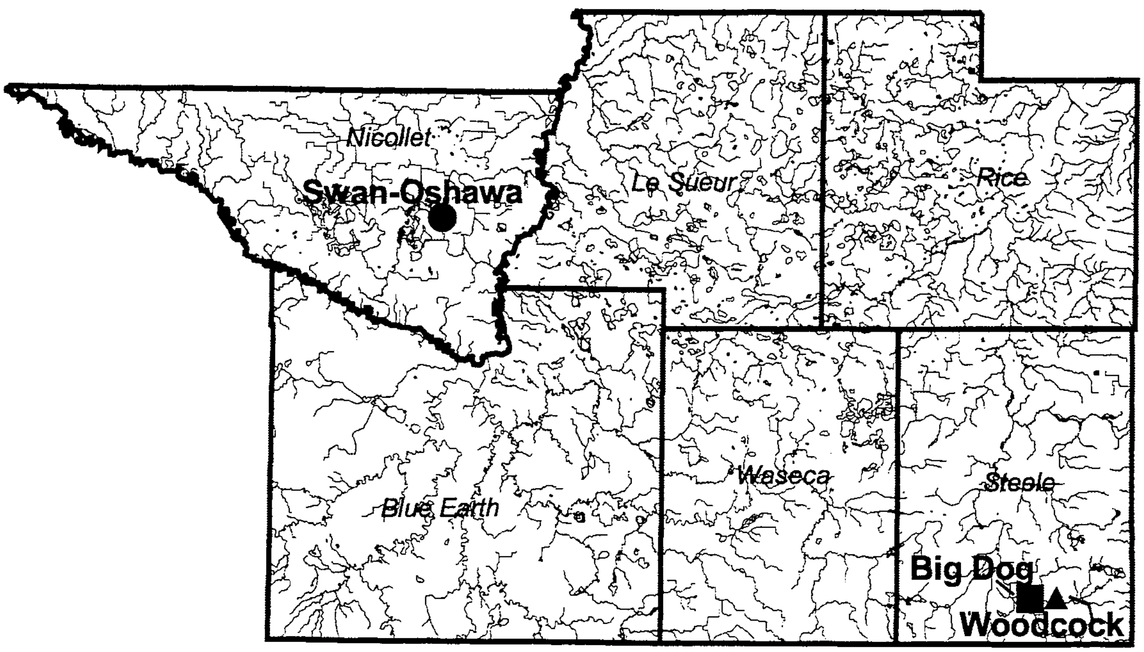


Figure 3.10. Regional map showing the location of the south triplet of wetlands.

Table 3.24. Averages of soil characteristics from four stations at each elevation (above, at, and below the water line).

		Big Dog			Woodcock			Swan Oshawa		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth										
0-5 cm	Total N (%)	0.19	0.32	0.55	0.59	1.00	1.44	0.67	1.36	1.93
	Total P (ppm)	557	735	889	1166	1483	2038	715	783	772
	Total Org. C (%)	1.68	2.73	4.85	4.55	7.74	8.58	5.94	12.4	16.6
5-25 cm	Texture	Loam			Silty clay, Silty clay loam, Clay loam			Silty clay, silty clay loam, clay loam		
25-35 cm	Total N (%)	0.16	0.43	0.63	0.34	1.28	1.22	0.37	0.81	0.61
	Total P (ppm)	529	1108	1174	807	1616	1690	552	534	400

Table 3.25. Summary of soil temperature data taken at 2 and 20 cm, 7 times between April and October, 1998. Four sampling stations per site were used to record temperatures at the stationd nearest to the water line, the stations closest to 30 cm above the water line, and the stations closest to 30 cm below the water line.

		Big Dog			Woodcock			Swan-Oshawa		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth	Temperature (C)									
2 cm	Mean	19.5	18.8	17	18.3	17	17.3	14.5	12.5	12.5
	Minimum	7	7	8	10	9	10	1	0	4
	Maximum	30	27	23	28	27	23	22	21	18
20 cm	Mean	16.3	16	15.3	14	15	16	12	11.5	11.8
	Minimum	7	7	6	8	7	8	1	1	3
	Maximum	22	22	22	28	22	22	19	18	17

Table 3.26. Total head gradients for piezometers (cm). Nests were submerged at Big Dog for most of 1998. A negative number indicates upward movement of water. A positive number indicates downward movement.

Big Dog									
	Nest 1			Nest 2			Nest 3		
Depth Interval (cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
9/22/98	-0.5	0.5	-4	2.5	3.5	-2		submerged	

Woodcock									
	Nest 1			Nest 2			Nest 3		
Depth Interval (cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
4/7/98	-5	-1	0.5	-1	-3	-17	-13	35	6
4/24/98	-4.5	0	0.5	-0.5	-11.5	-1	-1	-0.5	-1
5/9/98	-5.5	1	12	0	0	0	0	10	-3
5/27/98	-2.5	-1	5	0	0	0	5	-2	3
6/11/98	-2	3	-3	0	0	0	-1	2	1
8/20/98	-10	14.5	-2.5	0	0	0	1	-2	-2
9/22/98	13.5	-18	-0.5	0	0	0		-2.5	-4.5

Swan Oshawa									
	Nest 1			Nest 2			Nest 3		
Depth Interval (cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
4/10/98	0	0	0	2	25	2	3	31	12
5/1/98	0	0	0	2	2	-5	0	-4	2
5/20/98	0	0	0	1	2	-10	0	-1	0
6/5/98	3	-4	7	1	2	-14	1	-17	11
7/10/98	0	-1	1	2	0	-11	2	-1	1
8/19/98	1.5	0.5	1.5	3	3.5	-15.5	28	2	0
9/28/98	4.5	2	1	7	30	-21.5	29	22.5	-1.5

Table 3.27. Summary of alkalinity, conductivity, pH, DO, and water temperatures from April to October 1998.

	Big Dog			Woodcock			Swan Oshawa		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (C)	15.9	6.0	24.0	15.4	6.5	23.5	15.5	4.0	24.0
Dissolved Oxygen (mg/l)	4.8	1.1	9.0	6.1	0.6	12.0	1.7	0.8	3.2
Total Alkalinity (mg $CaCO_3$)	84.3	40.0	132.0	96.2	65.0	164.0	122.8	76.0	272.0
Conductivity (uS/cm)	284.4	137.3	395.0	273.5	168.7	383.0	330.0	165.2	471.0
pH	8.7	7.7	9.4	8.8	7.9	9.9	8.8	7.5	9.7

Table 3.28. Anion and cation composition of water.
A 'T' indicates trace levels.

	Big Dog	Woodcock	Swan Oshawa
Anions (mg/kg)			
F	0.252	0.313	0.23
Cl	11.45	3.519	2.103
NO2-N	T	T	0.099
Br	0.062	0.16	T
NO3-N	0.015	0.062	T
PO4-P	T	T	T
SO4	0.844	1.199	7.259
Cations (ug/g)			
Al	0.2366	0.0777	0.0641
Si	2.0623	2.3013	6.444
P	0.689	0.1129	0.1748
Fe	0.7577	0.6905	0.7801
Mn	0.1887	0.0476	0.2839
Sr	0.1429	0.2012	0.1323
Ba	0.1653	0.1999	0.0563
Ca	53.4151	79.3582	41.4239
Mg	19.0886	21.8028	20.239
Na	2.7933	3.768	3.3321
K	5.5666	3.4063	4.216

Table 3.29. Number of birds of each species detected during three bird surveys conducted between dawn and 0900 h between 5 May and 10 July. Upland bird species are not included in this listing. This list includes incidental detections.

Coded breeding evidence of birds detected in surveys at each site. 0 = species not present; 1 = species present; 2 = singing male detected; 3 = male and female of species seen together; 4 = nesting activity detected for this species; 5 = young produced for this species. Maximum breeding evidence for each species at each site is found in the Summary column. Upland bird species are not included in this listing. This list includes incidental detections.

	Common Name	Scientific Name	Big Dog Total	Big Dog - Breeding	Woodcock Total	Woodcock Breeding	Swan-Oshawa Total	Swan-Oshawa Bree
AMCO	American coot	*Fulica americana*	24	4	0	0	0	0
BNKS	Bank swallow	*Riparia riparia*	5	1	6	1	3	1
BARS	Barn swallow	*Hirundo rustica*	4	1	7	1	14	1
BBWD	Black-bellied Whistling Duck	*Denrocygna autumnalis*	1	1	0	0	0	0
BCNH	Black-crowned night heron	*Nycticorax nycticorax*	0	0	0	0	2	1
BLTE	Black tern	*Chlidonias niger*	8	1	1	1	3	1
BWTE	Blue-winged teal	*Anas discors*	17	3	27	3	13	3
CAGO	Canada goose	*Branta canadensis*	38	5	11	5	10	3
CLSW	Cliff swallow	*Hirundo pyrrhonota*	2	1	1	1	1	1
COGR	Common grackle	*Quiscalus quiscula*	18	1	10	1	4	2
COYE	Common yellowthroat	*Geothlypis trichas*	0	0	0	0	8	2
AGWT	Green-winged teal	*Anas crecca*	0	0	0	0	1	1
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	0	0	0
KILL	Killdeer	*Charadrius vociferus*	9	4	17	2	2	1
LESA	Least Sandpiper	*Calidris minutilla*	0	0	0	0	2	1
LESC	Lesser scaup	*Aythya affinis*	3	1	0	0	0	1
LEYE	Lesser Yellowlegs	*Tringa flavipes*	11	1	2	1	2	0
MALL	Mallard	*Anas platyrhynchos*	16	3	17	5	34	3
MAWR	Marsh wren	*Cistothorus palustris*	0	0	0	0	11	2
NOHA	Northern Harrier	*Circus cyaneus*	0	0	0	0	1	1
NSHO	Northern shoveler	*Anas clypeata*	0	0	0	0	2	1
NRWS	Northern rough-winged swallow	*Stelgidopteryx serripennis*	0	0	0	0	1	1
PESA	Pectoral Sandpiper	*Calidris melanotos*	0	0	1	1	0	0
PBGR	Pied-billed grebe	*Podilymbus podiceps*	1	1	0	0	1	1
REDH	Redhead	*Aythya americana*	9	3	0	0	0	0
RWBL	Red-winged blackbird	*Agelaius phoeniceus*	8	3	7	1	28	4
SESA	Semipalmated Sandpiper	*Calidris pusilla*	3	1	8	1	0	0
SBDO	Short-billed Dowitcher	*Limnodromus griseus*	0	0	2	1	0	0
SORA	Sora	*Porzana carolina*	0	0	0	0	3	2
SOSA	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	2	1
SWSP	Swamp sparrow	*Melospiza georgiana*	0	0	0	0	8	2
TRES	Tree swallow	*Tachycineta bicolor*	4	1	7	1	2	1
UNSH	Unknown shorebird		1	1	3	1	0	0
UNTE	Unknown tern		0	0	0	0	1	1
VIRA	Virginia rail	*Rallus limicola*	0	0	0	0	3	2
WODU	Wood duck	*Aix sponsa*	0	0	0	0	2	3
YHBL	Yellow-headed blackbird	*Xanthocephalus xanthocephal*	11	3	0	0	0	0
	Total Number of Species		20		16		27	
	Total Number of Breeding Birds			8		4		11
	Total Abundance		193		127		164	

Table 3.30. Total numbers of fish caught in minnow traps and aquatic activity traps at all site visits.

Common Name	Scientific Name	Big Dog	Woodcock	Swan-Oshawa
Brook Stickleback	*Culaea inconstans*	17	50	20
Brassy Minnow	*Hybognathus hankinsoni*	1	1	0
Fathead Minnow	*Pimephales promelas*	0	44	3
	Total abundance	18	95	23

Table 3.31. Amphibians detected in the following surveys: VES-Day - daytime visual encounter search, VES-Night - night time visual encounter search, Larval - minnow traps and aquatic activity traps, Chorus - chorusing sruveys.

Number of adults and/or juveniles detected during 30 min. visual encounter search (VES) conducted between 0800 and 1000 h. Surveys began 4/07/98 and ended 7/10/98.

Total amphibian larvae caught in minnow traps and aquatic activity traps on each site site and overall total. Adults were also occasionally found in these traps as well and these are reported here separately from the larval data and as totals only.

Chorusing surveys were conducted for 10 minutes beginning 2 h after sunset from 4/06/98 to 7/10/98. 0 = no individuals of this species detected 1 = individual calls can be distinguished, no overlap 2 = individual calls can be distinguished but are overlapping 3 = calls cannot be distinguished individually, constant and overlapping. Number given is the highest chorusing designation recorded over all site visits.

		Big Dog				Woodcock				Swan Oshawa			
Common Name	Scientific Name	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus
Northern leopard frog	*Rana pipiens*	15	17	419	2	14	15	27	3	38	13	68	0
Western chorus frog	*Pseudacris triseriata*	0	14	7	3	0	26	0	3	0	10	0	3
Cope's gray treefrog	*Hyla chrysoscelis*	0	11	0	2	0	2	0	2	0	16	0	3
Treefrog	*Hyla sp.*	0	0	0	0	0	0	1	0	0	0	0	0
American toad	*Bufo americanus*	201	131	184	3	257	397	106	3	2	96	3	3
Tiger salamander	*Ambystoma tigrinum*	0	0	2	0	0	0	0	0	0	0	13	0

Table 3.32. Floristic list annotated with abundance for each zone and plot at Big Dog Slough. Cover estimates were made on July 29, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: UP - Upland prairie, WP - Wet prairie, SM - Sedge meadow, EM - Emergent zone, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Cover by Zone					Plot Cover																									
Species	Authority	Family	UP	WP	SM	EM	OW	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Acer negundo	L.	ACE	0.5		0.5	0.5																												
Alisma plantago-aquatica	L.	ALI			0.5	1	0.5																		2				0.5				
Sagittaria latifolia	Willd.	ALI			0.5	0.5																											
Amaranthus rudis	Sauer	AMA	0.5	0.5																													0.5
Apocynum sp.		APO	0.5																														
Asclepias incarnata	L.	ASC	0.5	0.5	0.5	1																			2								
Asclepias syriaca	L.	ASC	0.5																														
Ambrosia artemisiifolia	L.	AST	3																2	3	1	2									0.5		0.5
Ambrosia trifida	L.	AST	1																												0.1		
Aster lanceolatus	Willd.	AST	0.5																														
Unknown Asteraceae		AST	0.5			0.5												0.1														0.5	0.1
Bidens connata	Muhl.	AST		0.5	0.5	0.5																		2							2		
Cirsium arvense	L. Scop.	AST	0.5																														0.5
Cirsium sp.		AST	0.5																														
Conyza canadensis	(L.) Cronq.	AST	2	0.5	0.5			0.5										0.1	1		2	0.5	0.5									0.5	0.5
Crepis tectorum	L.	AST	*																														
Crepis sp.		AST	0.5																														
Erigeron ciliatum	Raf.	AST		0.1				0.1																									
Eupatorium perfoliatum	L.	AST		0.5	0.5																												
Heliopsis helianthoides	(L.) Sweet	AST	0.5																1														
Liatris ligulistylis		AST	2																														
Ratibida pinnata	Vent.	AST	0.5																														
Rudbeckia hirta	L.	AST	2																													2	
Sonchus sp.		AST		0.1																													0.1
Capsella bursa-pastoris	(L.) Medic	BRA	0.5	0.5																													
Thlaspi perfoliatum	L.	BRA	0.5																														
Rorippa palustris		BRA		0.1																											0.5		
Lobelia cardinalis	L.	CAM			0.5																												
Lobelia siphilitica	L.	CAM		0.5	1																												
Silene antirrhina	L.	CAR	*																														
Ceratophyllum demersum	L.	CER					1																										
Chenopodium album	L.	CHE		0.1															0.5	0.5	0.5	0.5											0.5
Carex cf. scoparia	Schk. Ex Willd.	CYP		0.5	0.5																												
Carex comosa	F. Boott.	CYP		0.5	0.5																												
Carex vulpinoidea	Michx.	CYP		0.5	2																										1		
Carex sp.		CYP		0.5				0.5																0.1							0.5		
Cyperus sp.		CYP		0.5	0.5													1															
Eleocharis sp.		CYP		0.5	0.5	1																											
Scirpus atrovirens	Willd.	CYP				0.1																											
Scirpus cyperinus	(L.) Kunth	CYP	0.5		0.5																												
Scirpus fluviatilis	(Torr.) A. Gray	CYP					1							0.1																			
Scirpus validus	Vahl.	CYP		0.5	0.5	3	1																			0.5			2				
Unknown Cyperaceae		CYP		0.1															0.1														
Dalea purpurea	Vent.	FAB	0.5	0.5																													
Dalea candida	Michx. ex Willd.	FAB	0.5																														
Desmodium canadense	(L.) DC.	FAB	0.5	0.5																													
Lotus corniculatus	L.	FAB	0.5																														
Medicago lupulina	L.	FAB	0.5	0.5																													
Melilotus alba	Medikus	FAB	0.5					0.1																									
Melilotus officinalis	(L.) Pallas.	FAB	0.5																														
Trifolium hybridum	*	FAB	0.1																														
Trifolium pratense	L.	FAB	1																														
Trifolium repens	L.	FAB	0.5																														
Vicia sp.		FAB	0.5																0.1														
Juncus sp.		JUN		0.5	0.5	1																									0.5		
Mentha arvensis	L.	LAM		1																											0.5		
Stachys hispida	Pursh.	LAM	0.5				0.5																										
Unknown Lamiaceae		LAM		0.5														1						0.5									
Lemna minor	L.	LEM		0.5		3	0.5		2	0.5	0.5		0.5	0.5	0.5		0.5							3	4	0.5	0.5	0.5	0.5	0.5	0.5		
Lemna trisulca	L.	LEM					0.5									0.5																	
Spirodela polyrrhiza	(L.) Scheiden.	LEM				0.5	0.5																		0.5					0.5			
Ammania coccinea	Rottb.	LYT					0.5																										
Najas flexilis	(Willd.) Rostk.	NAJ					1						2																				
Epilobium ciliatum	Raf.	ONA	0.5	0.5	0.5	0.5		4										0.5				0.1	0.1								2	0.5	0.1

Table 3.32. Continued.

Species	Authority	Family	Cover by Zone UP	WP	SM	EM	OW	Plot Cover N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Oenothera biennis	L.	ONA	0.5																														
Oxalis stricta	L.	OXA	0.1																														0.1
Plantago major	L.	PLA	0.5	0.5																													0.1
Agropyron cristatum	(L.) Gaertn.	POA	0.5																														
Andropogon gerardii	Vitman	POA	0.5																0.1														
Avena sativa	L.	POA	0.5																														
Echinochloa muricata	(P.Beauv.) Fern.	POA		3	3	0.5												2				0.1	1								2		
Elymus canadensis	L.	POA	0.5																														1
Elymus trachycaulus	(Link) Gould.	POA	0.5	0.5																													
Glyceria grandis	S. Wats.	POA				0.5																											
Hordeum jubatum	L.	POA		0.5																													
Leersia oryzoides	(L.) Swartz	POA		2	1	5	2		2	2	2		2		0.5									4	5	3	3	3	3	2	3		
Lolium perenne (italicum)	L.	POA	0.5	0.5														0.5	0.5												0.5	0.5	
Panicum capillare	L.	POA		0.5														0.1					0.5								0.5		
Panicum virgatum	L.	POA	0.5	1	0.5																										2		
Phalaris arundinacea	L.	POA		0.5		1	0.5																										
Phleum pratensis	L.	POA	0.5																														
Setaria faberi	R. Herrm.	POA	3	2	1			0.5										1	3	2	5	5	5									3	5
Setaria glauca	(L.) P. Beauv.	POA	0.5	0.5														4	3	2		1										1	
Sorghastrum nutans	(L.) Nash	POA	0.5																														
Spartina pectinata	Link.	POA		1																													
Unknown Poaceae		POA				0.5																				0.5	1						
Polygonum amphibium	L.	POL					1																										
Polygonum lapathifolium		POL	0.5	0.5	0.5													1													1	0.1	
Polygonum pensylvanicum		POL		0.5																													
Polygonum sp.		POL	0.1																	0.5	0.1												
Rumex crispus	L.	POL		0.5	0.5	0.5	0.5											0.1					0.5								0.5		
Potamogeton foliosus	Raf.	POT					2						2	5	5	2	0.5																
Potamogeton nodosus	Poiret	POT				0.5																											
Potamogeton sp.		POT				0.1	1							0.1																			
Lysimachia thyrsiflora	L.	PRI				0.5																											
Anemone canadensis	L.	RAN			0.5																												
Ranunculus abortivus	L.	RAN		0.5	0.5	1																											
Salix sp.		SAL	0.5	0.5			0.5																										
Penthorum sedoides	L.	SAX		1		0.1																											
Mimulus ringens	L.	SCR	0.5	0.5	1	0.5																									0.5		
Veronica peregrina	L.	SCR		0.5														0.5	0.5		0.5										0.5	0.5	
Veronicastrum virginicum	(L.) Farw.	SCR		0.5																													
Typha angustifolia	L.	TYP				2	2																		0.5	1			1	1			
Typha sp.		TYP				0.5											1										1	0.5					
Urtica dioica	L.	URT		0.5																													
Verbena hastata	L.	VER	0.5	2	1	0.5																											
Verbena stricta	Vent.	VER		0.1																													

Table 3.33. Floristic list annotated with abundance for each zone and plot at Woodcock Marsh. Cover estimates were made on July 29, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: UB - upland berm, WE - Wet Edge, EM - Emergent zone, OW - Open water. A * indicates where a species is presumed to have occurred although cover estimates were not made.

			Total Cover By Zone				Plot Cover															
Species	Authority	Family	UB	WE	EM	OW	W1	W2	W3	W4	W5	W6	W7	W8	E1	E2	E3	E4	E5	E6	E7	E8
Alisma plantago-aquatica	L.	ALI			0.5																	
Amaranthus rudis	Sauer.	AMA		0.5												0.5						
Asclepias incarnata	L.	ASC	0.5	0.5												0.1						
Asclepias syriaca	L.	ASC	0.1																			
Ambrosia artemisiifolia	L.	AST	0.5	0.5	0.5		1							1		1						1
Ambrosia trifida	L.	AST		1				1								2						2
Aster sp.		AST		0.5			0.5	0.5					0.5			0.5					0.5	0.1
Bidens sp.		AST			1																	
Conyza canadensis	(L.) Cronq.	AST		1																		
Coreopis tinctoria	Nutt.	AST		0.5																		
Erigeron annuus	(L.) Pers.	AST		0.5																		
Eupatorium perfoliatum	L.	AST	0.5																			
Gaillardia aristata	Pursh.	AST		0.5																		
Helianthus grosseserratus	Martens	AST	0.5	0.5																		
Helianthus strumosus	L.	AST		0.1									0.1									
Heliopsis helianthoides	(L.) Sweet	AST		0.1																		0.1
Ratibida pinnata	Vent.	AST	0.5	0.5																		
Rudbeckia hirta	L.	AST	1	1																		
Solidago canadensis	L.	AST	0.5																			
Taraxacum officinale	Weber ex. Wigg.	AST	0.5	0.5			0.5						0.5									0.1
Chenopodium album	L.	CHE		0.5									0.5	1								0.5
Carex bebbii	(Bailey) Fern.	CYP	0.5																			
Carex sp.		CYP	0.5										0.5									
Carex vulpinoidea	Michx.	CYP	0.5				0.5															
Cyperus sp.		CYP		1				0.5													2	
Scirpus atrovirens	Willd.	CYP	0.5				0.5															
Scirpus validus	Vahl	CYP			0.5	0.5																
Equisetum arvense	L.	EQU	0.5	0.5			0.5	2														
Euphorbia vermiculata	Raf.	EUP	0.5				0.5															
Dalea purpurea	Vent.	FAB		0.5									0.1									0.5
Medicago lupulina	L.	FAB	0.5				0.5															
Melilotus alba	Medikas.	FAB	2	0.5			2	0.5														
Melilotus officinalis	(L.) Pallas.	FAB	0.5																			
Trifolium pratense	L.	FAB	0.5				2															
Trifolium repens	L.	FAB	0.5				1															
Juncus tenuis (dudleyi)	Willd./ (Wieg.)	JUN	0.5	0.5			0.5	0.5								0.5						0.5
Lycopus americanus	Muhl.	LAM	0.5																			
Teucrium canadense	L.	LAM	0.5																			
Lemna minor	L.	LEM			1	0.5			0.5			0.5					0.5	0.5	0.5			
Epilobium sp.		ONA	0.5	0.5									1	0.5							0.1	0.1
Oxalis stricta	L.	OXA		0.5																		
Plantago major	L.	PLA		0.5																		
Agrostis sp.		POA	1				3															
Echinochloa muricata	(P.Beauv.) Fern.	POA		0.5	3								2									

Table 3.33. Continued.

			Total Cover By Zone				Plot Cover															
Species	Authority	Family	UB	WE	EM	OW	W1	W2	W3	W4	W5	W6	W7	W8	E1	E2	E3	E4	E5	E6	E7	E8
Elymus canadensis	L.	POA	0.5	2				0.5						2	3	1						2
Glyceria grandis	S. Wats.	POA		0.5	2			2														
Hordeum jubatum	L.	POA			0.5																	
Leersia oryzoides	(L.) Swartz	POA			0.5											0.5						
Panicum capillare	L.	POA		0.5				0.5					0.5			0.5					0.1	
Phalaris arundinacea	L.	POA	0.5	0.5			1									1						
Phleum pratense	L.	POA	0.5																			
Phragmites australis	(Cav.) Trin.	POA	0.5	0.5																	0.5	
Setaria faberi	R. Herrm.	POA		3									5	5	4	3						4
Setaria glauca	(L.) P. Beauv.	POA	0.5	3			2	5							1	0.5					5	
Polygonum lapathifolium	L.	POL		0.5	0.5										0.5						0.5	
Rumex crispus	L.	POL	0.5	0.5																		
Potamogeton foliosus	Raf.	POT				0.5																
Lysimachia quadriflora	SIMS.	PRI		0.5																		
Ranunculus sp.		RAN		0.5																		
Potentilla sp.		ROS		0.1																		
Salix sp.		SAL		0.5									0.5			0.5						
Mimulus ringens	L.	SCR		0.5	0.1								0.1									
Veronica sp.		SCR		0.5									0.5									
Typha sp.		TYP		0.5	3	0.5					0.1	0.1	0.5				0.1			0.5		
Verbena hastata	L.	VER	0.5				0.1															
Viola sp.		VIO	0.5	0.5			0.5															

Table 3.34. Floristic list annotated with abundance for each zone and plot at Swan Oshawa Marsh. Cover estimates were made on July 29, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WP - wet prairie, SM - sedge meadow, EM - Emergent zone, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Total Cover By Zone				Plot Cover																	
Species	Authority	Family	WP	SM	EM	OW	N1	N2	N3	N4	N5	N6	N7	N8	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Alisma plantago-aquatica	L.	ALI				0.5																		
Sagittaria sp.		ALI		0.5	0.5	0.5										1								
Zizia aptera	(A. Gray) Fer	API	0.5																					
Zizia aurea	L.	API	0.5												1									
Apocynum cannabinum	L.	APO	0.5					2																
Asclepias incarnata	L.	ASC	0.5	0.5																				
Asclepias syriaca	L.	ASC		0.1																				
Aster sp.		AST	2	1			3								3									
Cirsium arvense	L. Scop.	AST	0.5															0.5						
Euthamia graminifolia	(L) Nutt.	AST	0.5																					
Helianthus grosseserratus	Martens	AST	1												2									
Ratibida pinnata	Vent.	AST	1																					
Solidago canadensis	L.	AST	1				1																	
Solidago rigida	L.	AST	0.5																					
Solidago sp.		AST	0.5												2									
Sonchus cf. oleraceus	L.	AST	0.5																					
unknown Asteraceae		AST						1								0.5								
Lobelia siphilitica	L.	CAM	0.1																					
Utricularia vulgaris	L.	CAM			0.5	1			0.5	2	1								0.5		2			
Carex bebbii	(Bailey) Fern.	CYP	*																					
Carex haydenii	Dew.	CYP		*																				
Carex lacustris	Willd.	CYP	0.5	3	2	0.5		4					1		4	4							3	0.5
Carex lanuginosa	Michx.	CYP	1	3				1	3							2	3	2						
Carex lasiocarpa	Ehrh.	CYP		*																				
Carex utriculata	F. Boott.	CYP		*	*																			
Carex sartwellii	Dew.	CYP		*	*																			
Carex stricta	Lam.	CYP		*																				
Carex sp.		CYP			1	0.5							0.5					1						
Eleocharis palustris	L.	CYP			0.5	0.5																		
Scirpus acutus	Muhl.	CYP	0.5	0.5																				
Scirpus validus	Vahl	CYP		0.5																				
Equisetum sp.		EQU			0.5	0.5																		0.1
Equisetum arvense	L.	EQU		0.5																				
Equisetum hyemale	L.	EQU		0.5					1															
Iris versicolor	L.	IRI		0.5																				
Sisyrinchium montanum	Greene	IRI	0.5																					
Lycopus americanus	Muhl.	LAM	0.5	0.5																				
Pycnanthemum virginianum	(L.) Durand & B.D. .	LAM	*																					
Stachys palustris	L.	LAM		*																				
Teucrium canadense	L.	LAM	0.5																					
unknown Lamiaceae		LAM				0.5																		
Lemna minor	L.	LEM			3	2			0.5	3	0.5	5	1				0.5	1	2	2	2	5		
Lemna trisulca	L.	LEM			0.5	0.5				0.5											0.1			
Spirodela polyrhiza	(L.) Scheiden	LEM			1	1			0.5	0.5	0.5	1	0.5				0.5	1	0.5	0.5	1	1		
Ludwigia polycarpa	L.	ONA		*																				

Table 3.34. Continued.

Species	Authority	Family	Total Cover By Zone WP	SM	EM	OW	Plot Cover N1	N2	N3	N4	N5	N6	N7	N8	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Agrostis gigantea	Roth.	POA	*																					
Agrostis sp.		POA	0.5																					
Andropogon gerardii	Vitman	POA	0.5																					
Bromus kalmii	A. Gray	POA	*																					
Calamogrostis stricta	(Timm.) Koeler.	POA	0.5	1																				
Glyceria grandis	S. Wats.	POA		*																				
Leersia oryzoides	(L.) Swartz	POA			0.5																			
Phalaris arundinacea	L.	POA	1	3	0.5	0.5	4	2						3									2	5
Phragmites australis	(Cav.) Trin.	POA		1	2	0.5									1	2								
Poa annua	L.	POA	*																					
Poa pratensis	L.	POA	*																					
Spartina pectinata	Link.	POA	1	0.5										3										
unknown Poaceae		POA	0.5			0.5	3											1						
Phlox pilosa	L.	POL	*																					
Polygonum amphibium	L.	POL	0.5	0.5	0.5	1			2				0.1			1	1	1						0.5
Polygonum lapathifolium	L.	POL				0.5																		
Polygonum sp.		POL						1															0.5	
Potamogeton foliosus	Raf.	POT				2				0.5	1								2		0.5			
Potamogeton zosteriformis	Fern.	POT				1				0.5	1													
Lysimachia quadriflora	Sims.	PRI		0.5																				
Lysimachia sp.		PRI	0.5																					
Lysimachia thyrsiflora	L.	PRI	0.1	0.5	0.5	0.5												0.5						
Thalictrum dasycarpum	Fischer & Ave-Lall.	RAN	0.5																					
Rhamnus cathartica	L.	RHA	0.1																					
Riccia fluitans	L.	RIC				0.5			0.5															
Fragaria virginiana	Duchesne	ROS	0.5																					
Prunus sp.		ROS	0.5																					
Galium sp.		RUB	0.5																					
Populus deltoides	Marshall	SAL	*																					
Salix sp.		SAL	1	0.5																				
Penthorum sedoides	L.	SAX		*																				
Veronica peregrina	L.	SCR		*																				
Sparganium eurycarpum	Engelm.	SPA			0.5	0.5			1				0.5				0.1							
Sparganium sp.		SPA				1																		
Typha angustifolia	L.	TYP			4	1						2	3									1	1	
Typha latifolia	L.	TYP			1	0.5											2							
Typha sp.	L.	TYP		0.5					0.5															

Big Dog Slough Site Description

Directions to Site from the Twin Cities:

Follow I-35W South past Owatonna to the Ellendale exit. Turn left (east) on Highway 30 and continue to SE 14, a gravel road on the left, just past the Summit town hall. Proceed north until the road turns sharply to the right (SE 138). Park alongside the road. Site is to the north. (Page 24 in MN Atlas)

Site Description:

The Big Dog Slough restoration was purchased by Mn/DOT as a wetland banking site. Prior to tiling and draining, the site consisted of approximately six hectares (15 acres) of sedge meadow surrounded by 20 hectares (50 acres) of prairie and/or mixed oak savanna. Originally tiled, drained, and farmed for corn and soybeans, portions of the basin were not farmed in wet years. In the late 1980's the site was enrolled in the Conservation Reserve Program (CRP) and planted with grasses.

The immediate land use adjacent to the site is row crop agriculture and pastures, some intensively grazed. The dominant land use in the watershed is row crop agriculture, although a few wetland, grassland and CRP parcels are found scattered in the area. The soil mapping unit is Canisteo clay loam and Colo silty clay loam.

Although the 26 hectare (65 acre) Big Dog Slough restoration is in the Cannon River watershed, it is not officially part of the multi-partner Straight River Marsh Restoration.

Planting Plan for Restoration:

<u>Basin Restoration & Site Preparation</u>

Immediately prior to the restoration, the drain tiles were still functional. In early June 1997 the tiles were plugged or broken and a large berm was constructed at the northwest corner of the wetland restoration area to impound a permanent pool of water. The original wetland depression had no surface inlets or outlets connecting it to other water bodies, but during restoration an outflow that runs to the Straight River was installed in the berm on the northern end. A second smaller berm was also constructed. A topographic map of the restoration is shown in Figure 3.11.

In early May, prior to the construction activities, Bob Jacobson reviewed the vegetation at the site. Fifteen to twenty percent of the basin area was covered with reed canary grass (*Phalaris arundinaea*). Patches of soft-stem bulrush (*Scirpus validus*), unidentified Carex, and grass species were also found. Mr. Jacobson concluded that recruitment of additional native species through drainage from neighboring wet areas was not possible and thus seeding was warranted. The reed canary grass was treated with glyphosate (Rodeo) in mid May 1997. The rest of the site was disced prior to seeding. The site was spot-herbicided several times in June and July 1997 for reed canary grass and Canada thistle. Thistle patches were hand scythed and the entire upland was mowed to a height of 6 inches in August. Spot spraying and hand scything of small thistle patches continued in May, June, and July of 1998. A tractor-pulled boom sprayer was also used to treat large thistle patches. Mr. Jacobson estimates that the thistle control was 90% effective.

Plant installation

All sedge meadow and prairie species were installed as seeds in June 1997. A complete planting list is shown in Table 3.35. Sedge meadow species were seeded approximately 20 feet to either side of an estimated high water elevation. Approximately 10 acres of sedge meadow were seeded using either a Truax native grass drill (large seeded species) or hand broadcast (small seeded species). The upland area was seeded using the Truax drill. All seeding was performed by Mn/DOT personnel. In the fall of 1998, 100 blue-flag iris seedlings (*Iris versicolor*) were hand planted along the southeast shoreline. In addition, 15-20 fowl-mannagrass (*Glyceria striata*) and cord grass (*Spartina pectinata*) seedlings were planted on the north side of the spillway overflow structure in a swale beyond the rock check.

Other

The water level in the basin rose higher than expected with as yet unknown impacts on the restoration seeding effort.

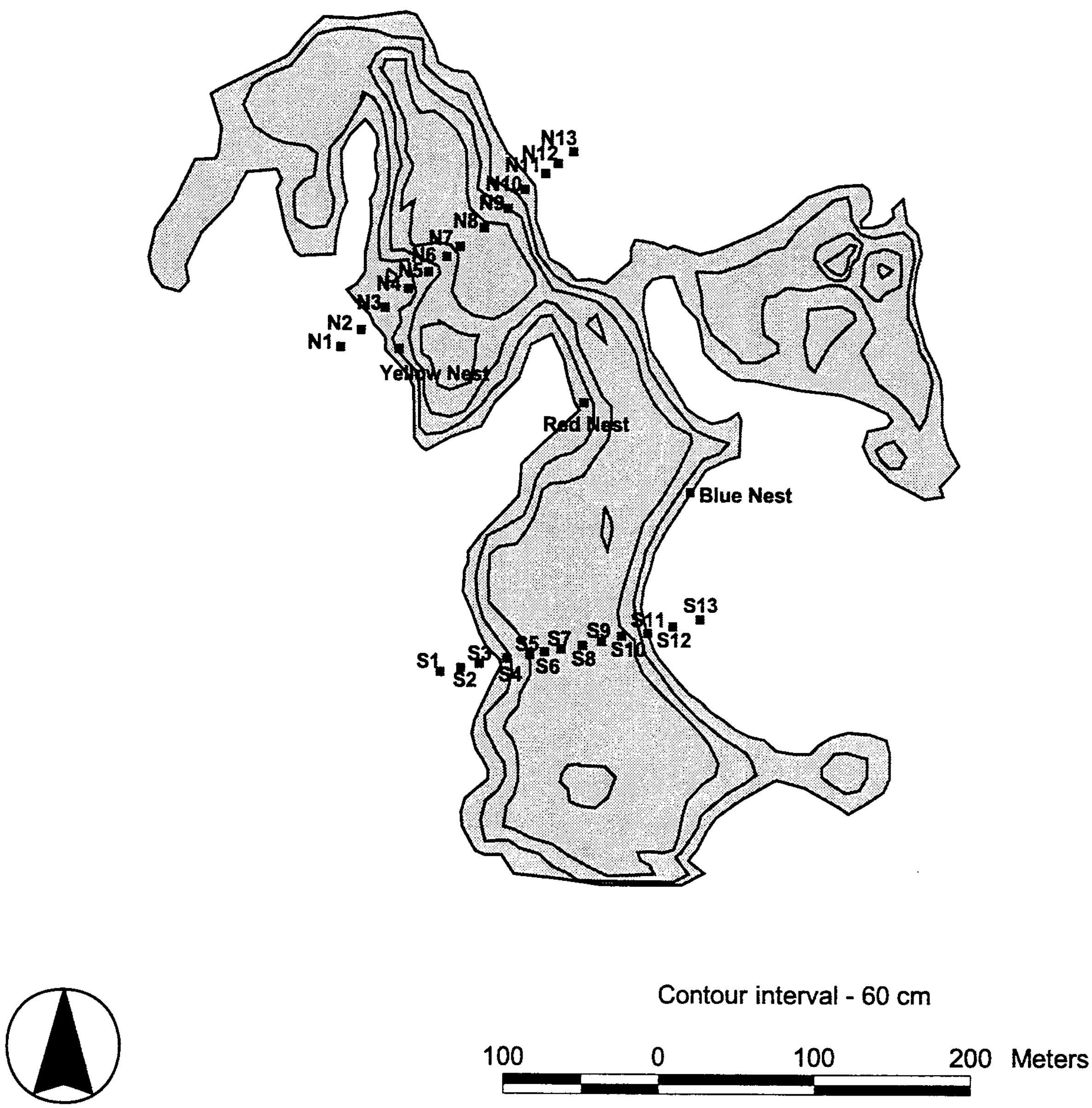


Figure 3.11. Topographic map of the Big Dog Slough planted wetland restoration. Numbered points represent data collection plots along the north (N) and south (S) transects. The red, blue, and yellow nests refer to location of the piezometer nests used for hydrological data collection.

Table 3.35. Quantities of seeds planted at Big Dog Slough in May, 1997. Plants were installec

		Seed Quantities (g)			
Scientific Name	**Common Name**	**Wetland**	**Upland**	**Plants**	**Notes***
Achillea millefolium	Yarrow		22.7		Bulk
Acornus calamus	Sweet flag	290.1			Bulk
Agastache foeniculum	Giant hyssop	15.8	90.7		Bulk
Agropyron trachycaulum	Slender wheat grass	1333.3	5442.0		PLS
Alisma plantago-aquatic	Water plantain	63.3			Bulk
Alisma subcordatum	Mud plantain	255.1			Bulk
Allium canadense	Wild garlic	167.0			Bulk
Allium stellatum	Prairie onion		272.1		Bulk
Amorpha canescens	Lead plant		362.8		Bulk
Andropogon gerardi	Big bluestem	13505.2	49318.1		PLS
Anemone canadensis	Canada anemone	167.0			Bulk
Asclepias incarnata	Swamp milkweed	938.9			Bulk
Asclepias tuberosa	Butterfly milkweed		612.2		Bulk
Aster azureus	Azure aster		385.5		Bulk
Aster ericoides	Heath aster		272.1		Bulk
Aster laevis	Smooth aster		90.7		Bulk
Aster lanceolatus	Red stalked aster	15.8			Bulk
Aster novae-angliae	New England aster	435.3	625.5		Bulk
Aster puniceus	Swamp aster	176.7			Bulk
Aster umbellatus	Flat-topped aster	56.7			Bulk
Astragalus canadensis	Canada milkvetch		498.9		Bulk
Bidens cernua	Nodding bur marigold	56.7			Bulk
Bidens connata	Purple-stemmed tickseec	113.4			Bulk
Bouteloua curtipendula	Sideoats grama		22448.3		
Bromus kalmii	Kalm's brome		680.3		PLS
Chamaecrista fasciculat	Partridge pea		272.1		Bulk
Calamagrostis canadens	Blue-joint grass	15872.5			Bulk
Carex comosa	Bottlebrush sedge	1133.8			Bulk
Carex scoparia	Pointed broom sedge	1133.8			Bulk
Carex vulpinoidea	Fox sedge	1133.8			Bulk
Chelone glabra	Turtlehead	56.7			Bulk
Cicuta maculata	Water hemlock	113.4			Bulk
Coreopsis palmata	Stiff tic-seed		521.5		Bulk

Table 3.35. Continued . . .

Scientific Name	Common Name	Seed Quantities (g) Wetland	Upland	Plants	Notes*
Dalea candidum	White prairie clover	15.8	612.2		Bulk
Dalea purpureum	Purple prairie clover	88.3	816.3		Bulk
Desmodium canadense	Canada tic-trefoil	271.1	226.8		Bulk
Elymus canadensis	Canada wild rye	4734.5	2807.2		PLS
Elymus virginicus	Virginia wild rye	1587.3			Bulk
Epilobium glandulosum	Northern willow herb	56.7			Bulk
Eryngium yuccifolium	Rattlesnake master		226.8		Bulk
Eupatorium maculatum	Joe Pye weed	463.7			Bulk
Eupatorium perfoliatum	Boneset	432.0			Bulk
Geum aleppicum	Yellow avens	283.4			Bulk
Glyceria grandis	Reed manna grass	113.4			Bulk
Glyceria striata	Fowl manna grass	170.1		20	Bulk
Helenium autumnale	Sneezeweed	296.2			Bulk
Helianthus giganteus	Giant sunflower	31.7			Bulk
Helianthus rigida	Stiff sunflower		22.7		Bulk
Heliopsis helianthoides	Common ox-eye	287.0	702.9		Bulk
Hypericum pyramidatum	Greater St. John's wort	31.7			Bulk
Iris versicolor	Wild iris	214.2		200	Bulk
Iris virginica shrevei	Blue-flag iris	223.7			Bulk
Koeleria macrantha	June grass		226.8		PLS
Leersia oryzoides	Rice cut grass	170.1			Bulk
Lespedeza capitata	Round-headed bush clover		340.1		Bulk
Liatris aspera	Rough blazingstar		498.9		Bulk
Liatris ligulistylis	Meadow blazingstar	223.7	498.9		Bulk
Liatris pycnostachya	Prairie blazingstar	778.8	362.8		Bulk
Lobelia cardinalis	Cardinal flower	56.7			Bulk
Lobelia siphilitica	Great blue lobelia	283.4			Bulk
Lysimachia quadriflora	Prairie loosestrife	28.3			Bulk
Mimulus ringens	Monkey flower	141.7			Bulk
Monarda fistulosa	Wild bergamot	88.3	634.9		Bulk
Panicum virgatum	Switch grass	4489.7	25464.0		PLS
Pedicularis lanceolata	Marsh betony	113.4			Bulk
Penstemon grandiflorum	Showy penstemon		272.1		Bulk

Table 3.35. Continued . . .

Scientific Name	Common Name	Seed Quantities (g) Wetland	Upland	Plants	Notes*
Pycnathemum virginianu	Mountain mint	176.7			Bulk
Quercus spp.	Oaks		120.0		
Ratibida pinnata	Grey headed coneflower	167.0	498.9		Bulk
Rudbeckia hirta	Black-eyed susan	287.0	816.3		Bulk
Sagittaria latifolia	Common arrowhead	170.1			Bulk
Schizachyrium scopariu	Little bluestem		18706.9		PLS
Scirpus atrovirens	Dark green bulrush	396.8			Bulk
Scirpus cyperinus	Wool grass	850.3			Bulk
Scirpus validus	Great bulrush	170.1			Bulk
Silphium laciniatum	Compass plant		226.8		Bulk
Solidago nemoralis	Gray goldenrod		45.4		Bulk
Silphium perfoliatum	Cup plant	167.0			Bulk
Solidago ptarmicoides	Upland goldenrod		45.4		Bulk
Solidago graminifolia	Grass-leaved goldenrod	60.0			Bulk
Solidago rigida	Stiff goldenrod	47.5	294.8		Bulk
Solidago speciosa	Showy goldenrod	68.0			Bulk
Sorghastrum nutans	Indian grass	7156.2	40361.5		PLS
Sparganium eurycarpum	Giant bur reed	396.8			Bulk
Sporobolus heterolepis	Prairie dropseed		113.4		Bulk
Spartina pectinata	Prairie cord grass	3155.4		20	Bulk
Thalictrum dasycarpum	Tall meadow rue	255.3			Bulk
Verbena hastata	Blue vervain	318.6	272.1		Bulk
Verbena stricta	Blue vervain		317.5		Bulk
Veronia fasciculata	Ironweed	302.8			Bulk
Veronicastrum virginianu	Culver's root	120.0			Bulk
Zizia aurea	Golden alexander	198.6	317.5		Bulk
Native Total		**67105.9**	**177712.7**	**240**	
Lolium italicum	Annual rye grass (cover (	4888.7			Bulk
Avena sativa	Oats (cover crop)	23110.4	141492.0		Bulk
Lolium italicum	Annual rye grass (cover crop)		29931.0		Bulk
Cover Crop Total		**27999.1**	**171423.0**		

Woodcock Marsh Site Description

Directions to Site from the Twin Cities:

Follow I-35W South past Owatonna to the Ellendale exit. Turn left (east) on Highway 30 and continue to SE 14, a gravel road on the left, just past the Summit town hall. Proceed north until the road turns sharply to the right (SE 138). Immediately to the left is the Big Dog site. Follow the road until it comes to a "T," then turn left (SE 34) and continue over the Straight Creek. The wetland is on the south side of the road after the farmhouse and a sharp left curve. Park alongside the road. (Page 24 in MN Atlas)

Site Description and Restoration History:

In corn production since the turn of the century or earlier, Woodcock Marsh was restored in October 1997 by breaking the existing drain tile and installing berms to impede water flow. A cover crop was planted to help control undesirable plant species and a spillway installed that drains into Straight Creek. A topographic map of the restoration site is shown in Figure 3.12.

Woodcock Marsh is part of the Straight Creek Waterfowl Production Area Restoration Project that restored 144 acres of cropland and 70 acres of drained wetland to a prairie wetland complex. By 1998, 43 wetlands had been reverted, all within the 323 acres of the project. The site is also adjacent to the 110 acre Pogones State Wildlife Area and abuts an effort to restore the 1,300+ acre Straight Creek Marsh. Besides the natural areas, row crop agriculture is the predominant land use both in the immediate area and in the watershed.

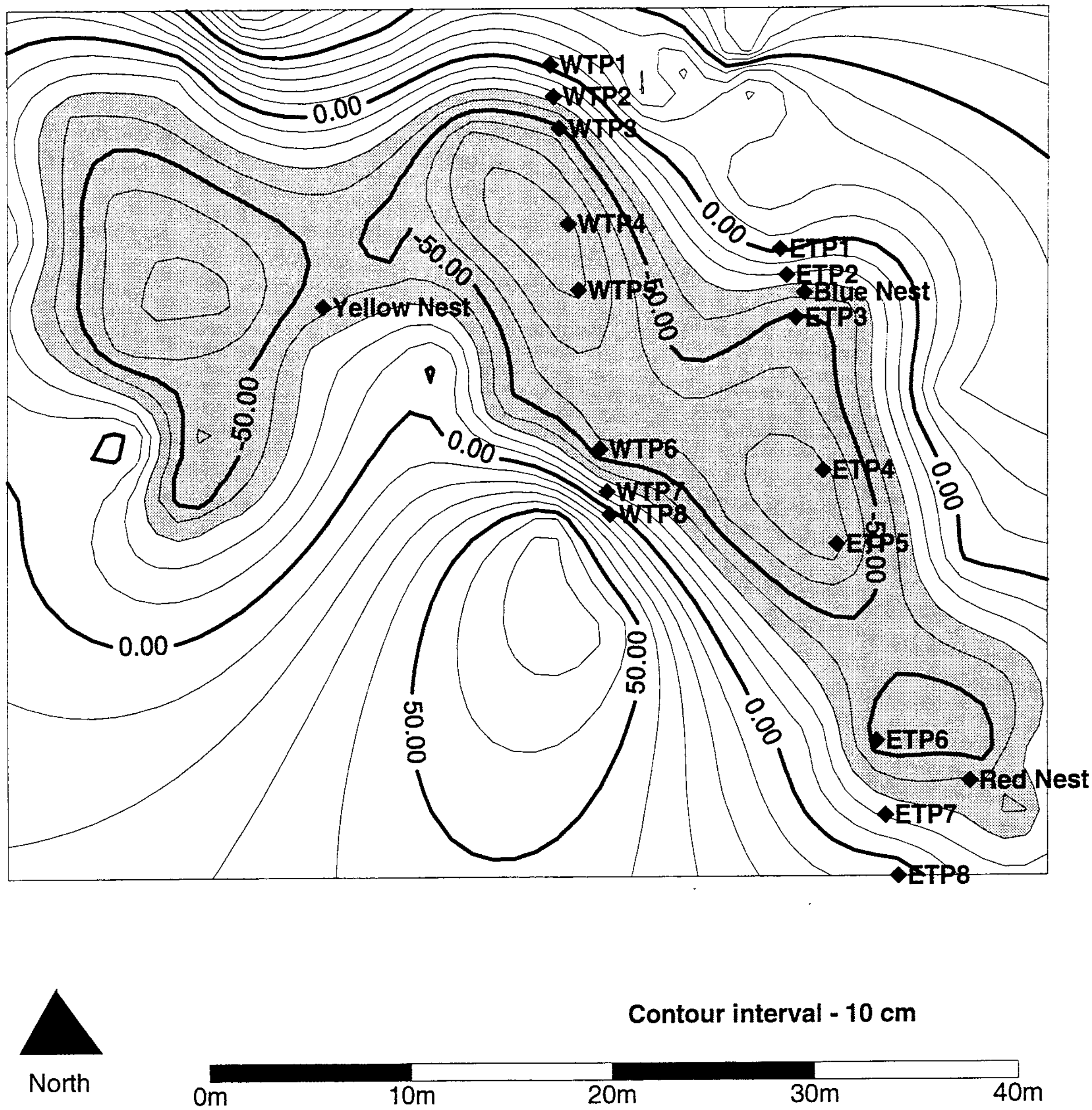


Figure 3.12. Topographic map of the Woodcock Marsh unplanted wetland restoration. Numbered points represent data collection plots along west (W) and east (E) transects. The red, blue, and yellow nests refer to location of the piezometer nests used for hydrological data collection.

Swan-Oshawa WMA Site Description

Directions to Site from the Twin Cities:

Follow U.S. Route 169 South to St. Peter. From St. Peter take County Route 5 out of town to Highway 13. Travel south on Highway 13 and turn at the first right. The site is on the right side of the gravel road immediately after the farm house. Park on the side of the road and walk north to the site.

Alternatively: Take 169 south to Jefferson St. W. at the southern end of St. Peter. Jefferson St. becomes T-81 and when it ends (in a "T"), turn left onto T-84. Site is on the north side of T-84, approximately 6.5 miles from St. Peter. (Page 32 in MN Atlas)

Site Description:

Located in the Minnesota River Prairie subsection of the North Central Glaciated Plains, Swan-Oshawa Wildlife Management Area (WMA) is an undrained prairie pothole wetland with a grassland buffer. The soil mapping unit is Muskego and the surrounding landscape is heavily agricultural. A gravel road borders the site on the south. Predominant land use in the watershed is almost exclusively row crop agriculture, although some sizable wetlands and other water bodies are present. Figure 3.13 shows a topographic map of the site.

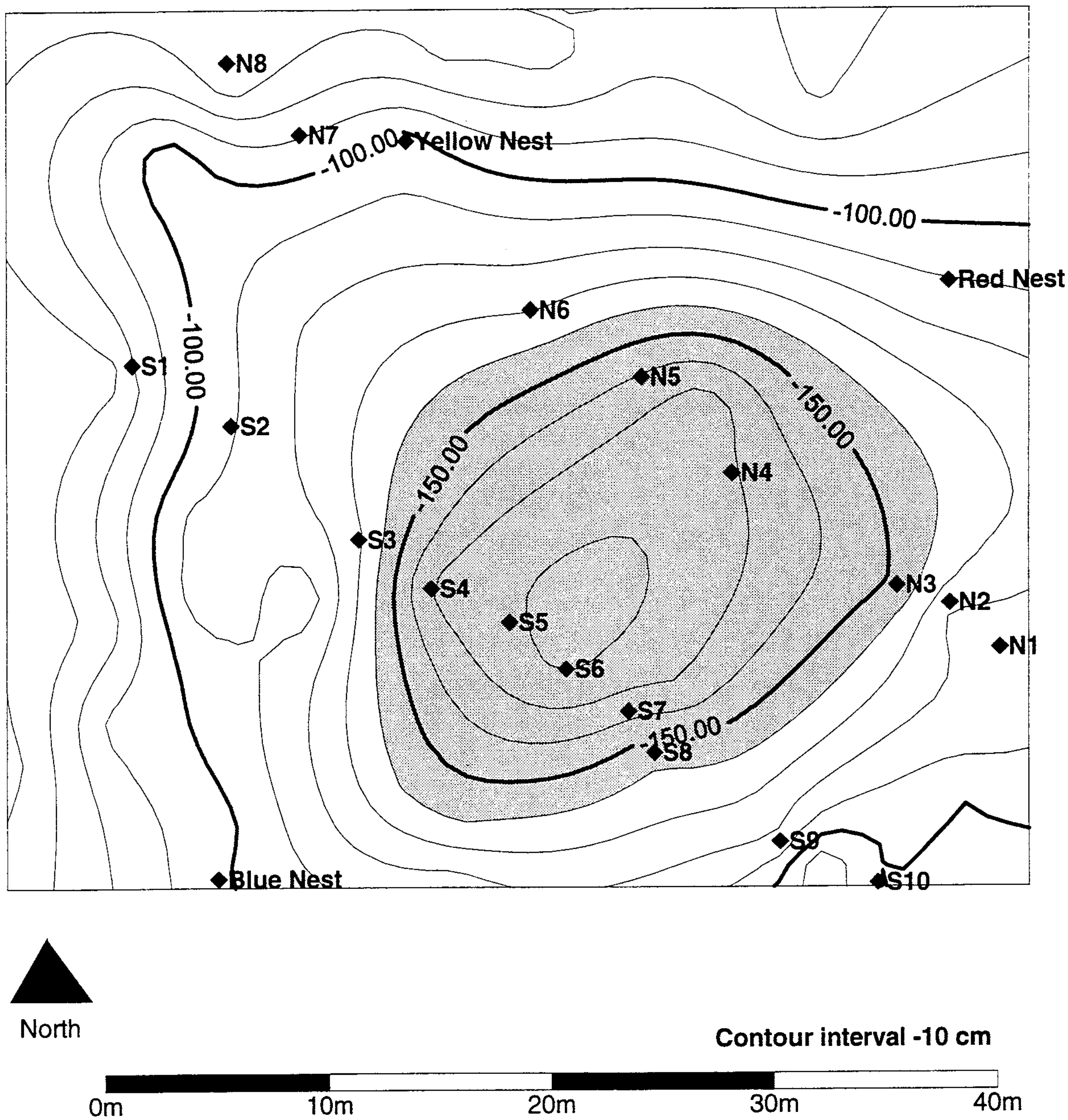


Figure 3.13. Topographic map of the Swan-Oshawa WMA reference wetland. Numbered points represent data collection plots along the north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

Western Group

Only two sites were included in this group (Figure 3.14). The location and size of each wetland is shown below.

	Site	Size (ha)	Location	Ownership
Planted	N/A			
Unplanted	Botker Marsh	3.19	Big Stone Co., T123 R46 S22	USFWS
Reference	Victory Marsh	5.11	Big Stone Co., T122 R45 S31	MNDNR

Characteristics of the Wetlands in the Group

Soils: The Botker Marsh wetland restoration had primarily silty clay to clay soils while the Victory Marsh reference wetland had clay loam to loamy soils (Table 3.36). Both sites had similar total N, total P, and total organic carbon at the soil surface. At 25-35 cm below the surface, the restored site had total N values that were twice that of the reference site. Total P values were also slightly higher below the surface at the restored site. Soil temperature (mean and maximum) was higher at the restored site than at the reference site (Table 3.37). Minimum soil temperatures were higher at the restored site above the water line, but were similar to the reference site at and below the water line.

Water: All of the wells at the Botker restoration were submerged soon after installation and then dried out completely as water levels rapidly dropped mid-summer. Thus no head gradient data were collected from this site (Table 3.38). At the beginning of the growing season, the Victory reference site showed no strong upward or downward water movement. As the season progressed, Victory became a recharge site as water began moving down through the wetland. The seasonal surface water fluctuation values for Botker (58 vertical cm) and Victory (43 cm) were similar. Water temperatures were also comparable between the sites (Table 3.39). The mean values for dissolved oxygen were higher at Victory than at Botker, but the range of values were similar. Total alkalinity at Victory was about twice that observed at Botker. Mean conductivities were similar between sites, but Botker had lower minimum values (262 uS/cm) than did Victory (402 uS/cm). The mean and maximum pH observed at both wetlands were comparable, although the minimum pH at Botker (7.9) was lower than that observed at Victory. Water chemistry analysis indicated that chlorine levels were about seven times higher at the Botker restoration site than at the Victory reference site, however the absolute numbers for both sites were relatively low (Table 3.40). Sulfate levels were three orders of magnitude higher at Botker than at Victory. Proximity of the Botker wetland to a highway where road salts are used during the winter may explain the disparity in values between sites. Calcium, sodium, potassium, and phosphorous were also significantly higher at Botker than at Victory. Runoff from surrounding farmland may contribute to the higher potassium and phosphorous values noted at Botker. In contrast, magnesium levels at Victory were twice as high as those at Botker.

Fauna: The total number of bird species as well as the number of breeding birds observed were similar at both sites (Table 3.41). Avian abundance at Botker was twice that seen at Victory. Yellow-headed blackbirds made up a substantial portion of the number of birds observed at Botker. The total abundance of fish observed at Victory was seven times greater than the number seen at Botker (Table 3.42). The difference was primarily the result of the number of fathead minnows (*Pimephales promelas*) caught at Victory. None were captured at Botker. Four species of amphibians were observed at Botker and three species were seen at Victory (Table 3.43). The northern leopard frog, the American toad, and the western chorus frog were the most abundant species at both sites.

Flora: Forty-five plant species were seen at Botker (Table 3.44) and 77 species were observed at Victory (Table 3.45).

Site	Wet Edge	Emergent	Ditch	Open Water
Botker Marsh	36	13	10	10
Victory Marsh	55	21	x	11

The ditch that ran through the Botker Marsh contained similar species to those found in the emergent zone at the site. It was noted as a unique zone because as the season progressed, the water level drew down dramatically until only the ditch held standing water. In general, the differences in species numbers between the two sites occurred in the wet edge zone. Botker lacked any *Carex* species and had half as many grass species as did Victory.

Figure 3.14. Regional map showing the location of the two wetlands in the western group.

Table 3.36. Averages of soil characteristics from four stations at each elevation (above, at, and below the water line).

		Victory			Botker		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth							
0-5 cm	Total N (%)	0.57	0.63	0.48	0.45	0.41	0.5
	Total P (ppm)	765	759	704	854	745	785
	Total Org. C (%)	4.43	4.98	3.69	3.93	3.48	3.95
5-25 cm	Texture	Clay loam, Loam			Silty Clay, Clay		
25-35 cm	Total N (%)	0.18	0.16	0.12	0.36	0.38	0.38
	Total P (ppm)	621	554	474	804	630	610

Table 3.37. Summary of soil temperature data taken at 2 and 20 cm, 7 times between April and October, 1998. Four sampling stations per site were used to record temperatures at the stationd nearest to the water line, the stations closest to 30 cm above the water line, and the stations closest to 30 cm below the water line.

		Victory			Botker		
	Station Location:	Above Water Line	At Water Line	Below Water Line	Above Water Line	At Water Line	Below Water Line
	Approx. Elevation:	(+30 cm)	(0 cm)	(-30 cm)	(+30 cm)	(0 cm)	(-30 cm)
Soil Depth	Temperature C						
2 cm	Mean	13	14.5	15	17.3	16.3	16.8
	Minimum	4	9	9	13	9	8
	Maximum	18	21	19	29	29	29
20 cm	Mean	11.8	14	14.5	15	14.3	14.8
	Minimum	3	7	8	7	7	5
	Maximum	19	21	22	23	26	23

Table 3.38. Total head gradients for piezometers (cm). A negative number indicates upward movement of water. A positive number indicates downward movement.

Botker									
	Nest 1			Nest 2			Nest 3		
Depth Interval (cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
All wells submerged or dry									

Victory									
	Nest 1			Nest 2			Nest 3		
Depth Interval (cm):	30-61	61-122	122-152	30-61	61-122	122-152	30-61	61-122	122-152
4/16/98	-3	4	-5	0	0	0	7	-4	-4
4/304/98	-2	1	-3	0	0	0	3	0	-3
5/13/98	-2	-5	3	0	0	0	4	1	-3
6/4/98	-4	4	-3	10	-1	1	14	1	-4
6/27/98	2	-2	-1	17	1	-8	18	4	-1
8/18/98	15	2	-3	30	33	0	19	65	-2
9/23/98	28	1	-5	32	37	3	19	79	26

Table 3.39. Summary of alkalinity, conductivity, pH, DO, and water temperatures from April to October 1998.

	Victory			Botker		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Temperature (C)	16.3	5.5	23.0	14.2	6.0	23.5
Dissolved Oxygen (mg/l)	7.1	2.4	10.2	4.6	1.4	10.0
Total Alkalinity (mg $CaCO_3$)	200.7	136.0	315.0	85.8	60.0	165.0
Conductivity (uS/cm)	569.3	402.0	905.0	537.4	262.0	907.0
pH	9.5	9.1	9.7	9.1	7.9	9.5

Table 3.40. Anion and cation composition of water. A 'T' indicates trace levels.

	Botker	Victory
Anions (mg/kg)		
F	0.19	0.168
Cl	36.61	5.425
NO2-N	0.59	T
Br	0.051	0.015
NO3-N	0.163	T
PO4-P	0.21	T
SO4	115.5	0.862
Cations (ug/g)		
Al	0.7902	0.0646
Si	8.4028	4.9159
P	33.3462	2.3888
Fe	1.679	0.1442
Mn	0.4921	0.0195
Sr	0.2453	0.1691
Ba	0.1227	0.0797
Ca	67.8648	36.743
Mg	35.84	63.5914
Na	61.8829	11.4046
K	77.3572	13.693

Table 3.41. Number of birds of each species detected during three bird surveys conducted between dawn and 0900 h between 5 May and 10 July. Upland bird species are not included in this listing. This list includes incidental detections.

Coded breeding evidence of birds detected in surveys at each site. 0 = species not present; 1 = species present; 2 = singing male detected; 3 = male and female of species seen together; 4 = nesting activity detected for this species; 5 = young produced for this species. Maximum breeding evidence for each species at each site is found in the Summary column. Upland bird species are not included in this listing. This list includes incidental detections.

	Common Name	Scientific Name	Botker Total	Botker Breeding	Victory Total	Victory Breeding
AMBI	American bittern	*Botaurus lentiginosus*	0	0	4	0
AMCO	American coot	*Fulica americana*	15	4	0	0
AMWI	American widgeon	*Anas americana*	0	0	2	3
AWPE	American White Pelican	*Pelecanus erythrorhynchos*	1	1	18	1
BARS	Barn swallow	*Hirundo rustica*	7	1	4	1
BLTE	Black tern	*Chlidonias niger*	2	1	3	1
BWTE	Blue-winged teal	*Anas discors*	20	3	10	3
CAGO	Canada goose	*Branta canadensis*	3	3	5	4
CANV	Canvasback	*Aythya valisineria*	0	0	1	4
COGR	Common grackle	*Quiscalus quiscula*	3	1	6	1
COMO	Common moorhen	*Gallinula chloropus*	6	4	1	2
COSN	Common snipe	*Gallinago gallinago*	0	0	1	1
COYE	Common yellowthroat	*Geothlypis trichas*	2	2	4	2
DOCC	Double-crested cormorant	*Phalacrocorax auritus*	3	0	2	0
GTBH	Great blue heron	*Ardea herodias*	0	0	3	1
GRYE	Greater Yellowlegs	*Tringa melanoleuca*	1	1	0	0
KILL	Killdeer	*Charadrius vociferus*	5	2	8	2
LESA	Least Sandpiper	*Calidris minutilla*	30	1	0	0
LEYE	Lesser Yellowlegs	*Tringa flavipes*	1	1	0	0
MALL	Mallard	*Anas platyrhynchos*	6	1	6	5
MAWR	Marsh wren	*Cistothorus palustris*	11	4	5	2
NOPI	Northern pintail	*Anas acuta*	0	0	1	1
NSHO	Northern shoveler	*Anas clypeata*	3	1	0	0
REDH	Redhead	*Aythya americana*	20	3	0	0
RWBL	Red-winged blackbird	*Agelaius phoeniceus*	6	4	28	4
RNDU	Ring-necked duck	*Aythya collaris*	0	0	2	3
SEWR	Sedge wren	*Cistothorus platensis*	0	0	1	2
SORA	Sora	*Porzana carolina*	3	4	0	0
TRES	Tree swallow	*Tachycineta bicolor*	0	0	1	1
UNDU	Unknown duck		3	4	0	0
UNBI	Unknown bird		1	1	0	0
UNSH	Unknown Shorebird		17	1	0	0
VIRA	Virginia rail	*Rallus limicola*	3	2	0	0
YHBL	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	82	5	7	5
YRWA	Yellow warbler	*Dendroica petechia*	0	0	2	2
	Total Number of Species		25		24	
	Total Number of Breeding Bird Species			10		8
	Total Abundance		254		125	

Table 3.42. Total numbers of fish caught in minnow traps and aquatic activity traps at each site visit.

Common Name	Scientific Name	Victory	Botker
Brook Stickleback	*Culaea inconstans*	719	442
Fathead Minnow	*Pimephales promelas*	2599	0
	Total abundance	3318	442

Table 3.43. Amphibians detected in the following surveys: VES-Day - daytime visual encounter search, VES-Night - night time visual encounter search, Larval - minnow traps and aquatic activity traps, Chorus - chorusing sruveys.

Number of adults and/or juveniles detected during 30 min. visual encounter search (VES) conducted between 0800 and 1000 h. Surveys began 4/07/98 and ended 7/10/98.

Total amphibian larvae caught in minnow traps and aquatic activity traps on each site site and overall total. Adults were also occasionally found in these traps as well and these are reported here separately from the larval data and as totals only.

Chorusing surveys were conducted for 10 minutes beginning 2 h after sunset from 4/06/98 to 7/10/98. 0 = no individuals of this species detected 1 = individual calls can be distinguished, no overlap 2 = individual calls can be distinguished but are overlapping 3 = calls cannot be distinguished individually, constant and overlapping. Number given is the highest chorusing designation recorded over all site visits.

		Victory				Botker			
Common Name	Scientific Name	VES-Day	VES-Night	Larval	Chorus	VES-Day	VES-Night	Larval	Chorus
Northern leopard frog	*Rana pipiens*	46	82	277	2	4	0	21	2
Western chorus frog	*Pseudacris triseriata*	0	0	85	0	4	17	0	3
Cope's gray treefrog	*Hyla chrysoscelis*	0	0	0	0	0	0	0	0
Treefrog	*Hyla sp.*	0	0	0	0	0	0	0	0
American toad	*Bufo americanus*	0	0	0	0	0	0	0	0
Canadian toad	*Bufo hemiophyrs*	220	95	2	3	110	3	3	3
Tiger salamander	*Ambystoma tigrinum*	0	0	0	0	1	0	0	0

Table 3.44. Floristic list annotated with abundance for each zone and plot at Botker Marsh. Cover estimates were made on July 28, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WE - Wet Edge, EM-Emergent, DI- Ditch, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded.

			Total Cover By Zone				Plot Cover										
Species	Authority	Family	WE	EM	DI	OW	N1	N2	N3	N4	N5	S1	S2	S3	S6	S5	S4
Alisma plantago-aquatica	L.	ALI	2	0.5	0.5			0.1				0.5					2
Sagittaria sp.		ALI	0.5	1	0.5	0.5		0.1		0.5			0.5				0.5
Zizia sp.		API	0.5												2		
Apocynum cannabinum	L.	APO	*														
Asclepias syriaca	L.	ASC	*														
Asclepias tuberosa	L.	ASC	0.5														
Ambrosia artemisiifolia	L.	AST	1				1					0.5					
Aster sp.	L.	AST	0.1														
Bidens sp.		AST	1				2					0.1				0.1	
Cirsium arvense	(L.) Scop.	AST	0.5												2		
Erigeron philadelphicus	L.	AST	*														
Lactuca serriola	L.	AST	*														
Sonchus oleraceus	L.	AST	2									1					
Xanthium strumarium	L.	AST	4				5					2					
Rorippa palustris	(L.) Bess.	BRA	*														
Ceratophyllum demersum	L.	CER		0.5										1			
Cyperus esculentus	L.	CYP	0.5														
Eleocharis acicularis	(L.) R. & S.	CYP	0.5	3		2		5		4							
Eleocharis palustris	L.	CYP		0.5													
Scirpus acutus	Muhl.	CYP	1	0.5		0.5		0.5		0.5			0.5				
Scirpus heterochaetus	Chase	CYP		*													
Scirpus fluviatilis	(Torr.) A. Gray	CYP	0.1		3	1								0.5			
Scirpus validus	Vahl.	CYP			1	1											
Melilotus alba	L.	FAB	*														
Melilotus officinalis	(L.) Pallas.	FAB	0.5														
Vallisneria americana	L.	HYD			0.5	0.5											
Juncus torreyi	Cov.	JUN	0.5														
Juncus sp.		JUN															
Lemna minor	L.	LEM		0.5	4			1	0.5	1			0.5	5			1
Beckmannia syzigachne	(Steud.) Fern.	POA	0.5	0.5		0.5	0.5										
Bromus inermis	Leyss.	POA	1												5		
Echinochloa muricata	(P.Beauv.) Fern.	POA	0.5				0.1										
Elytrigia repens	(L.) Nevski.	POA	*		*												
Hordeum jubatum	L.	POA	0.5														
Phalaris arundinacea	L.	POA	2	2	2						5	3				5	1
Unknown Poaceae		POA										2			0.5		
Polygonum amphibium	L.	POL	0.5														
Polygonum lapathifolium	L.	POL	0.5									0.5					
Rumex maritimus	L.	POL	0.5														
Rumex obtusifolius	L.	POL	0.5														
Rumex salicifolius	J.A. Weinm.	POL	0.5														

Table 3.44. Continued.

Species	Authority	Family	Total Cover By Zone WE	EM	DI	OW	Plot Cover N1	N2	N3	N4	N5	S1	S2	S3	S6	S5	S4
Rumex sp.		POL					2					0.5					
Potamogeton nodosus	Poiret.	POT				0.5											
Potamogeton pusillus	L.	POT				3			4								
Potamogeton sp.		POT				3											
Populus deltoides	Marshall	SAL	0.5	1													
Salix exigua (interior)	Nutt.	SAL	0.5		1												
Salix spp.		SAL			*												
Sparganium eurycarpum	Engelm.	SPA		0.5													
Typha angustifolia	L.	TYP	0.5	5	0.5	1				4							
Typha sp.		TYP					1	5	2				5				4

Table 3.45. Floristic list annotated with abundance for each zone and plot at Victory Marsh. Cover estimates were made on July 28, 1998. Taxonomy follows Gleason and Cronquist (1991) and McGregor (1986). When taxonomy differs between these two, both names are presented. Zone abbreviations are as follows: WE - Wet Edge, EM-Emergent, OW - Open water. A *indicates where a species is presumed to have occurred, although no cover estimate was recorded. Missing numbers represent indicate transect points in water too deep to survey.

			Cover by Zone			Plot Cover																					
Species	Authority	Family	WE	EM	OW	N1	N2	N3	N4	N5	N6	N8	N9	N10	N11	S1	S2	S3	S4	S5	S6	S7	S10	S12	S13	S14	S15
Alisma plantago-aquatica	L.	ALI	0.5																								
Sagittaria cuneata	Sheldon.	ALI		*																							
Sagittaria latifolia	Willd.	ALI		*																							
Sagittaria sp.		ALI		0.5																							
Cicuta bulbifera	L.	API	*																								
Cicuta maculata	L.	API	0.5																								
Zizia aptera	(A. Gray) F.	API	0.5			1																					
Apocynum cannabinum	L.	APO	3												5	2	3	2									3
Asclepias incarnata	L.	ASC	1	0.5										0.5													
Asclepias syriaca	L.	ASC	*			0.1												0.5									
Aster sp.	L.	AST	0.5			0.5									0.1	0.5											
Bidens cernua	L.	AST		0.5				1																			
Bidens comosa	(A. Gray) Wiegand.	AST		0.5																							
Bidens sp.		AST		0.5																							
Cirsium arvense	(L.) Scop.	AST	0.5			1	0.5								1	1	0.5										2
Erigeron philadelphicus	L.	AST	*																								
Helianthus grosseserratus	Martens.	AST	0.5																								
Sonchus oleraceus	L.	AST	1	1		2		2						0.5	2	2	1	1									2
Symphoricarpos occidentalis	Hook	CAP	0.5																								
Ceratophyllum demersum	L.	CER			0.5						0.5	0.5															
Chenopodium rubrum	L.	CHN	0.5																								
Carex atherodes	Sprengel.	CYP	0.5																							2	
Carex festucacea	Schk.	CYP	*																								
Carex lacustris	Willd.	CYP	*	*																							
Carex lasiocarpa	Ehrh.	CYP	*																								
Carex pellita	Muhl.	CYP	4	1		5	5	0.5								2	4	3									3
Carex sartwellii	Dew.	CYP	*																								
Carex sychnocephala	Carey.	CYP	0.5					1																			
Cyperus esculentus	L.	CYP	*																								
Eleocharis sp.		CYP	0.5	0.5																							
Scirpus acutus	Muhl.	CYP		*	0.5																						
Scirpus fluviatilis	(Torr.) A. Gray	CYP		*					0.5										4								
Scirpus validus	Vahl.	CYP		*																							
Dalea purpurea	Vent.	FAB	0.5													0.5											
Glycyrrhiza lepidota	Pursh.	FAB	*																								
Elodea canadensis	Michx.	HYD			1																						
Sisyrinchium campestre	E. Bickn.	IRI	0.1																								
Juncus tenuis (dudleyi)	Wieg.	JUN	*																								
Juncus sp.		JUN							0.5										1								
Juncus torreyi	Cov.	JUN	0.5																								
Lycopus americanus	Muhl.	LAM	*					0.5						0.5	0.5			1	0.5								1
Lycopus asper	Michx.	LAM	1	0.5			1								1			0.5									3
Lemna minor	L.	LEM	0.5	0.5																							
Utricularia vulgaris	L.	LEN			3				0.5		1	0.5	0.5									2	3	0.5			
Najas flexilis	(Willd.)Rostk.	NAJ			2																						
Epilobium ciliatum	Raf.	ONA		2																							
Andropogon gerardii	Vitman	POA	*													1	1										3
Bromus inermis	Leyss.	POA	*																								
Calamagrostis inexpansa	(Michx.) Beauv.	POA	0.5			0.5																					
Elytrigia repens	(L.) Nevski.	POA	0.5																								0.5
Hierchloe odorata	(L.) P. Beauv.	POA	*																								
Hordeum jubatum	L.	POA	*																								
Leersia oryzoides	(L.) Swartz.	POA	*					0.5																			
Panicum capillare	L.	POA	0.5					0.5											0.5								
Panicum sp.		POA													0.5			0.5									
Panicum virgatum	L.	POA	0.5			0.5																					
Phalaris arundinacea	L.	POA	0.5	2				2						0.5	0.5		0.5	3								3	
Poa sp.		POA	0.5			2											0.5										

Table 3.45. Continued.

Species	Authority	Family	Cover by Zone			Plot Cover																					
			WE	EM	OW	N1	N2	N3	N4	N5	N6	N8	N9	N10	N11	S1	S2	S3	S4	S5	S6	S7	S10	S12	S13	S14	S15
Spartina pectinata	Link	POA	0.5			0.5	1																				
Unknown Poaceae		POA				2											3	2									
Polygonum amphibium	L.	POL			0.5																						
Polygonum lapathifolium	L.	POL	•					1																			
Polygonum sp.		POL		0.5					0.1										0.1								
Rumex maritimus	L.	POL		0.5				2											0.5								
Rumex obtusifolius	L.	POL	0.5					0.1											0.5								
Rumex sp.		POL							0.5																		
Potamogeton illinoensis	Morong	POT			3			0.5	1				0.1						1								
Potamogeton nodosus	Poiret.	POT			2																						
Potamogeton pectinatus	L.	POT			1														1								
Potamogeton pusillus	L.	POT			0.5							0.1								0.5	0.5						
Potamogeton zosteriformis	Fern.	POT			3				0.5	2	2	0.5								2	2	3		0.5			
Anemone canadensis	L.	RAN	0.5													3	3	1									
Ranunculus sceleratus	L.	RAN	0.5					0.5											0.5								
Fragaria virginiana	Duchn.	ROS	0.5			2																					
Potentilla rivalis	Nutt.	ROS	0.5					0.5																			
Rosa sp.		ROS	•																								2
Populus deltoides	Marshall	SAL	•																								
Salix cf. discolor	Muhl.	SAL	•																								
Salix exigua (interior)	Nutt.	SAL	0.5					4																			
Salix nigra	Marshall	SAL		0.5		2	5																				
Sparganium eurycarpum	Engelm.	SPA		•																							
Typha angustifolia	L.	TYP	0.5											5											5	4	
Typha latifolia	L.	TYP		•																							
Typha sp.		TYP		•				1	0.5				2														
Verbena stricta	Vent.	VER	0.5																								

Botker Marsh Site Description

Directions to Site from the Twin Cities:

Follow I-94 West towards Sauk Centre. Just south of Sauk Centre exit onto U.S. Highway 71 South, following it only briefly, then exit onto State Highway 28 West. Continue on 28 west towards Graceville, then exit south on U.S. Highway 75. Botker is located immediately south of Clinton on the east side of 75. Park on the east shoulder of the highway, not in the driveway. (Page 43 of MN Atlas)

Site Description and Restoration History:

Botker Marsh, previously in corn production for many years, was restored in July 1996 by plugging a ditch that formerly drained the site. Corn will continue to be produced on the surrounding uplands and no management scheme has been implemented to control undesirable plants.

The immediate land use adjacent to the site includes the Botker farmstead and the associated buildings and cornfields. There is also a major highway bordering the site on the west. The dominant land use in the region is row crop agriculture with many small wetlands and prairie lakes. Several grassland remnants are in the area, as well as the town of Clinton (pop. Appx. 500). A series of wastewater detention ponds are also nearby. The soil mapping unit is Dovray silty clay. A topographic map for the restoration is shown in Figure 3.15.

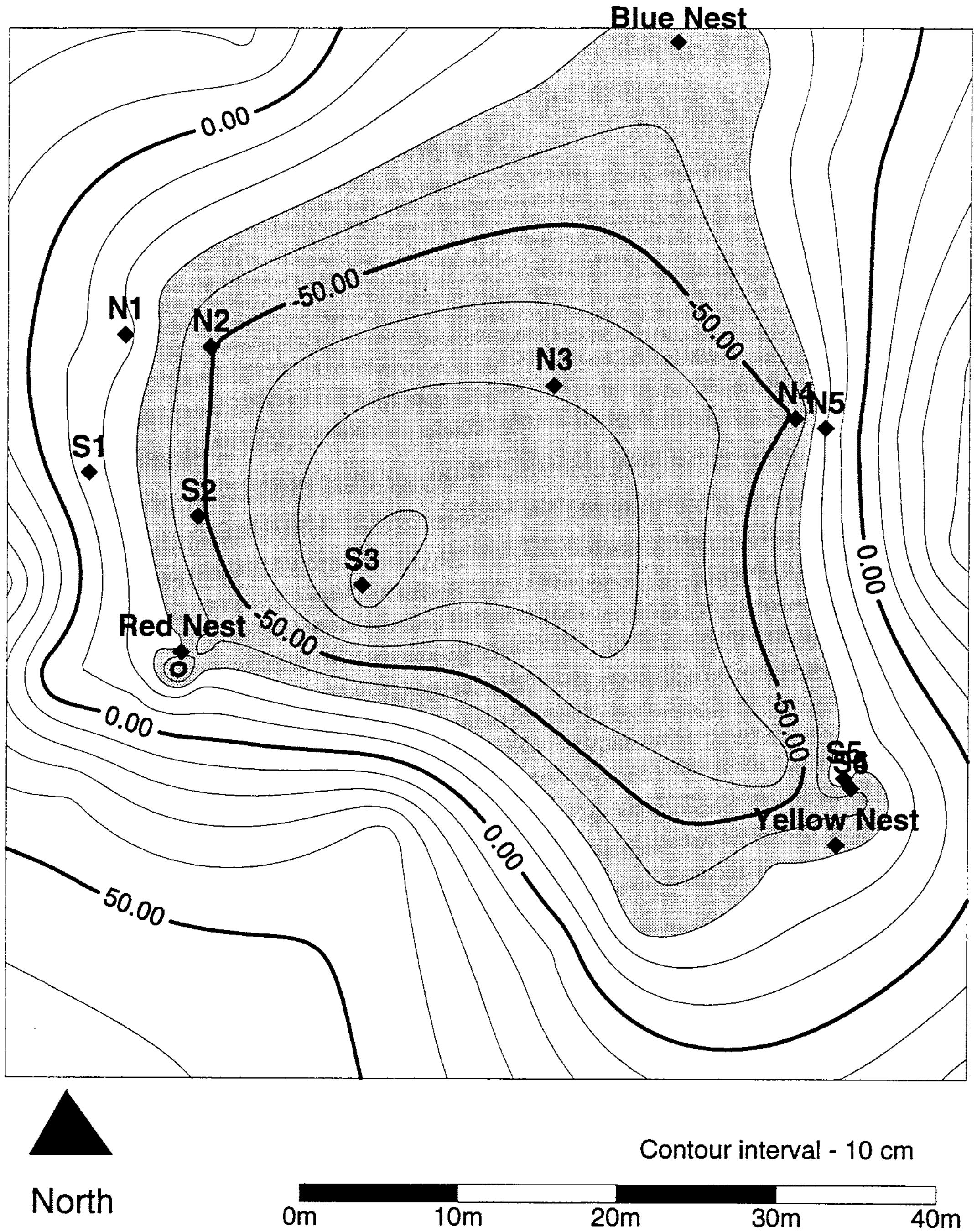


Figure 3.15. Topographic map of the Botker Marsh unplanted wetland restoration. Numbered points represent data collection plots along north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection.

Victory Marsh Site Description

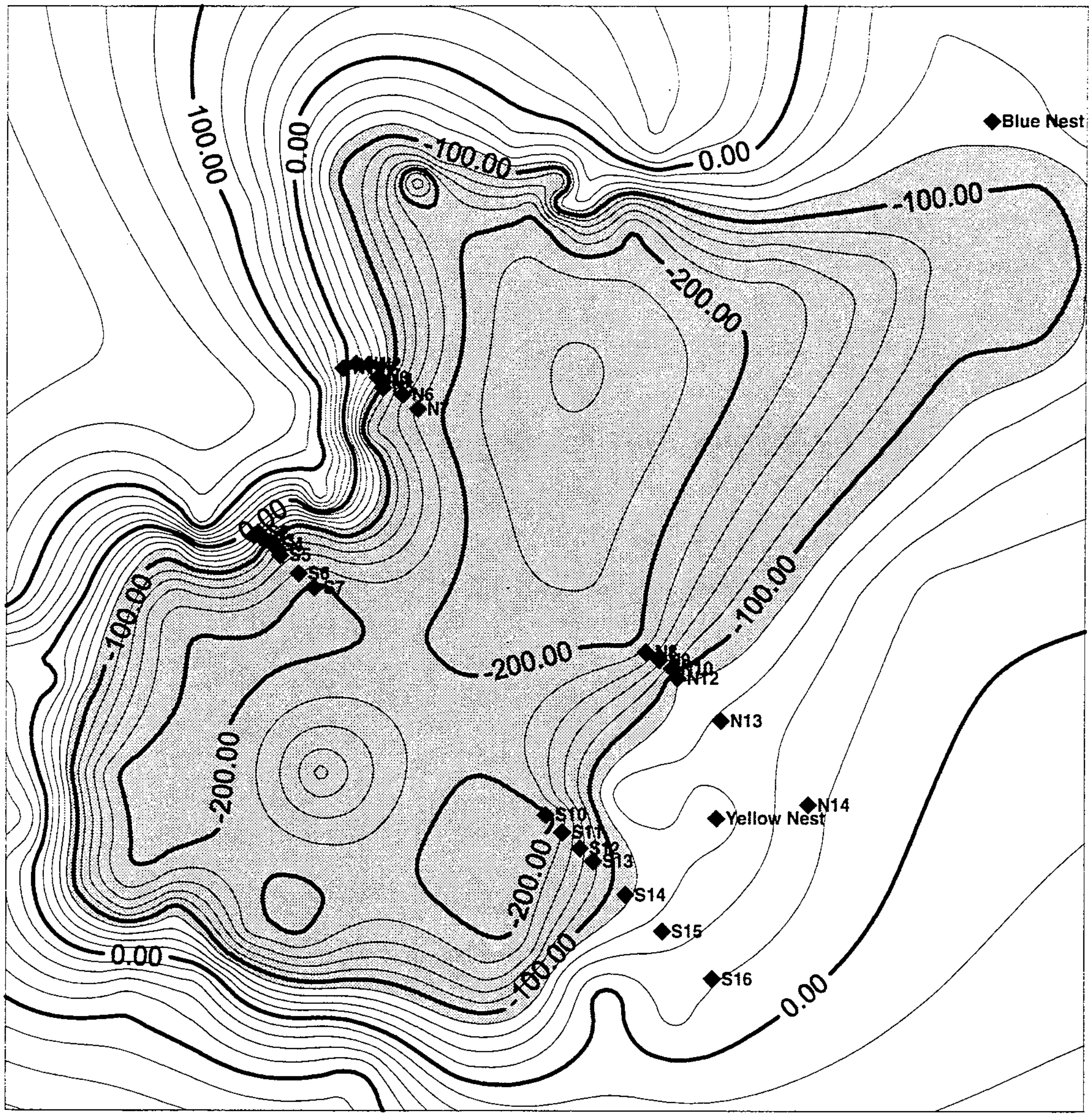
Directions to Site from the Twin Cities:

Follow I-94 West towards Sauk Centre. Just south of Sauk Centre exit onto U.S. Highway 71 South, following it only briefly, then exit onto State Highway 28 West. Continue on 28 towards Graceville, then exit south on U.S. Highway 75. Follow 75 past the Botker site to County Road 64 east (left turn off the highway). Take 64 to County Road 67. Follow this road to the fork, then take the left fork and proceed north to an abandoned farmhouse on the right. Look for Wildlife Management Signs and park in the pull-in on the left. Wetland is immediately west of road. (Page 36 of MN Atlas)

Site Description:

Designated as a Wildlife Management Area, Victory Marsh is an intact depressional wetland located within a large complex of wetlands and remnant prairie that has apparently never been plowed, although it has received relatively heavy grazing pressure in the past. The site contains native prairie of high quality, meriting inclusion on the Minnesota Natural Heritage Register in a region otherwise heavily agricultural. Management is directed towards "perpetuating or establishing natural processes," including prescribed burning in certain areas and, as a last resort, chemical treatment to halt the encroachment of noxious species.

The immediate land use adjacent to the site is prairie/wetland with some nearby row crop agriculture and pastures. The dominant land use in the watershed is a mixture of shallow prairie lakes and wetlands, grassland remnants and row crop agriculture. The soil mapping unit is a Fram-Vallers-Parnall complex. Figure 3.16 shows a topographic map of the site.



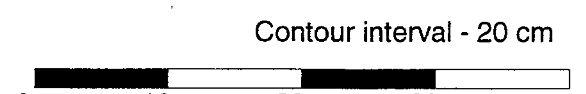


Figure 3.16. Topographic map of the Victory Marsh reference wetland. Numbered points represent data collection plots along north (N) and south (S) transects. The red, blue, and yellow nests refer to the location of the piezometer nests used for hydrological data collection

APPENDIX A

FIELD DATA SHEETS

Wetland Ecosystems Monitoring Project
Field Data Sheet (Physical/Chemical/Hydrological)

Site Name:______________________

Observer(s)______________________

Date______________

Water Chemistry

	Red Nest	Blue Nest	Yellow Nest
Time			
Water Temperature			
Dissolved Oxygen (mg/L)			
Sky condition			

Water samples collected for lab analysis (activity 2)? Yes No
Water samples collected for detailed analysis (activity 3)? Yes No

LABEL STANDARDS
Site Name
Date
Nest #

Hydrology

	Red Nest		Blue Nest		Yellow Nest	
total pipe length	depth to water	depth to soil	depth to water	depth to soil	depth to water	depth to soil
30 cm						
61 cm						
122 cm						
152.5 cm						
Observation Well						

Water Depth at Water level monitoring station: Station:__________ Depth:__________

Soil Temperature

Transect:_______

Pole #						
2 cm						
20 cm						

Transect:_______

Pole #						
2 cm						
20 cm						

Soil texture analysis

Site: Analysis date:

Transect: Pole: Regime:

Core depth label (cm): Core depth actual (cm):

Sample Weight (g): Beaker no.: Cylinder no.:

Hydrometer reading in dispersing solution (blank), g/l:

Temperature: 40sec. (C): Temperature: 7hr. (C):

	Sample time	Suspended	Uncorrected	Corrected	Amt. of sus.
	(Actual time)	fraction	hydro rdg (g/l)	hydro rdg (g/l)	fraction (%)
40 sec:		Silt & Clay			
7hr:		Clay			

Particle size analysis of sample:
%sand: % silt: % clay:

Site: Analysis date:

Transect: Pole: Regime:

Core depth label (cm): Core depth actual (cm):

Sample Weight (g): Beaker no.: Cylinder no.:

Hydrometer reading in dispersing solution (blank), g/l:

Temperature: 40sec. (C): Temperature: 7hr. (C):

	Sample time	Suspended	Uncorrected	Corrected	Amt. of sus.
	(Actual time)	fraction	hydro rdg (g/l)	hydro rdg (g/l)	fraction (%)
40 sec:		Silt & Clay			
7hr:		Clay			

Particle size analysis of sample:
%sand: % silt: % clay:

Wetland Ecosystems Monitoring Project
Field Data Sheet (Vegetation Yearly Plot Survey)

Site Name________________________,

Observer(s)________________________,

Date________,

Transect__________**Pole**____________

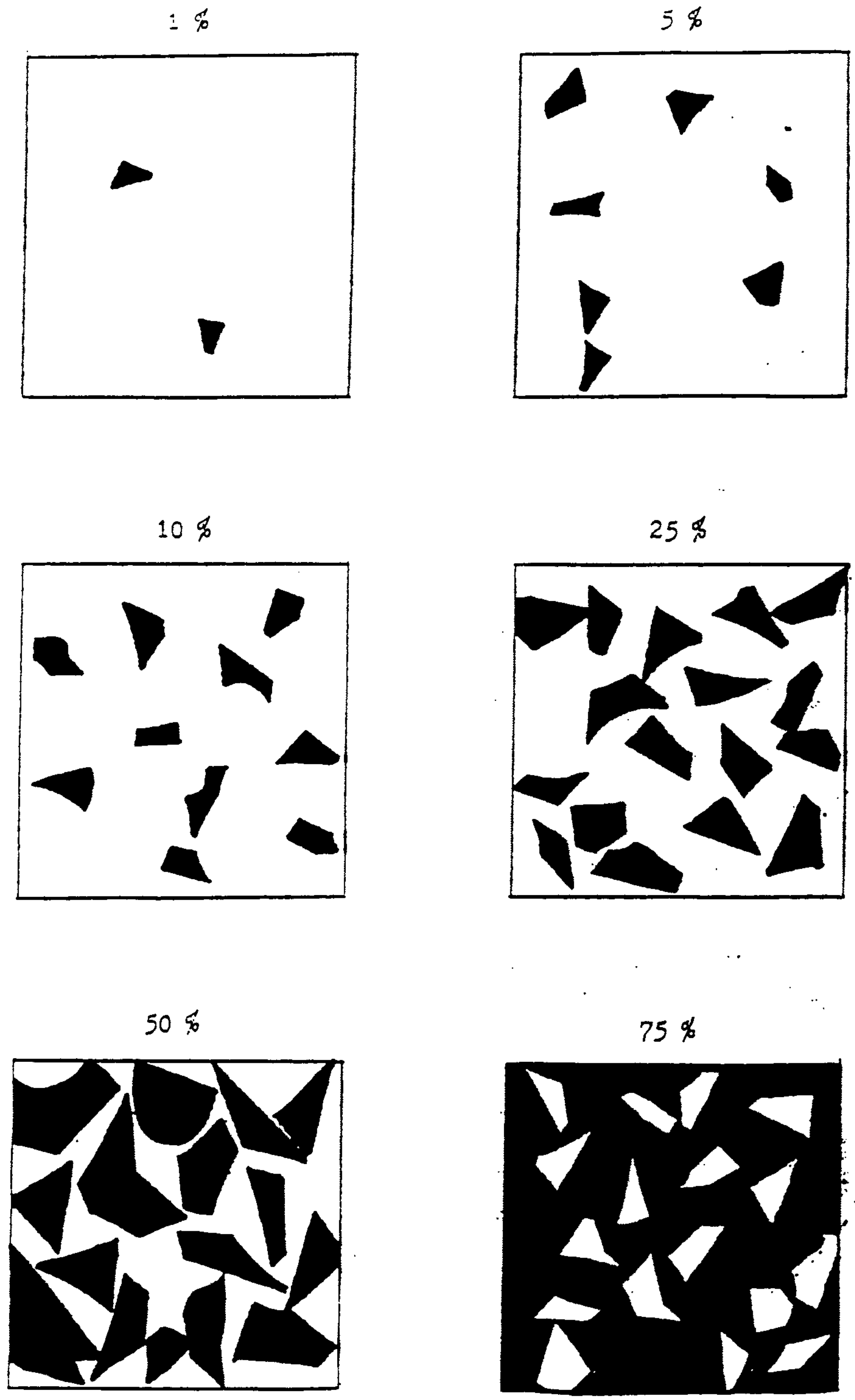
	Cover class	Voucher #	Remarks
standing water			
litter			
no vegetation			
Species Name			

Transect__________**Pole**____________

	Cover class	Voucher #	Remarks
standing water			
litter			
no vegetation			
Species Name			

r <1% cover, rare
+ <1% cover, uncommon
1= 1-5%
2= 5-25%
3= 25-50%
4=50-75%
5=75-100%

Comparison diagrams for visual estimation of percentage cover



Wetland Ecosystems Monitoring Project
Field Data Sheet (Total Floristic Composition)

Site Name__________________________,

Observer(s)__________________________,

Date________,
Page _1_ of ____

ZONE DESCRIPTIONS
Zone 1:

Zone 2:

Zone 3:

Zone 4:

COVER CLASSES

r = less than 1% cover, rare
+=less than 1% cover, uncommon
1=1- 5% cover
2= 5-25% cover
3= 25-50% cover
4= 50-75% cover
5= 75-100% cover

COVER CLASS

	Zone 1	Zone 2	Zone 3	Zone 4	Remarks
Area covered by standing water					
Area covered by litter					
Area with no vegetation cover (open water, bare dirt)					

General Remarks:

Wetland Ecosystems Monitoring Project
Field Data Sheet (Total Floristic Composition)

Date________,
Page ___ of ____

Site Name_________________________,

Observer(s)_______________________,

COVER CLASS

Species Name	Voucher #	Zone 1	Zone 2	Zone 3	Zone 4	Remarks

Wetland Ecosystems Monitoring Project
Field Data Sheet (Amphibians)

Site Name________________________________.

Observer(s)________________________________.

Chorusing Survey

Date: Time (Begin): Time (End): Wind Speed:

Air temp (C): Water temp (C): Humidity: Sky:

Species	**Call Index**			
Wood Frog (*Rana sylvatica*)	0	1	2	3
Northern Leopard Frog (*Rana pipens*)	0	1	2	3
Green Frog (*Rana clamitans*)	0	1	2	3
Mink Frog (*Rana septentrionalis*)	0	1	2	3
Western Chorus Frog (*Pseudacris triseriata*)	0	1	2	3
Spring Peeper (*Pseudacris crucifer*)	0	1	2	3
Gray Tree Frog (*Hyla versicolor*)	0	1	2	3
Cope's Gray Tree Frog (*Hyla chrysocelis*)	0	1	2	3
Cricket Frog (*Acris crepitans*)	0	1	2	3
American Toad (*Bufo americanus*)	0	1	2	3
Canadian Toad (*Bufo hemiophrys*)	0	1	2	3
Great Plains Toad (*Bufo cognatus*)	0	1	2	3
Other (Must voucher):	0	1	2	3

The call index is an estimate of the abundance of calling males of each species, using the following scale:

- 0 = no individuals of this species detected
- 1 = individual calls can be distinguished; space between calls
- 2 = individual calls can be distinguished, but are overlapping
- 3 = calls cannot be distinguished individually. Chorus is constant and overlapping.

Visual Encounter Survey (VES) (Day and Night)

Date: Time (Begin): Time (End): Wind Speed:

Air temp (C): Water temp (C): Humidity: Sky:

Species	Night Tally	Day Tally	Night Total	Day Total

Reference Specimens collected? Yes No

Date: Time (Begin): Time (End): Wind Speed:

Air temp (C): Water temp (C): Humidity: Sky:

Larval Sampling
Date: Time (Begin): Time (End): Water Temp:

Amphibian Species	**Trap #**	**Tally**	**Total Larvae**	**Total Adults**

Reference Specimens collected? Yes No

Fish Species	**Trap #**	**Total**

Reference Specimens collected? Yes No

Sky Code	Sky Condition
0	Clear or few clouds
1	Partly cloudy
2	Cloudy or overcast
3	Fog
4	Drizzle
5	Showers

Incidental detections, notes, etc.

B.M.N.H., U. of M. __________ Spec. __________

Species __________

Loc. __________

____

County __________ T ______ R ______ S ______

Date __________ Coll. __________

B.M.N.H., U. of M. __________ Spec. __________

Species __________

Loc. __________

____

County __________ T ______ R ______ S ______

Date __________ Coll. __________

B.M.N.H., U. of M. __________ Spec. __________

Species __________

Loc. __________

____

County __________ T ______ R ______ S ______

Date __________ Coll. __________

B.M.N.H., U. of M. __________ Spec. __________

Species __________

Loc. __________

____

County __________ T ______ R ______ S ______

Date __________ Coll. __________

Wetland Ecosystems Monitoring Project
Field Data Sheet (Birds)

Site Name________________________.

Observer(s)________________________.

Point Count

Date: Time (Begin): Time (End): Point #:

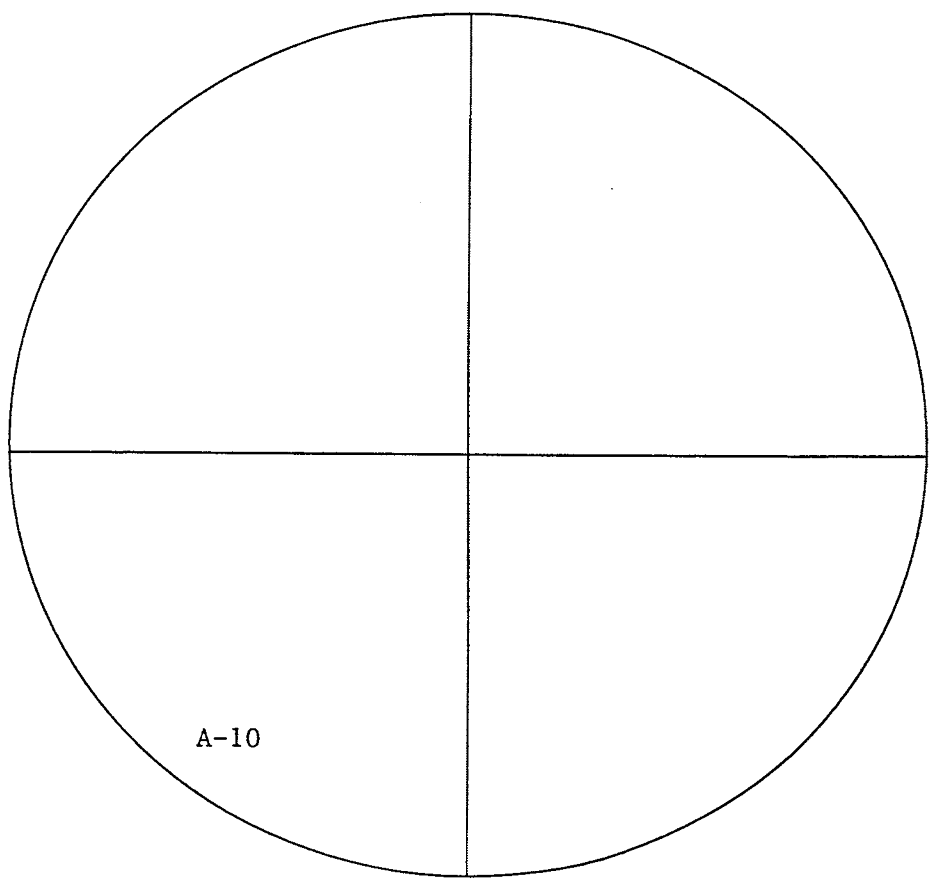
Air temp (C): Water temp (C): Wind Speed: Sky:

Species Abbrev.	Tally	Total	Notes

Notes: Breeding evidence (1) Singing male (2) male and female together (3) nest (4) young

Symbols

Use species abbreviations, symbols, and arrows to keep track of the location, number, and breeding status of birds at each point. See sample data sheet for examples.



Nest Search

Date: Time (Begin): Time (End):

Species	Abundance	Notes (Point number, eggs, chicks, etc.)

Secretive Species Responses to Tape

Species	Abundance	Notes

Birds detected outside of sampling period

Species	Abundance	Notes (Breeding evidence, etc.)

Sky Code	Sky Condition
0	Clear or few clouds
1	Partly cloudy
2	Cloudy or overcast
3	Fog
4	Drizzle
5	Showers

CAUTION: Do not conduct bird survey if (1) it is raining heavily, (2) it is foggy, and/or (3) winds exceed 20 mph.

APPENDIX B

FISH KEY

Fish Key

R. Lehtinen (adapted from Eddy and Underhill)

Fish are not always thought of in regards to wetlands, as few species are able to tolerate the low oxygen concentrations. However, some species can survive and others may occasionally be washed in during periods of high water. What follows is a list of the most common species that inhabit depressional wetlands. If a species is found that is not on this list or otherwise unknown, collect a reference specimen.

Fathead minnow (*Pimephales promelas*)

Description: This minnow is one of the most commonly found species in wetlands and is often used as a baitfish. It typically ranges from 2-3 inches in length and is a prolific breeder often found in large aggregations. The fathead minnow has a small mouth and rounded fins. A good characteristic for identification is the crowding of smaller scales in front of the dorsal fin, as compared to the larger scales behind. Also, the male of this species had prominent spike-like tubercles on its head and back during the breeding season.

Brook stickleback (*Culaea inconstans*)

Description: This fish is common and easy to identify. Rarely growing beyond 3 inches, it has a very characteristic body shape with 4 to 6 prominent spines on its back. This species can also tolerate low dissolved oxygen levels and has been known to burrow in the mud to survive drought conditions.

Common carp (*Cyperinus carpio*)

Description: This non-native species has successfully invaded water bodies throughout the world, including Minnesota wetlands. In contrast to other species found in wetlands, the Common Carp can attain an impressive size, weighing over 20 pounds and reaching over 2 feet in length. Of course, fish of this size will not be found in a wetland. This species migrates into wetlands through ditches and even drainage tiles and can uproot much of the aquatic vegetation. It is identified by a long dorsal fin and prominent projections, called barbels, on the upper jaw.

Central mudminnow (*Umbra limi*)

Description: This hardy species is most closely related to pike and muskie, although its appearance is much different. Often found in the more forested parts of Minnesota, this fish is usually less than 4 inches long, but can be up to 7. It can be identified by its small mouth, torpedo-shaped body and a dorsal fin that is placed well back on the body. There is also a prominent black bar where the body meets the tail.

Reference:

Eddy, S. and J.C. Underhill. 1976. Northern fishes. University of Minnesota Press, Minneapolis, MN.

APPENDIX C

AMPHIBIAN KEYS

A Key to the Tadpoles of Minnesota

R. Lehtinen (adapted from Altig (1970) and Preston (1982))
Note: This key includes species of *possible* occurrence in MN.

1a. Anus medial: eyes dorsal 2
1b. Anus dextral; eyes dorsal or lateral.. 6

2a. Papillae encircle mouth or nearly so; May be interrupted by a small gap in the middle of the upper labium .... *Spea bombifrons*
2b. Papillae of upper labium with a wide dorsal gap (equal to A-1); papillae of lower labium with ventral gap equal to or larger than P-3 3

3a. P-1/P-3 more than two; upper jaw angulate; several to many submarginal papillae at the lateral tips of P-3; A-2 gap wide; dorsum usually lightly pigmented .... *Bufo cognatus*
3b. P-1/P-3 less than two; upper jaw not noticeably angulate; submarginal papillae at tips of P-3 not prominent or absent; A-2 gap narrow, dorsum lightly or darkly pigmented 4

4a. Clear throat patch extends nearly to gut; remainder of venter unicolored or with reticulate melanophores; light ventral part of tail musculature narrow; western tier of counties from Lac Qui Parle Co. north .... *Bufo hemiophrys*
4b. Throat patch small or absent; remainder of venter evenly pigmented with reticulate melanophores; light ventral part of tail musculature wide or narrow; western tier of counties or otherwise 5

5a. Throat largely pigmented; no melanic gaps in dorsal tail musculature pigment; snout sloping in lateral view; eye small; tail height/musculature height 2.0 or less; dorsum dark without contrasting markings; widespread in MN ....*Bufo americanus*
5b. Throat patch present; often irregular melanic gaps in dorsal tail musculature; light ventral portion of tail musculature wide; snout rounded in lateral view; eyes large; tail height/musculature height 2.0 or more; dorsum dark; found possibly in extreme SW MN .... *Bufo woodhousii*

6a. Eyes dorsal; oral disc emarginate; papillary border does not or barely reaches above lateral tips of A-1; lip margin indented at sides .... .13
6b. Eyes lateral or dorsal; oral disc not emarginate; papillary border commonly reaches considerable distance above lateral tips of A-1; lip margin not indented 7

7a. Two rows of teeth in lower labium 8
7b. Three or four rows of teeth in lower labium 10

8a. Tail tip distinctly black ....*Acris crepitans*
8b. Tail tip not black 9

9a. One row of oral papillae .... *Pseudacris triseriata*
9b. Two rows of oral papillae .... *Pseudacris crucifer*

10a. Papillae of lower labium without distinct gap .... *Pseudacris crucifer*
10b. Papillae of lower labium without a gap 11

11a. Third row of lower labial teeth longer than upper jaw.. *Hyla sp.*
11b. Third row of lower labial teeth equal to or shorter than upper jaw 12

12a Fins commonly blotched.. *Pseudacris crucifer*
12b. Fins not blotched.. *Pseudacris triseriata*

13a. Upper labium with four rows of teeth... *Rana sylvatica*
13b. Upper labium with one to three rows of teeth 4

14a. Lower labium with four rows of teeth .... *Rana sylvatica*
14b. Lower labium with two or three rows of teeth... 5

15a. Tail and body greenish; commonly patterned with distinct black dots; tail appears bicolored; specimens often quite large (up to 12cm); confined to extreme SE MN except for a few introduced populations elsewhere in the state .... *Rana catesbeiana*
15b. Not as above 16

16a. Lower jaw wide; nostrils medium sized; gut usually visible 17
16b. Lower jaw narrow; nostrils small or medium sized; gut usually not visible 18

17a. A-2 gap ratio 2.0 or more; marginal papillae below P-3 large, ten or less present; tail usually heavily marked; P-1/P-3 1.3 or more; gut often only slightly visible; SE portion of state only... .... *Rana palustris*
17b. A-2 gap ratio less than 2.0; marginal papillae below P-3 small, more than ten present; if tail marked, usually not with large spots; unpigmented throat patch with contrasting margins present; gut usually visible; widespread in MN... *Rana pipiens*

18a. Dorsal fin terminates at spiracle... ...*Rana sylvatica*
18b. Dorsal fin terminates posterior to the spiracle .... .19

19a. Ratio of one section of the second row of the upper labial teeth to the interval between the sections less than five ....*Rana septentrionalis*
19b. Ratio of one section of the second row of the upper labial teeth to the interval between the sections five or more.. .*Rana clamitans*

<u>Dichotomous Key to the Selected Adult Amphibian of Minnesota</u>

R. Lehtinen

Note: Only those species likely to occur on study sites are included here.

1a. Obvious tail present 2
1b. No tail present 3

2a. Costal grooves apparent and numerous; usually dark colored with yellowish spots over body .... *Ambystoma tigrinum*
2b. No costal grooves; juveniles are terrestrial and reddish; adults are aquatic and greenish with red spots .... *Notophthalmus viridescens*

3a. Skin dry and covered with numerous bumps and warts 4
3b. Skin moist; not covered in warts 6

4a. Warts on body are relatively small and of the same size ....*Bufo cognatus*
4b. Warts on body are of many different shapes and sizes 5

5a. Cranial ridges join to form a distinctive bump between the eyes .... *Bufo hemiphrys*
5b. Cranial ridges are not fused; no distinctive bump .... *Bufo americanus*

6a. Toe pads are present; no dorsolateral ridges 7
6b. Toe pads not present on toes; dorsolateral ridges present 10

7a. Toe pads as wide as toes 8
7b. To pads obviously wider than toes 9

8a. Distinctive stripes in bands along length of body .... *Pseudacris triseriata*
8b. No distinctive stripes; dark triangle behind head .... *Acris crepitans*

9a. Distinctive X-pattern on back .... *Pseudacri crucifer*
9b. No X-pattern on back; gray or green in color .... *Hyla chrysoscelis/versicolor*

10a. Distinctive dark "mask" across snout; body tan or brown in color .... *Rana sylvatica*
10b. No dark mask across snout; body brown or otherwise 11

11a. Many obvious, irregularly shaoed dark spots on back .... *Rana pipiens*
11b. No obvious dark spots are present .... .12

12a. Webbing on hind feet extends to the tip of the fifth toe .... *Rana septentrionalis*
12b. Webbing on hind feet extends only to second toe .... *Rana clamitans*

**Hyla chrysoscelis* and *Hyla versicolor* are best distinguished by call.

Descriptive Key of Minnesota Amphibians

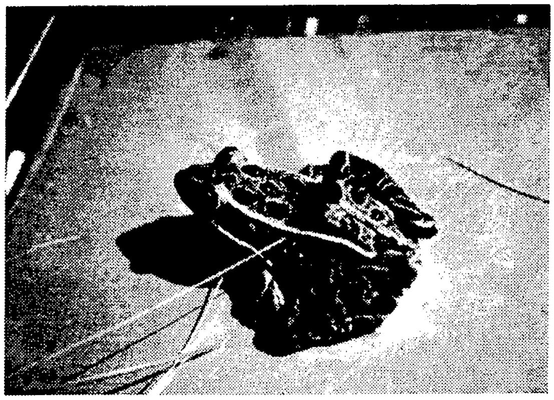
The following pages provide descriptions of common Minnesota amphibians, including salamanders, newts, frogs and toads. Common species are:

Northern leopard frog *(Rana pipiens)*
Mink frog *(Rana septentrionalis)*
Green frog *(Rana clamitans)*
Wood frog *(Rana sylvatica)*
Spring peeper *(Pseudacris crucifer)*
Western chorus frog *(Pseydacris triseriata)*
Northern cricket frog *(Acris crepitans)*
Cope's gray tree frog *(Hyla chrysoscelis)*
Gray tree frog *(Hyla versicolor)*
American toad *(Bufo americanus)*
Canadian toad *(Bufo hemiophrys)*
Great plains toad *(Bufo cognatus)*
Tiger salamander *(Ambystoma tigrinum)*
Eastern newt *(Notophthalmus viridescens)*

Listed below are several species which are found occasionally in Minnesota, but are unlikely to be encountered during this study as they are either not found near the study sites or do not typically breed in depressional wetlands. Descriptions of these five amphibians are not included, but if they are found at a study site it should be officially documented:

Blue-spotted salamander *(Ambystoma laterale)*
Redback salamander *(Plethodon cinerus)*
Mudpuppy *(Necturus maculosus)*
Bullfrog *(Rana catesbeiana)*
Pickerel frog *(Rana palustris)*

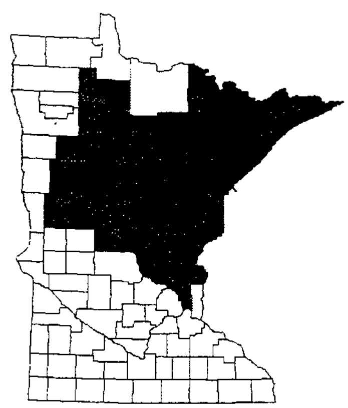
Northern Leopard Frog (*Rana pipiens*)



Description: This common medium to large sized frog is green or brown with large, dark spots over much of the body. The belly is white and there are prominent ridges along the body extending back from the eyes. The breeding call of the northern leopard frog sounds like a low-pitched snore, often with grunts and squeaks mixed in. This frog normally breeds from late April until early June. Distribution: *Rana pipiens* is found throughout the state.

Distribution maps are adapted from Oldfield and Moriarty's book "Amphibians and Reptiles Native to Minnesota". If a species has been recorded from a county it is shaded in green. This does not necessarily mean that a species is found throughout the entire county or is currently extant in that locality. These maps were constructed from museum records, literature, sighting records, and personal observations.

Mink Frog (*Rana septentrionalis*)



Description: Mink frogs are found most commonly sitting on vegetation in lakes and ponds. This species usually is greenish with brown mottling, with the belly distinctly lighter in color. It looks, and is often confused with, the Green Frog. However, the complete webbing on the hind feet and the distinctive "rotten onion" odor that is given off when handled, distinguish this species. Mink frogs breed from late May to late July or early August. The male breeding call sounds like a hammer striking wood in rapid succession. Distribution: The mink frog is found in north-central and northeastern Minnesota.

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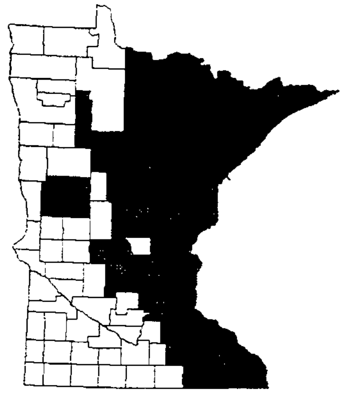
Green Frog (*Rana clamitans*)



Description: Green frogs range in color from brown to green and may become quite large in size (up to nearly 11 cm). The upper lip, in particular may be a bright green and the belly is white. Webbing on the hind feet is incomplete, distinguishing it from the Mink Frog. They are more often associated with more permanent water bodies (like rivers or streams), but they can be found elsewhere on occasion. Green frogs breed from late May to early August and the breeding call is a single "plunk" that sounds like a rubber band being snapped. Distribution: The green frog is found in the eastern portion of the state.

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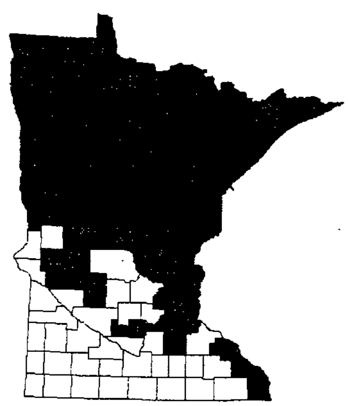
Wood Frog (*Rana sylvatica*)



Description: This small to medium-sized frog is distinguished easily by its black face mask that runs from the tip of the snout and past the eye on both sides of the head. Skin color is usually tan or brown with dark markings and a white belly. Prominent ridges are present on the back. The wood frog is the earliest breeding of Minnesota's frogs, often beginning in late March or early April. Its call is a series of quacks given in quick succession. Distribution: The wood frog is found in the north and in portions of central and south-eastern Minnesota.

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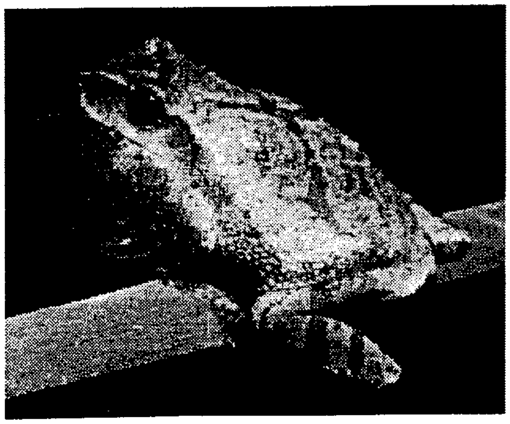
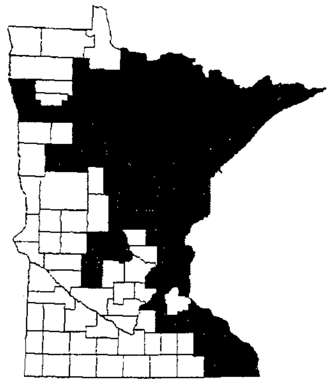
Spring Peeper (*Pseudacris crucifer*)





Description: This frog is a small (3/4 inch to 1 1/4 inch snout-vent length) but noisy member of the tree frog family. Skin color varies with temperature, from dark brown (cold) to light brown or gray (warm). The most distinctive features of this frog are the large X-shaped mark on its back and the toe pads on the ends of its digits. Note the lack of prominent ridges on its back. Spring peepers breed from early or mid April through May. The breeding call is a high-pitched 'peep'. Distribution: *Pseudacris crucifer* is found eastern portions of the state with some populations in central and northwestern Minnesota.

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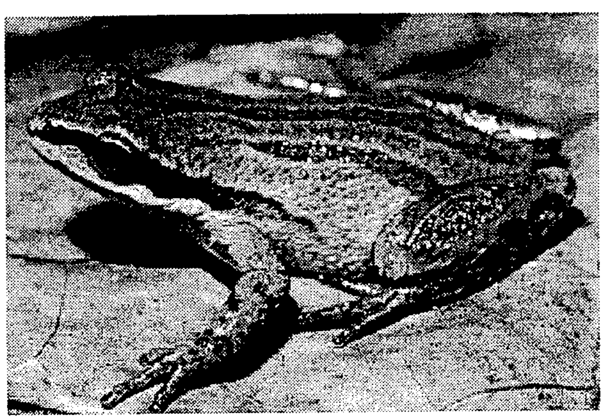
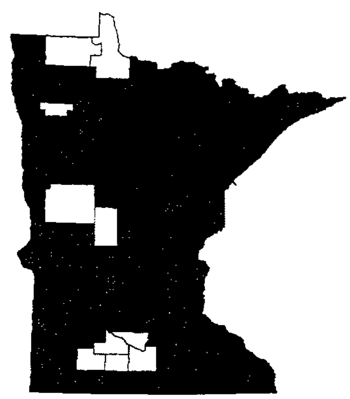
Western Chorus Frog (*Pseudacris triseriata*)

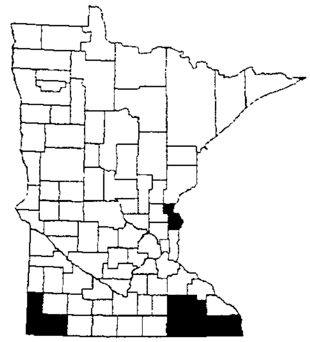




Description: This is another small frog with a slender body. Coloration can be variable from tan to bronze or even reddish or green. Stripes are usually present on the body and toe pads are on the digits, although they are often difficult to see. Chorus frogs breed as early as late March and continue on into May. The breeding call sounds very much like running your finger across the teeth of a comb. This call is occasionally given outside the normal breeding season. Distribution: *Pseudacris triseriata* is found throughout most of Minnesota.

Distribution maps are adapted from Oldfield and Moriarty's book "Amphibians and Reptiles Native to Minnesota". If a species has been recorded from a county it is shaded in green. This does not necessarily mean that a species is found throughout the entire county or is currently extant in that locality now. These maps were constructed from museum records, literature sighting records, and personal observations.

Northern Cricket Frog (*Acris crepitans*)



Description: These small brown or gray frogs were once common in parts of south-eastern and south-western Minnesota, now they are classified as an endangered species and have not been spotted in many years. Any sightings should be reported immediately. They can be identified by a dark triangle shape between the eyes. The breeding call (glick, glick, glick) sounds like small pebbles being knocked together. Unfortunately, identification by call is complicated by the Virginia Rail, which makes a similar sound. The Northern Cricket Frog breeds from late May into July. Distribution: *Acris crepitans* historically was found in portions of southeastern and southwestern Minnesota.

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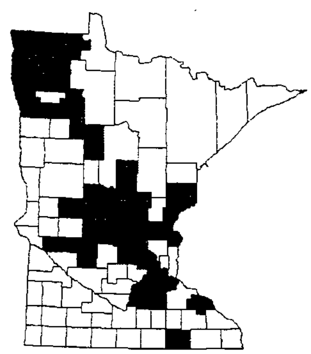
Cope's Gray Treefrog (*Hyla chrysoscelis*)



Description: This medium-sized treefrog can be green or gray depending on temperature and habitat. When gray, it often has dark spots on its back. Its toe pads are large and easily seen. Breeding begins in May and usually continues through most of June. The call of this species is a fast metallic trill and is the only way to reliably tell this species from *Hyla versicolor*, the gray treefrog. Distribution: *Hyla chrysocelis* is found in parts of eastern, central, and northwestern Minnesota.

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Gray Treefrog (*Hyla versicolor*)

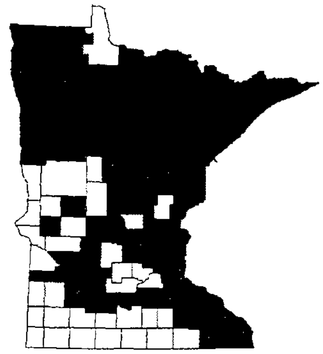

Photo by G. S. Casper

Description: This medium-sized frog is gray or green with large toe pads and is often indistinguishable from Cope's Gray Treefrog. The breeding call of this species is a slower, more musical trill and is the most certain way to identify this species. Breeding typically begins in May and goes through June. Distribution: The gray treefrog is found throughout much of the northern, eastern, and central portions of the state.

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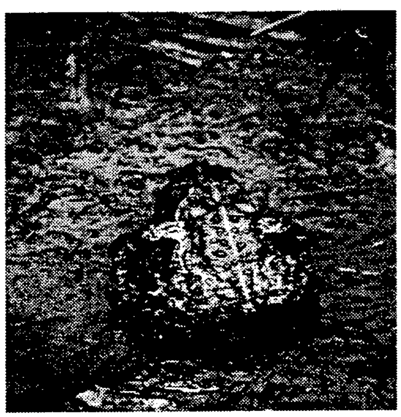
American Toad (*Bufo americanus*)



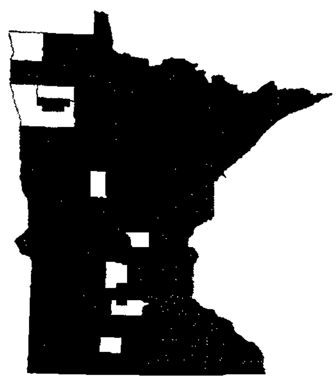


Photo by J. Husveth

Description: This common toad is very variable coloration, as shown above, but is usually brownish. Warts are abundant on the skin surface and are of various sizes. Oval-shaped parotid glands are located behind the eyes, but toe pads and dorsolateral ridges are absent. Breeding activity begins in late April and can continue until mid-June. The breeding call is a prolonged (20 - 30 sec), high pitched trill. This call is occasionally given outside the normal breeding season or during daylight hours. Distribution: *Bufo americanus* is found in throughout the state with the exception of parts of extreme western Minnesota.

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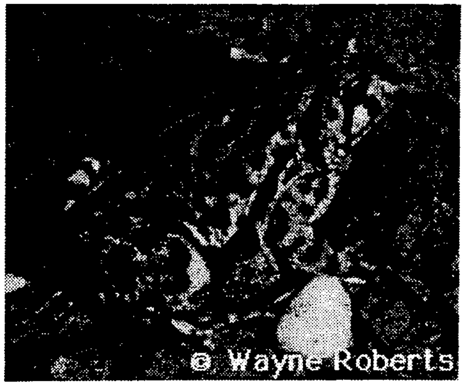
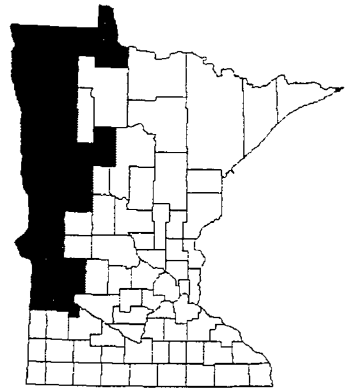
Canadian Toad (*Bufo hemiophrys*)





Description: The Canadian Toad looks very much like the American Toad, however a prominent bump or "boss" between the eyes distinguishes this species. In addition, the coloration often includes variable patterns of black and/or white mixed with the brown. Breeding duration and call are similar to that of the American Toad. However, the length of the breeding call is shorter (2 - 8 sec). Distribution: The Canadian toad is found in western Minnesota south to Yellow Medicine Co.

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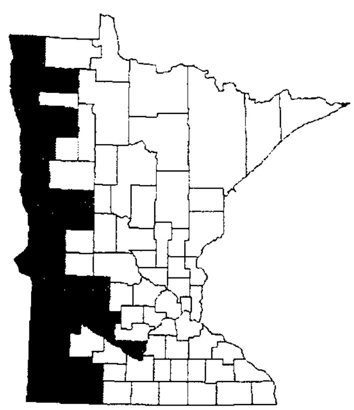
Great Plains Toad (*Bufo cognatus*)



Description: This toad has an overall color of brown or greenish with distinctive dark spots with lighter edges. The warts on the skin's surface are generally small and the parotid glands are not very prominent. Breeding takes place between May and July. The breeding call of this species is a harsh pulse lasting 20 - 50 seconds. Distribution: The Great Plains toad is found throughout western Minnesota and slightly into the Minnesota River Valley.

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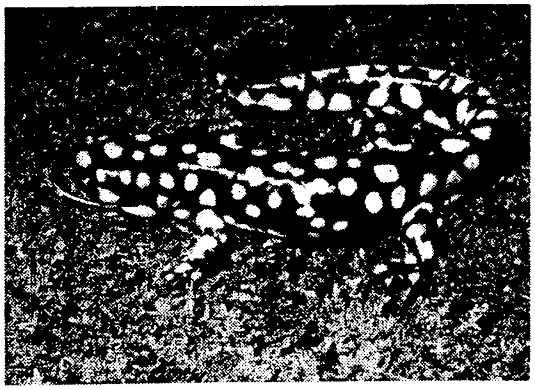
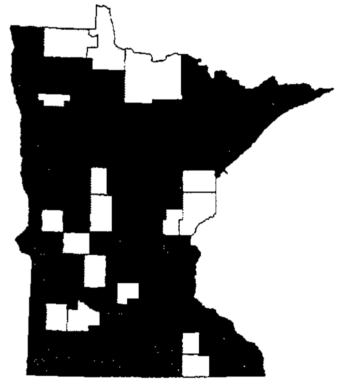
Tiger Salamander (*Ambystoma tigrinum*)





Description: This heavy-bodied salamander can become quite large (total length 7 - 13 inches) and is a common, but rarely seen, pond-dweller. The long tail, stout body, and thick head are distinctive, as are the 11 - 14 costal grooves present along the sides of the body. Coloration is variable. Usually, adult tiger salamanders are black or dark brown with numerous yellowish spots, but other color schemes have been reported, including all black individuals. Salamanders are rarely found out of the water and emit no breeding call. Distribution: Tiger salamanders are found, with some exceptions, throughout most of Minnesota.

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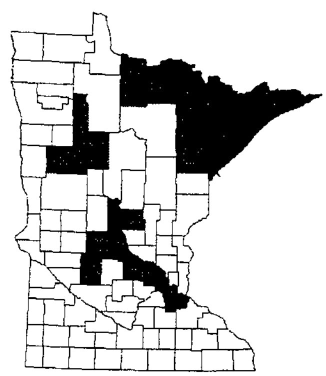
Eastern Newt (*Notophthalmus viridescens*)



Description: This small salamander is olive green with reddish spots. Its belly is usually yellowish with scattered dark spots. The body is slender and elongated and the rear legs are longer than the front legs. Costal grooves are not present and no breeding call is given. Adults are aquatic, while juveniles (called efts) can be found on land. The efts look similar, but the skin is dry and usually have reddish brown coloration. Distribution: The eastern newt is probably found throughout much of the forested portions of Minnesota, but is rarely reported.

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APPENDIX D

STANDARD ORNITHOLOGICAL ABBREVIATIONS

Appendix D. Abbreviations, common names and scientific names for birds found in or near wetlands.

Abbreviation	Common Name	*Scientific Name*
ALFL	Alder flycatcher	*Empidonax alnorum*
AMAV	American avocet	*Recurvirosta americana*
ABDU	American black duck	*Anas rubripes*
AMBI	American bittern	*Botaurus lentiginosus*
AMCO	American coot	*Fulica americana*
AMWI	American widgeon	*Anas americana*
AWPE	American White Pelican	*Pelecanus erythrorhynchos*
BNKS	Bank swallow	*Riparia riparia*
BARS	Barn swallow	*Hirundo rustica*
BEKI	Belted Kingfisher	*Ceryle alcyon*
BBWD	Black-bellied Whistling Duck	*Denrocygna autumnalis*
BCNH	Black-crowned night heron	*Nycticorax nycticorax*
BLTE	Black tern	*Chlidonias niger*
BWTE	Blue-winged teal	*Anas discors*
CAGO	Canada goose	*Branta canadensis*
CANV	Canvasback	*Aythya valisineria*
CATE	Caspian tern	*Sterna caspia*
CLSW	Cliff swallow	*Hirundo pyrrhonota*
COGR	Common grackle	*Quiscalus quiscula*
COME	Common merganser	*Mergus merganser*
COMO	Common moorhen	*Gallinula chloropus*
COSN	Common snipe	*Gallinago gallinago*
COTE	Common tern	*Sterna hirundo*
COYE	Common yellowthroat	*Geothlypis trichas*
DCCO	Double-crested cormorant	*Phalacrocorax auritus*
FOTE	Forster's tern	*Sterna forsteri*
GADW	Gadwall	*Anas strepera*
GTBH	Great blue heron	*Ardea herodias*
GREG	Great egret	*Casmerodius albus*
GRYE	Greater Yellowlegs	*Tringa melanoleuca*
GRHE	Green heron	*Butorides striatus*
AGWT	Green-winged teal	*Anas crecca*
HOME	Hooded merganser	*Lophodytes cucullatus*
HOGR	Horned grebe	*Podiceps auritus*
KILL	Killdeer	*Charadrius vociferus*
KIRA	King rail	*Rallus elegans*
LEBI	Least bittern	*Ixobrychos exilis*
LESA	Least Sandpiper	*Calidris minutilla*
LESC	Lesser scaup	*Aythya affinis*
LEYE	Lesser Yellowlegs	*Tringa flavipes*
MALL	Mallard	*Anas platyrhynchos*
MAGO	Marbled godwit	*Limosa fedoa*
MAWR	Marsh wren	*Cistothorus palustris*
NOHA	Northern Harrier	*Circus cyaneus*
NOPI	Northern pintail	*Anas acuta*
RWSW	Northern rough-winged swallow	*Stelgidopteryx serripennis*
NSHO	Northern shoveler	*Anas clypeata*
PESA	Pectoral Sandpiper	*Calidris melanotos*
PBGR	Pied-billed grebe	*Podilymbus podiceps*

PUMA	Purple martin	*Progne subis*
RBME	Red-breasted merganser	*Mergus serrator*
RWBL	Red-winged blackbird	*Agelaius phoeniceus*
REDH	Redhead	*Aythya americana*
RNDU	Ring-necked duck	*Aythya collaris*
RUDU	Ruddy duck	*Oxyura jamaicensis*
SACR	Sandhill crane	*Grus canadensis*
SEWR	Sedge wren	*Cistothorus platensis*
SESA	Semipalmated Sandpiper	*Calidris pusilla*
SBDO	Short-billed Dowitcher	*Limnodromus griseus*
SOSA	Solitary Sandpiper	*Tringa solitaria*
SORA	Sora	*Porzana carolina*
SPSA	Spotted sandpiper	*Actitis macularia*
SWSP	Swamp sparrow	*Melospiza georgiana*
TRES	Tree swallow	*Tachycineta bicolor*
UNGU	unid. Gull	
UNTE	unid. Tern	
UNYE	unid. Yellowlegs	
VIRA	Virginia rail	*Rallus limicola*
WILL	Willet	*Catoptrophorus semipalmatus*
WIPH	Wilson's phalarope	*Phalaropus tricolor*
WODU	Wood duck	*Aix sponsa*
YEAR	Yellow rail	*Coturnicops noveboracensis*
YWAR	Yellow warbler	*Dendroica petechia*
YCNH	Yellow-crowned night heron	*Nycticorax violaceus*
YHBL	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*

NON-WETLAND BIRD ABBREVIATIONS

AMCO	American Crow
AMGO	American Goldfinch
AMRO	American Robin
BCCH	Black-capped chickadee
BLJA	Blue jay
BOBO	Bobolink
BHCO	Brown-headed cowbird
CWAX	Cedar waxwing
CHSW	Chimney swift
CHSP	Chipping sparrow
DICK	Dicksissel
DOWO	Downy woodpecker
EABL	Eastern bluebird
EAKI	Eastern kingbird
EUST	European starling
GRSP	Grasshopper sparrow
GRCA	Gray catbird
HAWO	Hairy woodpecker
HOWR	House wren
MODO	Mourning dove
NOCA	Northern cardinal

NOFL	Northern flicker
PEFA	Peregrine falcon
RBWO	Red-bellied woodpecker
RPHE	Ring-necked pheasant
RODO	Rock dove
SAVS	Savannah sparrow
SOSP	Song sparrow
WBNU	White-breasted nuthatch