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Final Report
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Biodiversity in Selected Natural Communities Related to Global Climate Change

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Biodiversity in Selected Natural Communities Related to Global Climate Change

Final Report

Submitted to:
Wisconsin Focus on Energy
Environmental Research Program

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Executive Summary

Date of Report: 30 June 2008

Title of Project: Changes in Biodiversity in Selected Natural Communities Related to Global Climate Change.

Investigators:

Craig Anderson-Program Botanist, Natural Heritage Inventory (NHI)
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Institutions: Wisconsin Department of Natural Resources, Bureau of Endangered Resources

Category: II.Carbon sequestration/greenhouse gas emissions. A. Biotic model for global warming in Wisconsin

Project Period: 1 June 2003 to 30 June 2008

Object of Research: The primary goals of this project were 1) to obtain baseline data on the presence/absence, abundance, and distribution of species in multiple taxa groups associated with peatland communities in Wisconsin, and 2) to document selected biotic and abiotic variables that could potentially influence the organisms being studied.

Summary of Results/Accomplishments:

1. Taxon groups were all breeding passerine birds, amphibians, small mammals, selected groups of terrestrial and aquatic invertebrates, selected secretive marsh birds, and rare plants. Bryophyte surveys were also done at selected sites.
2. Evaluated and selected 13 sites ("Intensive Sites") that were surveyed for one or more taxon groups each year. Intensive Sites were distributed by Ecological Sections to provide coverage for the state.
3. Developed a replicable method for selecting 200 other sites ("Extensive Sites") that were surveyed for one or more taxon groups 1 out of 4 years.
4. We initially used the Wisconsin Breeding Bird Survey state-wide grid to randomly select potential sites. Due to a lack of suitable sites in southern Wisconsin, the selection process was modified by using another selection grid.
5. A land owner contact specialist tried to obtain permission to use Extensive Sites on private land but had a low rate of success.
6. Assessed 335 potential Extensive Sites and found 223 that met study criteria.
7. Field surveys for almost all groups were conducted from 2004 to 2007. Marsh birds were surveyed from 2005 to 2008.
8. Evaluated survey techniques used by each taxon group and modified the techniques as needed. The greatest changes were made by the amphibian and small mammal investigators after the 2004 field season.
9. Ancillary vegetation data were collected through a variety of efforts including site assessments, passerine bird point count vegetation plots, amphibian/small mammal vegetation plots, and a related study on the natural communities of the Intensive Sites.

10. Phenological and seasonal distribution data were collected for amphibians and small mammals at Intensive Sites.
11. Systematic micro-habitats surveys for odonates were conducted at 2 sites. These surveys also provided phenological information on these species of dragonflies and damselflies.
12. Repeated surveys for rare plants at Intensive Sites provided an indication of the range of variation in reproduction as measured by the number of flowering plants.
13. Plant and animal specimens were identified, processed as needed, and deposited into the appropriate location (e.g., the Wisconsin State Herbarium for plants).
14. A total of 700 amphibians and reptiles were documented by all techniques. About 98% of these were of 13 species of amphibians. Wood frogs (at 33%) were the most commonly recorded species.
15. In general species richness and evenness was greater than similar studies in Minnesota. Species use of peatlands varies for most species throughout the season with June having the most captures.
16. Nearly 2600 small mammals were captured with masked shrews accounting for 1/2 of all specimens. There was a lot of variation between sites in abundances and distribution of species. The insectivore foraging group was the most commonly captured group at 9 of the 12 Intensive Sites surveyed. Samples from the small mammals were sent to the Marshfield Clinic Research foundation for genetic identification.
17. Boreal and Arctic butterflies were targeted for surveys. No new sites were found for one of the most uncommon species in the state. Ten grasshopper species were targeted for surveys in northern Wisconsin and 5 in southern Wisconsin. Thirty-one Extensive Sites were surveyed for aquatic invertebrates in the north and 27 in the south. Twenty-nine species were targeted. Of that group, 2 were not encountered during the project. However, 4 other insects were found for the first time.
18. Rare plants were surveyed for at all Intensive Sites, 140 northern Extensive Sites, and 71 southern Extensive Sites. Botanists found populations of 50 rare species totaling 283 occurrences at 128 sites; 178 of the occurrences were new. Significant new finds included the state Endangered species *Platanthera leucophaea* (also listed as threatened by the federal government) and *Vaccinium vitis-idaea*.
19. Data were entered into the appropriate database or spreadsheet and quality controlled.
20. Data from rare animals were used to revise the NHI working list.
21. As a value-added product, habitat models were developed for the passerine birds.
22. The project supplied some of the first quantitative assessments of factors affecting the abundance and distribution of birds in Wisconsin peatlands.
23. Project staff presented at a number of conferences and forum including the Energy Forum and the Wisconsin Wetlands Association annual conference.

<u>Future Directions/Activities:</u> As we suggested in our proposal, the study should be repeated in 10 to years to detect changes in our baseline data. At a minimum, Intensive Sites should be periodically surveyed for selected taxa.

Section Authors:

Introduction, General Methods, General Results, and Rare Birds: Craig Anderson
Breeding Passerine Birds Methods, Results, and Discussion: Stephanie Zolkowski (modified by Craig Anderson)
Amphibian Methods, Results, and Discussion: Tara Bergeson
Small Mammal Methods, Results, and Discussion: Loren Ayers and Craig Anderson
Secretive Marsh Birds, Frogs, and Toads Methods, Results, and Discussion: Kim Grveles and Craig Anderson
Invertebrates: Terrestrial: Kathy Kirk; Aquatic: Bill Smith

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Introduction

Biological as well as physical systems on all continents are being affected by recent climate change. The evidence from a wide variety of species and communities shows that warming is strongly affecting natural biological systems. There are elevational and poleward shifts of species, phenological advances, and changes in the abundance of some species (IPCC, 2007). For example, Schwartz and Reiter (2000) examined spring seasons across North America from the period of 1900-1997 and found an average 5 to 6 day advance toward earlier springs.

The ability of biological systems and entities to adapt, migrate, and disperse in response to climate change will depend, in part, on the rate and magnitude at which climate change occurs. Human land use patterns will likely further complicate ecosystem adaptations by hindering migrations (Higgins and Hart, 2006). In fragmented landscapes, rapid climate change is likely to overwhelm the capacity for adaptation in many plant populations. A range-wide increase in extinction risk is likely to result (Jump and Penuelas, 2005). Range-restricted species have shown severe range contractions and have been the first groups in which entire species have gone extinct due to the recent climate change (Parmesan, 2006). In certain regions (e.g., the Arctic) and for certain species, dispersal per se may not be the problem. Alsos et al (2007) examined nine Arctic plant species and found that the plants were able to disperse readily but establishment was the critical factor. Parmesan (2006) noted that for many species the primary impact of climate change might by mediated through effects on the synchrony with a species' food and habitat resources; potential disruption in the timing between predators and prey; insect pollinators with plants; and other interspecific interactions.

Bradley et al. (1999) looked at phenological records kept in the periods of 1936-1947 and 1976-1998 and found that of the 55 species (plants and animals) observed at a site in Wisconsin, 17 showed earlier phenophases. Large areas within the state are fragmented due to human land use patterns (Figure 1) thereby by rendering migration problematic for many species. Wisconsin is also home to many plants and animals, e.g., *Carex exilis* and the lake emerald dragonfly, that are on the edge of their range. If climate change advances more rapidly than the species ability to disperse or alters the timing of their interspecific relationships, these edge-of-range species may become extirpated in the state.

To help gauge the effects on climate change on the species and natural communities in Wisconsin, systematically collected baseline data are needed. With a flora of over 2000 vascular plants (Wetter et al., 2001), a fauna of about 680 vertebrates (Watermolen & Murrell, 2001), and 80 natural community types (WNHI, 2008), it is important to define what data should be collected to detect the effects of climate change on the biota of Wisconsin. Systematically gathered baseline information on multiple taxa will provide a better opportunity to detect changes in biotic communities in future inventories.

Wisconsin peatlands provide a good opportunity to detect change in a natural system that results from global climate change. The rate of natural vegetation growth and change in closed (forested) peatlands is very slow. Black spruce, tamarack, and white cedar have minimal growth rates in peatland habitats, adding perhaps only fractions of an inch in diameter and perhaps several feet in height over years, even decades. Many closed peatlands contain unmerchantable timber and harvest on some public lands has been restricted through moratoria (e.g., the USDA-Forest Service). In addition, the peatland complex provides an enclosed system within a basin and has easily identifiable boundaries, unlike upland systems that have much more subtle gradients between habitat types. These peatland characteristics become advantageous when determining the

Figure 1. Example of a fragmented landscape in Dane County, Wisconsin. Note the Dane County Regional Airport on the left edge of the photograph.

trends in wildlife distribution and abundance since a large subset of variables, namely vegetation structure and composition, are essentially constant in comparison to other terrestrial habitats which could be proposed for study. Peatland complexes occur primarily in northern Wisconsin, becoming progressively rarer to the south. The composition of these communities includes many specialized plants and animals that are not typically found in other habitats, including many rare species. As these habitats contain many species south of their normal range limits, one might expect to detect a response due to a changing climate. For example, species might be expected to shift their ranges to maintain their viability. Within peatland complexes, there is most likely some resilience or “relicts” in southern Wisconsin that would no longer exist. However, many stands, especially in the tension zone and southern Wisconsin, appear to be in marginal condition at present, having already been affected by hydrological alterations, recent colonization by invasive plants, and insect infestations (e.g., larch sawfly in coniferous wetlands). These stands may not recover if subjected to yet another perturbation.

Peat-dominated wetlands are typically discrete features on the landscape. However the component natural communities are rarely distinct entities but typically are gradients of a large system interconnected and influenced by similar biotic and abiotic factors. The scope of this project might most easily be visualized by examining the two major physiognomic groups: the coniferous wetland forests and the open peatlands. Coniferous wetland forests and open peatlands often form a complex continuum between the dense, closed canopy swamp that grades into muskeg and a variety of different types of open peatlands. Coniferous wetland forests are dominated by black spruce, tamarack, or white cedar, and are most common in the northern and central part of the state with the distribution getting progressively less common in southern Wisconsin. Open peatlands include northern and southern sedge meadows, and fens (boreal rich, poor, and central poor). Northern sedge meadows, boreal rich fens, and poor fens are mainly found in the north and in the tension zone. Southern sedge meadows occur mostly in and south of the tension zone. Central poor fens are confined to central Wisconsin. More northerly species in these peatland communities are often at the southern edge of their ranges in the tension zone and southern Wisconsin. Descriptions of the peatland natural communities are in Appendix A.

The primary goals of this project were 1) to provide baseline data on the presence/absence, abundance, and distribution of species in multiple taxa groups associated with peatland communities in Wisconsin, and 2) to document selected biotic and abiotic variables that could potentially influence the organisms being studied. Taxon groups surveyed were breeding passerine birds, amphibians, small mammals, selected groups of terrestrial and aquatic invertebrates, selected secretive marsh birds, rare frogs and toads, and rare plants. In order to determine the effects of climate change on these groups, baseline data were collected in a way that is replicable in future inventories.

Sagarin (2002) identified the following three important components for studies related to global climate change: 1) fine scale temporal resolution, 2) broad scale spatial resolution, and 3) wide taxonomic resolution. Fine scale temporal resolution is important to identify the frequencies of biological changes and to establish the relationship between those biological changes and any associated physiological events. Broad scale spatial resolution helps establish whether changes are occurring throughout the range of a species or are simply due to smaller scale local perturbations. Wide taxonomic resolution helps to rule out alternate hypotheses. If a change is seen across several or many taxonomic groups or life history strategies it is more likely to be a general biological response to climactic changes.

The basic challenge of this study is to provide sufficient temporal, spatial, and taxonomic coverage to gain an adequate understanding of "normal" variation and interactions in both the abiotic and biotic components of Wisconsin's peatland complexes. Information on these "normal" or expected variations will be critical in understanding the larger picture and will help eliminate alternate hypotheses regarding causes behind any observed changes over time. In order to overcome this challenge, taxa surveys and ancillary data collection for this study will be carried out at two different levels: intensive and extensive.

Using two levels of survey intensity, we attempted to identify "normal" variation of the taxa surveyed. This approach will allow future inventory and monitoring efforts to eliminate alternative hypotheses regarding causation mechanisms behind observed differences between baseline and future surveys. That is to say, it will be easier to relate detected differences in biotic communities to climate change by dismissing confounding variables.

Data collected from this project augmented and extended an earlier Wisconsin Department of Natural Resource (WDNR) study (the Coniferous Wetland Forest Bird Inventory (CWFBI)). The CWFBI was a survey of birds and plants associated with coniferous wetlands designed to directly support conservation planning, forest management and land-use planning statewide. The objectives of the CWFBI were 1) to produce information on the presence, local and regional distribution, and habitat associations of coniferous wetland birds, rare vascular plants, and invasive plant species, 2) to build models that predict bird and plant species distributions, and 3) to produce a manual with information on the identification, distribution, and composition of bird and plant communities in coniferous wetland forests throughout the state.

Baseline surveys conducted during this project also benefited an ongoing statewide mammal inventory. The objectives of this mammal inventory are to provide information on: 1) local and regional distribution, 2) relative abundance, 3) habitat association, 4) population trends, 5) population status, and 6) the influence of land use and management practices on 40 smaller, primarily non-game mammal species in Wisconsin.

Wisconsin currently has several long-term monitoring efforts for amphibians, including the Wisconsin Frog and Toad Survey (WFTS) and the Wisconsin Herpetological Atlas. These efforts provide information on population trends and distribution of amphibians in the state. However, there are gaps in both data sets for specific habitat types and for quantitative data for most of the state. The objective of the amphibian segment is to obtain information on the presence, species composition and richness, local distribution, and seasonal activity of amphibians living in or at the boundaries of peatlands where amphibians have been little studied in Wisconsin. The framework for this study may be used as a model for future amphibian inventory and monitoring projects at the statewide level. Information obtained through this study will also fill gaps in species accounts for the Wisconsin Frog and Toad Survey and the Wisconsin Herpetological Atlas.

Surveys from this study directly supported rare species status determinations made by the Natural Heritage Inventory (NHI) Program. NHI data are an integral part of rarity status determinations, legal listing as Endangered or Threatened, and master planning for the DNR and other agencies. These data are also used as part of the environmental review process for development undertaken by the state, business, and industry.

Overall, this climate change project will provide a replicable, representative survey of occurrences of species associated with peatland habitats as well as building on existing rare species and high quality natural community information that is housed in the NHI database, past inventory reports (e.g., biotic inventories for the Northern Highland-American Legion State Forest, Black River State Forest, tamarack swamp bird surveys), and other efforts like county surveys that have been used to identify potential state natural areas.

General Note

More detailed results for individual taxon groups can be obtained from the appropriate taxon group lead.

Methods

Survey Types

Following the recommendations of Sagarin (2002), our study was designed to provide fine scale temporal resolution through intensive surveys of a few sites, broad-scale spatial resolution through surveys of many additional sites across the state, and also wide taxonomic coverage to allow comparison of demographic trends across a diversity of species. Varying levels of surveys will provide a broad range of information and quantification that will allow rare species status surveys and comprehensive species inventories to be conducted simultaneously.

Figure 2. Ecological Provinces

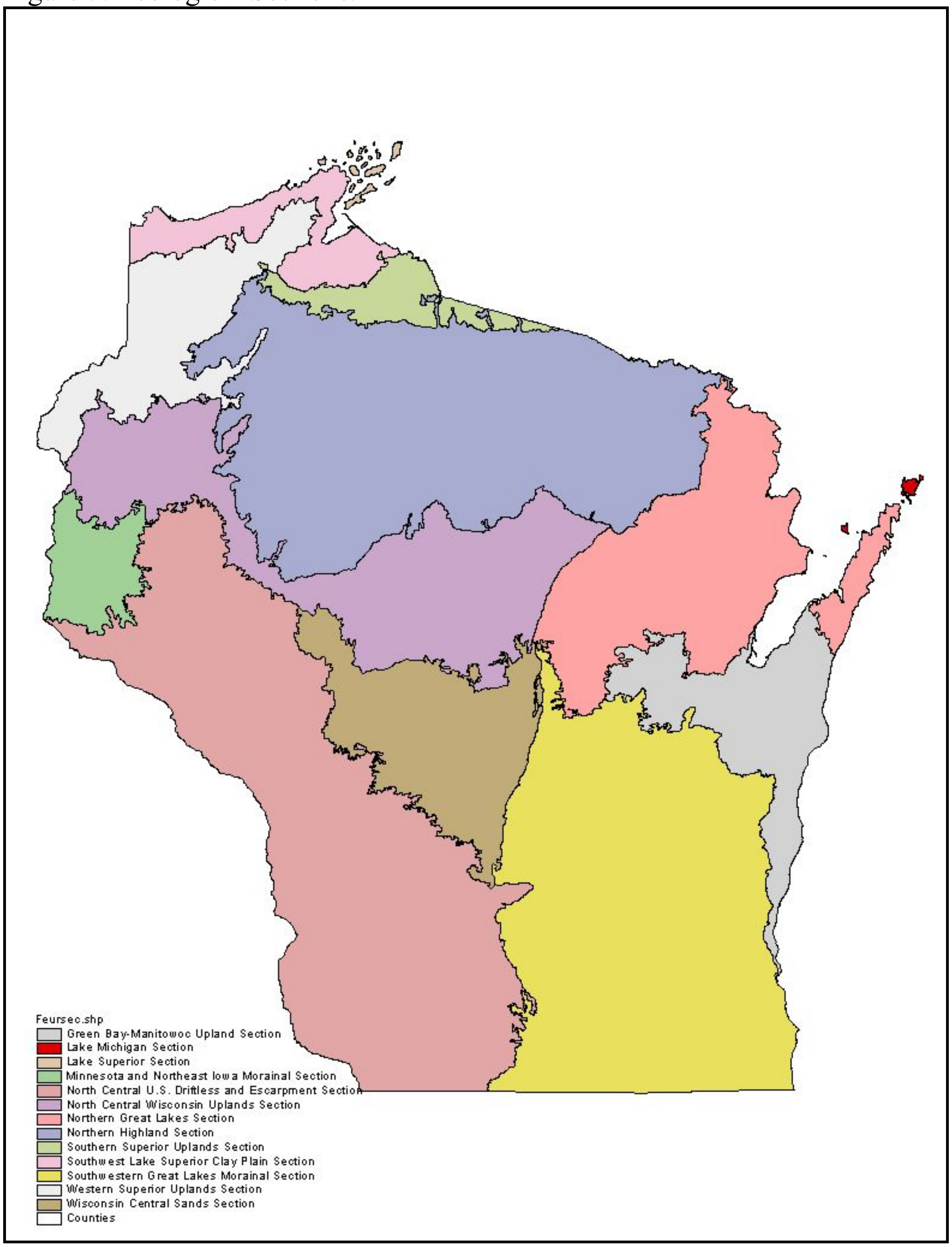
We designated our two levels of survey sites Intensive or Extensive. Intensive Sites were comprehensively surveyed for selected taxon groups each year for the four field seasons. Extensive Sites were stratified by Ecological Province (Figure 2, Cleland et al. 1997) and randomly selected and then surveyed one season out of the four field seasons. Because of survey protocols, some taxon groups (e.g., breeding passerine birds) surveyed a subset of the Extensive Sites instead of all sites.

Site selection

Intensive Sites

Intensive Sites were nominated and selected based on specific criteria. To obtain a more even geographic dispersal, sites were distributed by Ecological Section (Figure 3, Cleland et al. 1997). We wanted sites to remain anthropogenically undisturbed for at least 50 years so we chose sites having the highest degree of protection such as State Natural Areas (SNA) and federal Research Natural Areas (RNA). Ideally, an entire wetland complex would fall within the boundaries of the protected land. Candidate sites also had to have a minimal amount of recent or proposed anthropogenic disturbance. For example, a site that had large, active drainage ditches did not qualify as an Intensive Site. Landscape context was an important consideration as well, in part to provide buffer and minimize undesirable inputs. Because some of the potential rare species, especially invertebrates, are open habitat specialists, we sought sites that had both an open and a closed canopy component. Finally we wanted sites that had reasonable access because some of the survey methods required the movement of large amounts of equipment (e.g., pitfall traps).

Figure 3. Ecological Sections.



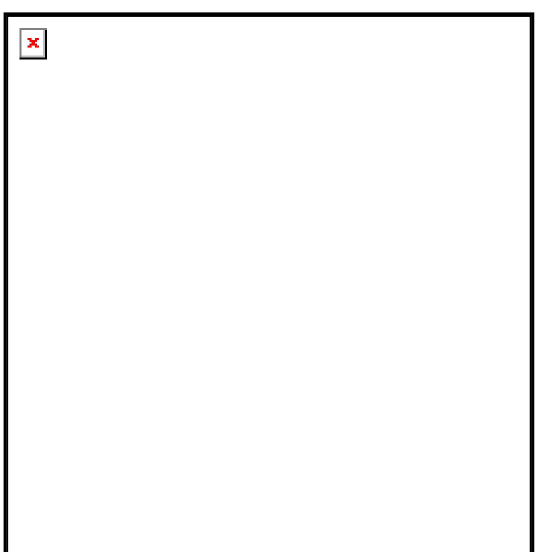
For each Ecological Section, a list of potential Intensive Sites was compiled (Table 1). Each site was given an unique designator (e.g., 212X-01) and associated with total acreage of potential peat natural communities, percent of site in some sort of protected status, type of protected status (SNA, RNA, etc.), soil units, county, acreage in an one mile buffer zone, acreage of public ownership within that buffer, acreage of protected lands within the buffer, and percentages of the site that was suitable for the project. Once the tables were completed, the investigators selected sites with the greatest potential for project use, evaluated those sites in the field, and presented their findings to the remainder of project staff who then selected the most suitable site per ecological section.

Table 1. Potential Intensive Sites.

Ecological Section	***Name***	***Decision***
Wisconsin Central Sands Section (222R)	Blue Swamp SNA	drop
	Quincy Bluff And Wetlands SNA	Chosen
	Washburn Marsh	drop
	Pea Creek Sedge Meadow SNA	drop
	Dewey Marsh SNA	drop
North Central US Driftless and Escarpment Section (222L)	Lower Chippewa River SNA	Chosen
	Lambs Creek Wildlife Area	drop
	Augusta Wildlife Area	drop
	Hay Creek Hunting Grounds	drop
Southwestern Great Lakes Morainal Section (222K)	Cedarburg Bog	Chosen
	White River Prairie/Tamaracks SNA	drop
	Jefferson Tamarack Swamp	drop
	Milwaukee River And Swamp SNA-Haskell Noyes Woods	drop
	Milwaukee River And Swamp SNA	drop
	Milwaukee River Tamarack Lowlands & Dundee Kame	drop
	Comstock Bog-Meadow/Germania Wet Prairie	drop
	Spruce Lake Bog	drop
Minnesota and Northeast Iowa Morainal Section (222M)	Lower Chippewa SNA	Chosen
	Cylon Marsh Wildlife Area	drop
Green Bay-Manitowoc Upland Section (212Z)	Navarino Wildlife Area	drop
	Killsnake Wildlife Area	drop
	C.D. (Buzz) Besadny Fish And Wildlife Area	drop
	Hortonville Bog	Chosen
	Deer Creek Wildlife Area	drop
	Maine Wildlife Area	drop
	Gardner Swamp Wildlife Area	drop
	Brillion Wildlife Area	drop
	Point Beach State Forest	drop
Northern Great Lakes Section (212T)	Miscauno Cedar Swamp	Chosen
	Spread Eagle Barrens	drop
	Mink River Estuary	drop
	Thorp Pond	drop
	North Bay	drop

Ecological Section	***Name***	***Decision***
	The Ridges Sanctuary	drop
North Central Wisconsin Uplands Section (212Q)	Mead Conifer Bogs	Chosen
	Bear Lake Sedge Meadow	Chosen
	Tula Lake SNA	drop
	Loon Lake Woods SNA	drop
	Interstate Park	drop
	Mikana Swamp	drop
	Pigeon Creek	Chosen
Northern Highland Section (212X)	Kidrick Swamp	Chosen
	Bogus Swamp	drop
	Black Creek Bog (See RNA sheet)	drop
	Wilson Creek (See RNA sheet)	drop
	Headwaters	drop
	Aurora Lake	drop
	Goodyear Lake East	drop
	Rice Lake	drop
Southwest Lake Superior Clay Plain Section (212Y)	Bibon Swamp	Chosen
	Bark Bay	drop
	Lost Creek	drop
Southern Superior Upland Uplands Section (212J)	Caroline Lake	drop
	Moose Lake	drop
	Lake Evelyn	drop
	Dry Lake RNA	Chosen
Western Superior Uplands Section (212K)	Belden Swamp	Chosen
	Black Lake Bog	drop
	Erikson Creek	drop
	Blomberg Lake	drop
	Empire (low protection)	drop
Lake Superior Section (212I)	Big Bay SNA (Big Bay SP)	Chosen

Extensive Sites



Extensive Sites were randomly selected across the state. To evenly distribute sampling sites, we initially used a grid based on Wisconsin Breeding Bird Atlas (WBBA) blocks. WBBA blocks use the central-east one-sixth of each USGS 7.5 minute quadrangle map to provide a framework for selecting breeding bird survey routes (http://www.uwgb.edu/birds/wbba/surveyareas.htm). The WBBA layer was intersected with selected potential peatland cover types (Floating Aquatic Herbaceous Vegetation, Lowland Broad-leaved Evergreen and Needle-leaved Shrub, and Coniferous and Mixed Deciduous/Coniferous Forested types) from WISCLAND Land Cover data (land cover interpreted from 1992 satellite imagery, please see http://dnr.wi.gov/maps/gis/datalandcover.html for additional information) to eliminate grid blocks which had no potential peatlands. Because climatic influences differ between northern and southern Wisconsin (Curtis, 1959), we stratified the selection of potential Extensive Sites by ecological province (Figure 2, Cleland et al. 1997). Also, because peatlands are much more abundant in the Northern Province (Figure 4), we designated 64% of our sites in the Northern Province and 36% in the south, roughly mirroring the distribution of potential peatland natural communities across the state.

We quickly realized that we would not have sufficient sites in the Southern, and possibly in the Northern, Province, using only the WBBA grid. To meet project goals, we developed a second grid by intersecting peatland natural community polygons taken from the Natural Heritage Inventory (NHI) database with the remaining five-sixths of the 7.5 minute topographic maps. The NHI database houses information on high quality natural communities and rare plants and animals. Even realizing that the natural community data has gaps (due to past survey efforts, age of some of the data, etc), we chose to use the NHI data because of the higher likelihood of finding suitable sites.

Extensive Site Selection Criteria

Selection criteria for Extensive Sites were less restrictive than those used for Intensive Sites. Grid blocks that already had Intensive Sites were excluded. A site had to have at least 40 acres (ca 16 ha) of contiguous peat inside the grid block and be embedded within a wetland complex of at least 100 acres (ca 40 ha). The wetland complex could, and often did, extend beyond the grid block. Because we weren't interested in any special degree of protection, sites could be on public or private land and have any protection status. Ideally a site would have both an open and a closed canopy component. Because of the open habitat requirements for many of the target invertebrate species, an additional "animal" (i.e., invertebrate) site might be selected in the grid block if a potential survey site had only closed canopy natural communities.

Extensive Site Selection Process

Grid blocks containing potential peatlands were randomly numbered and sorted, and each block was assessed for potential study sites using the following steps.

1. Chose a grid block based on the selection order.
2. Looked for potential peatland natural communities starting closest to the centroid of the block first using the WISCLAND GIS layer.
3. Using all of the other data that were available (GIS layers, digital aerial photographs, and other available sources), ascertained if that peatland met the minimum criteria (at least 40 acres (ca 16 ha) embedded within a minimum 100 acre (ca 40 ha) wetland) for determining potential suitability as a site. Other GIS layers that may have been available, depending on site location, included Wisconsin Wetland Inventory, soil surveys, hydrography, digital raster graphics (7.5 minute quadrangles), and NHI natural community polygons.

4. If the potential peat closest to the centroid did not meet the criteria, the assessor located the next closest potential peat type within the block.
5. If a potentially suitable peatland site was within the block, the assessor visually delineated and digitized a core area of about 100 ac (40 ha). When delineating the core area, the assessor chose a contiguous feature that minimized the periphery to core ratio and avoided linear appendages.
6. Using GIS, we produced printable topographic maps and aerial photographs for each Intensive Site and potential Extensive Site (Figures 5a, b). For portability and accessibility, we converted the maps/images to a PDF format for use by the field staff.
7. If no sites in that grid block met the minimum criteria, we rejected the grid block and recorded the decision in the grid table and then evaluated the next grid block.

Figure 5a. An example of a topographic map for a potential Extensive Site.

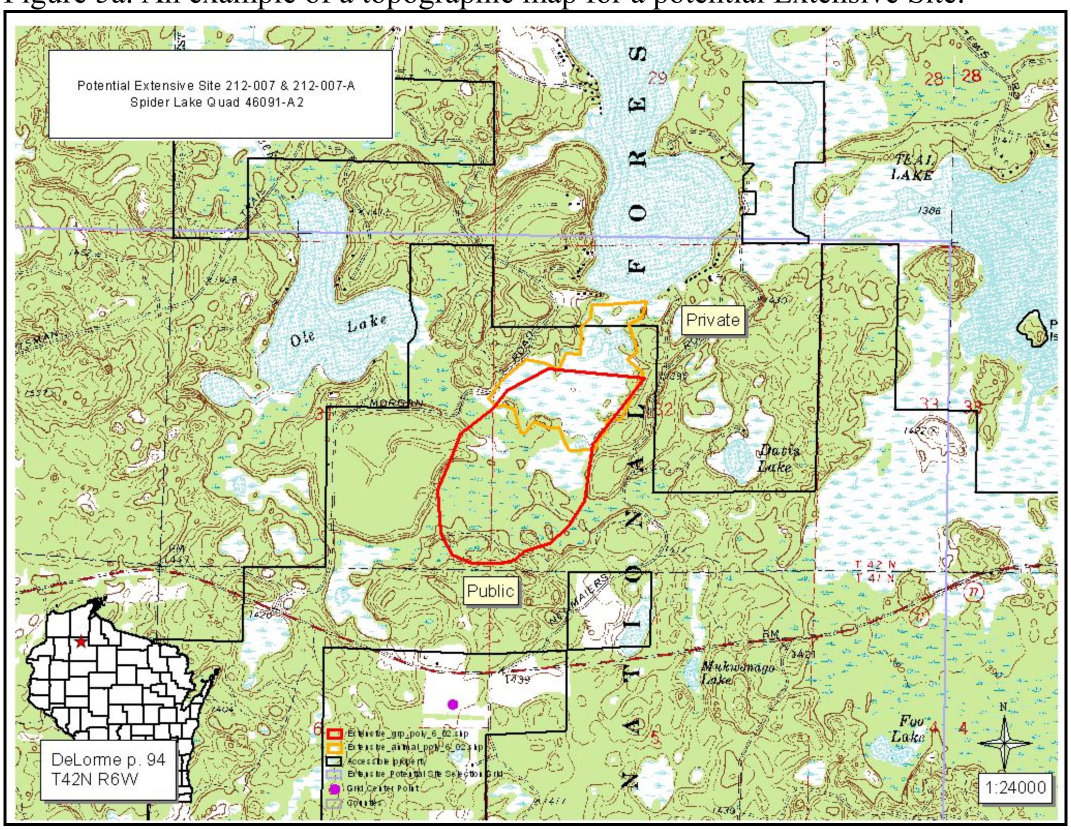
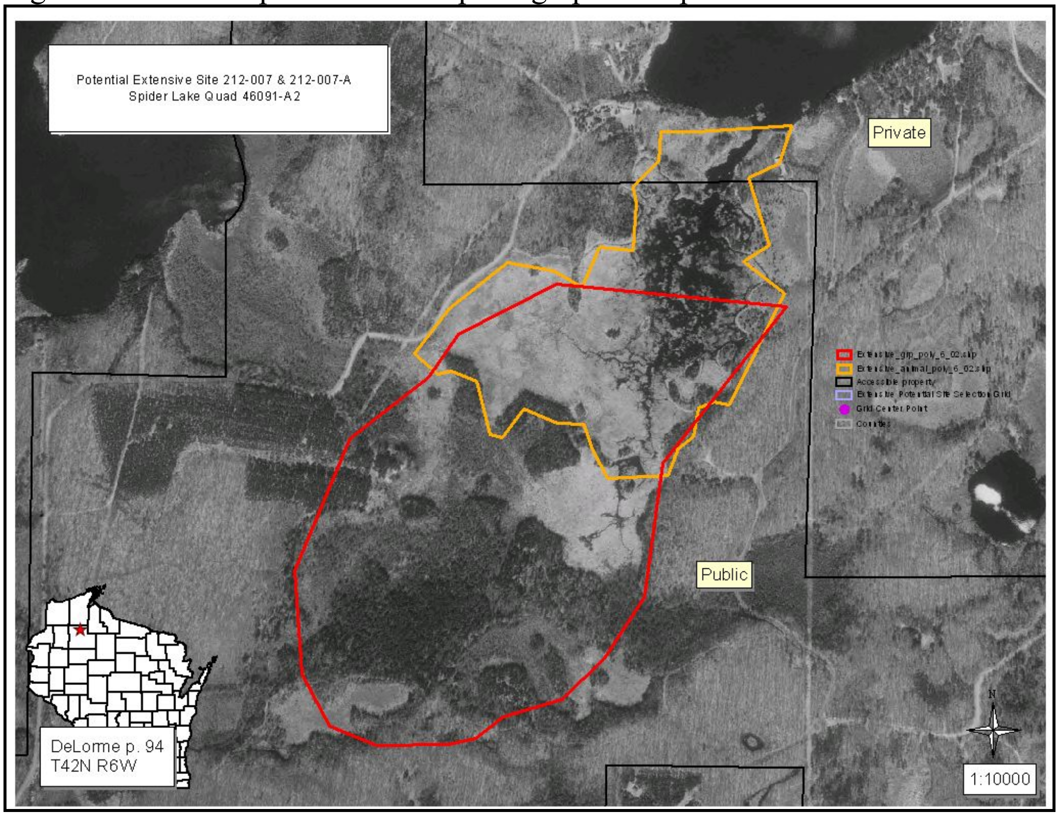


Figure 5b. An example of an aerial photograph for a potential Extensive Site.



Landowner Contact

Because potential Extensive Sites could be wholly or partly on private land, we developed a landowner contact program. The landowner contact specialist determined current land ownership and contact information. The specialist then created educational materials that were included with introductory letters and stamped return postcards in packets that were sent to individual private landowners. The specialist also answered questions from landowners, and designed an Access database to manage landowner contact information and level of interest.

Field Evaluations

Once potential Extensive Sites were delineated, we physically evaluated the sites because the GIS layers either did not completely cover the state or were at a scale that was too coarse to remotely ascertain the suitability of particular sites. The ages of the imagery that were available (often 10 or more years old at the time of use) added another cause of uncertainty, because in the interim sites could have been converted to other uses (e.g., cranberry production beds).

Standardized site summary and natural community evaluation forms were developed. The site form included the site designator and ancillary information (e.g., county), access directions, site suitability, a core site summary, core site disturbances and threats, and site characteristics grouped by hydrologic parameters, microhabitats, and surrounding land use.

The primary initial objective for assessors was determining whether or not the site met the study criteria. If a site was rejected, then the surveyor stated the reason for rejection (e.g., muck instead of peat soils) as well as documenting what was at the site. To help expedite site evaluations, assessors generally completed neither the remainder of the site summary form nor natural community forms at rejected sites. The evaluators did note any unusual features, like rare plants, that were observed.

For the sites that met study criteria, surveyors completed all the sections of the site summary form as well as a natural community evaluation form, including a species list, for each peat community type at the site. The major NHI natural communities were outlined on topographic maps or aerial photographs and referenced to GPS waypoints. GPS waypoints were collected when entering a new community type and marking the location of any other significant species and features. If there was more than one representative of a particular community type at a site, one form was used for all of the representatives of that type; any differences in microhabitats, plant species, and condition for each patch were noted. Photographs were taken at each site to document the overall site condition. Assessors also supplied information pertinent to site access and any noteworthy communities, species, and microhabitats encountered.

Information from the site summary and natural community evaluation forms was entered into an Access site database that was developed for this project and accessible to all project staff.

Individual Taxon Group Field Survey Methods

Breeding Passerine Birds
Mid-way through the project, the ornithologist conducting this aspect of the project left for another position. At that time, the passerine bird segment was transferred to a graduate student, Stephanie Zolkowski, at UW-Stevens Point.

Point Counts
Point counts (Ralph et al. 1995, Howe et al. 1997) were used to assess presence and relative abundance of breeding passerine birds (Robbins 1991) within both Intensive (n = 14) and Extensive (n = 74) Sites. Point-count stations were established along a transect running through the midsection of each site. Because sites varied in size, the number of sampling points was proportional to peatland area, with more points at larger sites. For peatlands at least 100-ha the number of points was limited to nine to ensure that all points within a site could be surveyed during one visit (Bub and Werner 2004). Stations were located at least 250-m apart in forested peatlands and a minimum of 300-m apart in open peatlands to ensure independence of detections between points (Ralph et al. 1995, Howe et al. 1997). Point-count stations were established at least 125-m from habitat edges to minimize detection of birds associated with non-peatland habitat types (Howe et al. 1997).

Unlimited-radius point counts were conducted at each station for 10 minutes from 0400 to 0930 Central Daylight Time. Unlimited-radius counts were used because differences in vegetation among sites make judgment of exact distances difficult (Ralph et al. 1995). Point count surveys were conducted from late May to mid-July between 2004 and 2007. The starting date should have minimized detection of non-breeding migrant species (i.e., transients). To minimize potential effects of seasonal variation in bird activity, Intensive Sites were surveyed in reverse order during the second visit. Because field technicians assisted with point counts, observers were rotated among Intensive Sites to minimize observer bias. Each year a different set of less than 50 Extensive Sites were surveyed once. Surveys were not conducted during periods of rain, heavy fog, or winds greater than 12-19 km/h (8-12 mph) since these are known to decrease detectability of birds. The wind code (Table 2), sky code (Table 3), and temperature (°C) were recorded at each point-count station prior to initiating a survey.

Table 2. Beaufort Wind Scale codes used to describe wind conditions for bird surveys.

Beaufort Code	mph	km	Description	Surroundings
0	< 1	< 1	Calm	Smoke rises vertically
1	1-3	1-5	Light Air	Smoke drift shows wind direction
2	4-7	6-11	Light Breeze	Leaves rustle, wind felt on face
3	8-12	12-19	Gentle Breeze	Leaves, small twigs in constant motion
4	13-18	20-28	Moderate Breeze	Raises dust, leaves, small branches in motion
5	19-24	23-38	Fresh Breeze	Small trees in leaf sway
6	25-31	39-49	Strong Breeze	Larger branches in motion
7	32-38	50-61	Moderate Gale	Whole trees in motion
8	39-46	62-74	Fresh Gale	Walking impeded, broken branches
9	> 47	> 75	Strong Gale	

Table 3. List of sky codes used to describe weather conditions for bird surveys.

Sky Code	Description	Cloud Cover
0	Clear	0-15%
1	Partly cloudy	16-50%
2	Mostly cloudy	51-75%
3	Overcast	76-100%
4	Wind-driven sand, dust, snow	-
5	Fog or haze	-
6	Drizzle	-
7	Rain	-
8	Snow	-
9	Thunderstorm, w or w/out precipitation	-

Species and sex (if known) of all birds heard or seen during counts were recorded. Counts were subdivided into 3 intervals (0-3 min, 3-5 min, 5-10 min), and the interval during which each bird was first detected was recorded. Birds that flew over the point during surveys ("flyovers") or that were detected before and after the 10-min period were recorded separately. Although exact distances to each bird could not be measured, the horizontal detection distances from the point center to each bird was mapped in classes. Within forested (closed-canopy) peatlands, bird distances were mapped at either 0-50 m or >50 m. Distances to birds in open habitats are easier to estimate (Ralph et al. 1995, Howe et al. 1997), and bird detections at these sites were be mapped at either 0-50 m, 50-100 m, or >100 m.

Habitat Variables

Vegetation was sampled at and surrounding each point-count station. Vegetation was surveyed at each point within Intensive Sites once per season in 2004, 2006, and 2007. Extensive Sites were surveyed only once during the study, therefore vegetation at these sites was surveyed immediately after bird surveys. The point-centered quarter method (Cottam and Curtis 1956) was used to estimate tree species composition, size, and density at each point-count station. At each point, species, diameter at breast height (dbh; cm), height (measured with a clinometer; m), and distance (m) of the nearest ≥ 7.5-cm tree in each quarter was measured. Within open peatlands, an "N/A" was recorded for each quadrant in which no trees were encountered within 50 m of the point center.

Within a 10-m radius plot surrounding each point-count station, percent cover classes (≤ 1%, 2-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%) of 5 vegetation height strata were recorded: trees (>10 m), trees-tall shrubs (2-10m), short shrubs and tall herbs (0.5-2 m), short herbs (0-0.5 m), and mosses (0 m). For tree and tree-tall shrub strata, percent cover classes were recorded separately for total cover, conifer cover, and broadleaf cover. The number of snags, or standing dead trees, was tallied within each plot. Structural position and relative abundance of tree, shrub, sub-shrub, and herbaceous plant species were subjectively estimated within each plot using structure and relative abundance codes (CNPS 1998). Structural codes include canopy dominant, canopy associate, subcanopy/sapling, seedling, shrub dominant, and shrub associate. To categorize relative abundance, a designation of "Rare" was used for species with very few individuals. "Uncommon" was used for species that are infrequently encountered, "Common" for species that are locally abundant or frequently encountered, and "Abundant" for species that are dominant within their strata in the plot.

Additional Vegetation Sampling

To further quantify vegetation characteristics within Intensive and Extensive Sites, additional vegetation measurements were recorded at all point-count stations surveyed in 2007. Within the 10-m radius plot, tree species, tree height, and tree dbh were recorded for three additional randomly-selected trees in each quarter. The dbh of snags within the 10-m radius plot was also measured. Percent canopy closure in each plot was estimated with a spherical densiometer with readings readings taken in each cardinal direction and averaged for the plot. The percent cover of herbaceous vegetation, woody debris, and leaf litter were recorded using a 1-m^2 Daubenmire frame (Daubenmire 1959) in the center of the 10-m radius plot. Sapling height was measured with a meter-stick or clinometer for the three tallest saplings and averaged for the plot. Canopy height was measured with a clinometer for the three tallest canopy trees and averaged (Moorman and Guynn 2001). Visual obscurity was measured using a 2.5 × 150-cm cover pole (Robel et al. 1970), marked in 10-cm sections. The pole was placed in the center of the plot and the total number of sections ≥ 75% obscured from each cardinal direction was recorded, measured at eye level. The mean of the four readings was used to estimate percent shrub obscurity for each plot.

Landscape variable
Using GIS, the total area (ha), a landscape-level variable, was determined for each peatland site.

Modeling and analysis overview
Bird point count and habitat variables were used to model two aspects: 1. explanatory models of bird presence and abundance in peatlands, and 2. model habitat relationships for three bird species strongly associated with peatlands. These species specific models can then be compared with the former models and with previous qualitative habitat descriptions.

Bird species were grouped into three habitat-use guilds (forest, open-shrub, and peatland-associated) for analyses (Robbins 1991, Calmé et al. 2002, Cutright et al. 2006). Further, species were grouped as residents, short-distance migrants, and neo-tropical migrants (Robbins 1991, Cutright et al. 2006). Bird species present at 5% or more of sampling stations were selected for individual analyses (e.g., Bulin 2005, Heltzel & Leberg 2006). Three analytical methods were used: logistic and linear regression and canonical correspondence analysis (CCA; Ter Braak 1986, McGarigal 2000) to model bird habitat relationships. Stepwise logistic and stepwise linear regressions were used to analyze 42 species with sufficient detections. One dependent variable in models was average bird abundance and another was presence by species per site by habitat association and migratory strategy as well as selected individual species which presently are near the edge of their distribution range. Because of different sampling intensities (i.e., years, number of point-count surveys/year) within Intensive and Extensive Sites, data from these sites were modeled separately. The 2007 Extensive Sites was also analyzed separately to examine any differences resulting from including additional habitat variables measured in 2007. Intensive and Extensive Sites were analyzed separately to evaluate potential differences in the adequacy of these two sampling methodologies. Bird habitat relationships were then examined using CCA, stepwise linear and stepwise logistic regression, as well as *a priori* linear and logistic regression models with information-theoretic model selection.

More complete descriptions of passerine breeding bird modeling and data analysis and results can be found in Zalkowski (in prep).

Amphibians

Several different amphibian survey techniques were used to increase the likelihood of adequately sampling the most species. The two primary techniques used were pitfall trapping and visual encounter surveys (VES). In addition to these two techniques, field technicians recorded as “incidental observations” any amphibians they observed while at the study sites, regardless of whether they were observed as part of an official pitfall or visual encounter survey. Amphibian surveys were conducted at the thirteen Intensive Sites (Figure 6) in 2004 and 2005. In 2004, field surveys were conducted from May 5 to July 21, 2004 and consisted of visual encounter surveys and incidental observations. In 2005, field surveys were conducted from May 23 through October 6, 2005 and used pitfall trapping, visual encounter surveys, and incidental observations.

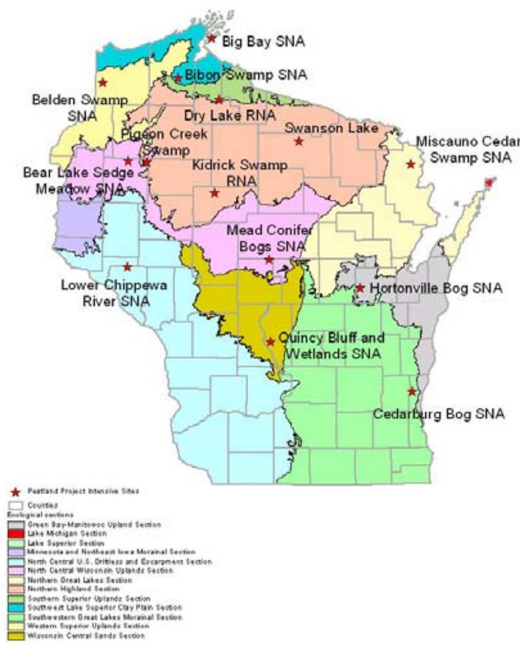


Figure 6. Intensive Site names and locations.

Pitfall Trapping

Pitfall traps were used to capture both amphibians and small mammals (Heyer et al. 1994). At each Intensive Site, pitfall traps were installed along two, 300-meter transects (Figure 7). One transect ran from open canopy peatland into surrounding upland habitat ('Open' transect); the second transect ran from closed canopy (i.e., forested) peatland into surrounding upland habitat ('Closed' transect). From the edge of the peatland/upland habitat, each transect extended 150 meters into the upland habitat and 150 meters into the peatland habitat. The location of the transects within each site was based on the presence of suitable open and closed peatland habitat and adjacent upland habitat. The characteristics of the Intensive Sites did not always allow a complete 300-meter transect to be installed at a site, and sometimes it was not possible to get 150-meters of both upland and peatland habitat. In these cases, transects were adjusted to meet the limitations of the site. For each transect, one drift fence (5 m x 23 cm) was installed at the transition between the peatland and upland, parallel to the edge between the two habitats (Figure 8). Drift fences were buried approximately eight centimeters into the ground to prevent animals from passing underneath. Pitfall traps were plastic floral cooler buckets (38 cm x 20 cm). Traps were installed every 30 meters along each transect. Along each side of the drift fences, three pitfall traps were installed adjacent to the fence and spaced approximately 2 meters apart with

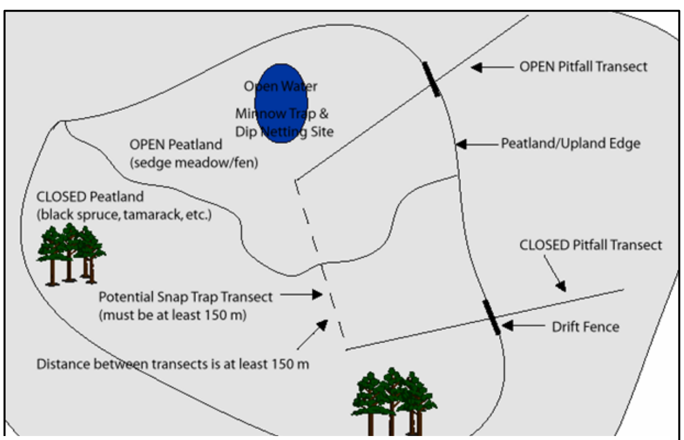


Figure 7. Generalized amphibian and small mammal sampling array in 2005.

the first trap positioned approximately one tenth of one meter from the end of the fence.

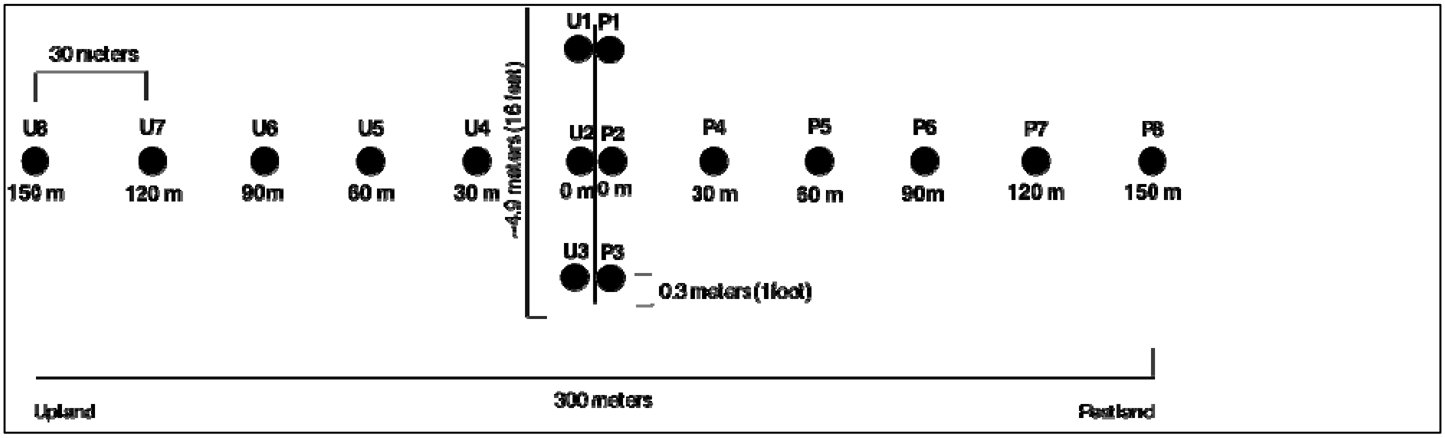


Figure 8. Amphibian and small mammal pitfall trap array.

All traps were sunk into the peat or other substrate until they were flush with the ground surface.

Usually, to prevent desiccation of amphibians, a small amount of water (2 to 5 cm) is placed in the bottom of the trap (Heyer et al. 1994); however, this can cause hypothermia in small mammals, and too much water in a pitfall trap can drown both amphibians and small mammals. Because the traps were used to capture both amphibians and small mammals, some compromises in the methods were made. To help prevent desiccation of amphibians and to provide cover, a small amount of wet sphagnum moss was placed in the bottom of each trap. We did not add additional water to the pitfall traps, which would have killed the small mammals, but instead relied on the wet sphagnum moss placed in the bottom to provide ample moisture for the amphibians. Each pitfall trap also had a cover to help provide protection.

Pitfall traps and drift fences were installed in mid-May 2005 and remained in place for the duration of the field season. They were removed at the end of the season. Traps were operated at each Intensive Site every other week from mid-May through July. Pitfall trap surveys took place over a four day period at each site, which resulted in three trap nights per trapping session. Traps were opened on day 1 (generally Monday) and checked for captured animals on days 2 through 4 (Tuesday-Thursday). On day 4, the traps were closed until the next session. When traps were not in use, they were covered with a lid, which was secured with a bag of soil excavated when the traps were initially installed.

Visual Encounter Surveys

Visual encounter surveys are a commonly used method for assessing amphibian populations and provide information about both species richness and relative abundance (Heyer et al. 1994). Visual encounter surveys do not require much equipment and are especially effective for surveying large areas. These surveys typically involve walking a predetermined route and looking for and recording all individual amphibians observed. They may involve active searching under objects, or may simply be a meandering walk through an area recording any amphibians seen on the substrate surface. While visual encounter surveys are good at monitoring many species, they are targeted toward terrestrial species, rather than aquatic, fossorial, or arboreal species.

For this project, transect design VES were used. In 2004, surveys were conducted along the transects used for the breeding passerine bird surveys (described above). In 2005, surveys were conducted along the 300-meter pitfall transects with field personnel walking slowly along each transect and recording all animals observed within 2 meters of either side of the transect line. To standardize effort among the survey sites, we recorded the time spent walking each transect. We tried to conduct all visual encounter surveys between late morning and early afternoon. However because of logistical, weather, and other factors it was not always possible to achieve this. Surveys were not conducted when temperatures were below 55°F or in moderate to heavy rain, but they were conducted in light rain as most amphibians are especially active under these conditions.

Quantitative Analyses
Data were recorded in the field on hard copy data sheets and later entered into a Microsoft Excel spreadsheet for summarization and analyses. Because trapping effort was not equal at all sites or in peatland and upland habitats, capture rates are presented as catch per unit effort. The captures reflect relative catchability and surface activity of the species, and not necessarily actual abundances. Species richness, evenness, and diversity were determined for each site. Species richness (S) is simply the number of species present in a natural community. Species evenness is a measure of variation in the abundance of individuals per species within a community. A community with less variation in the relative abundance of species is considered more "even" than one with greater variation in relative abundance. Species diversity is measured using both species richness and evenness.

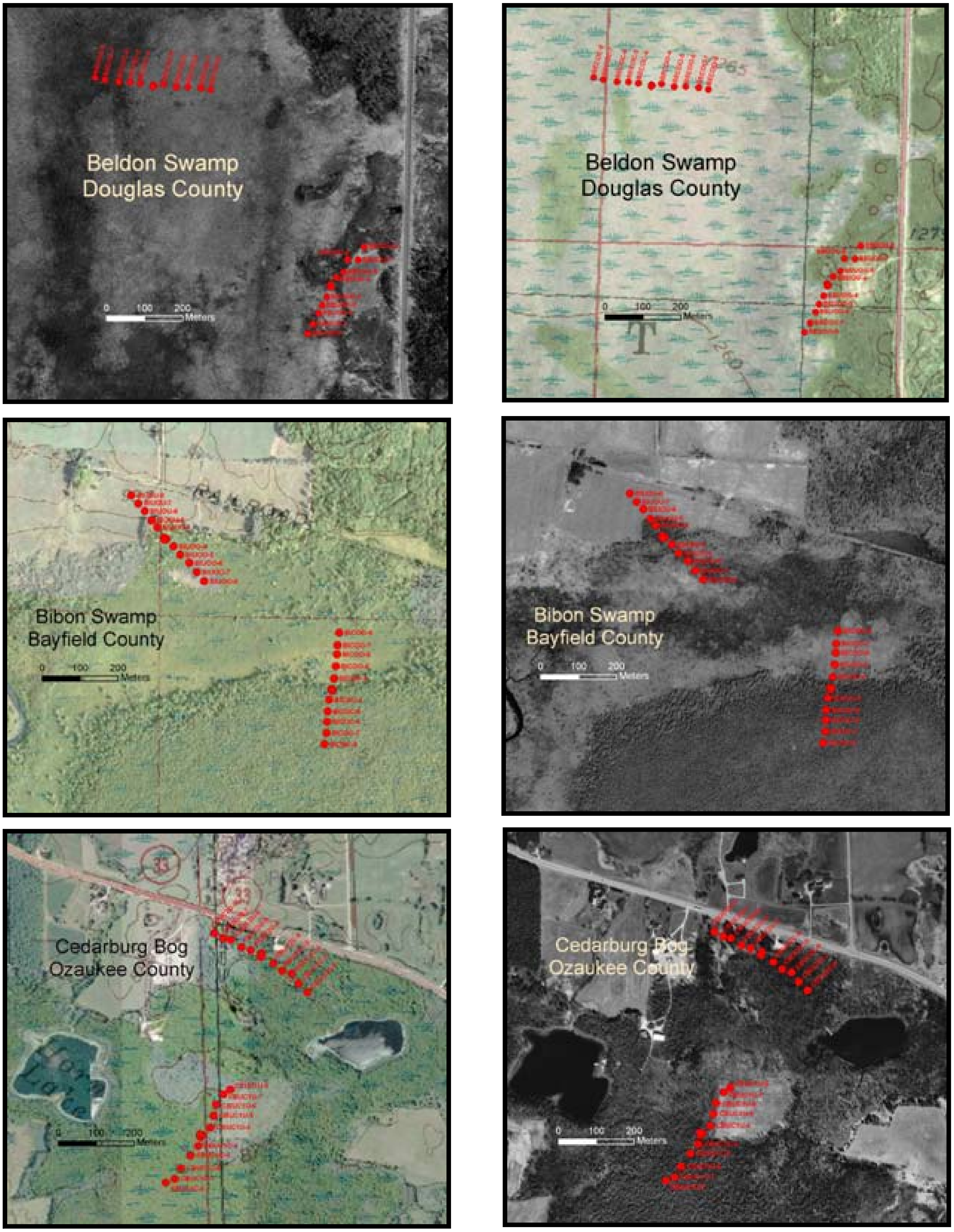
Species evenness was calculated (Krebs 1999) as:
$E = H' / \ln(n)$
where n = Total number of species present

Amphibian diversity indices were calculated using the Shannon-Wiener Index (Krebs 1999):
$H' = (-\Sigma p_i \log_e p_i)$
where H' = Index of species diversity
S = Number of species (species richness)
p_i = Proportion of total sample belonging to the *i*th species

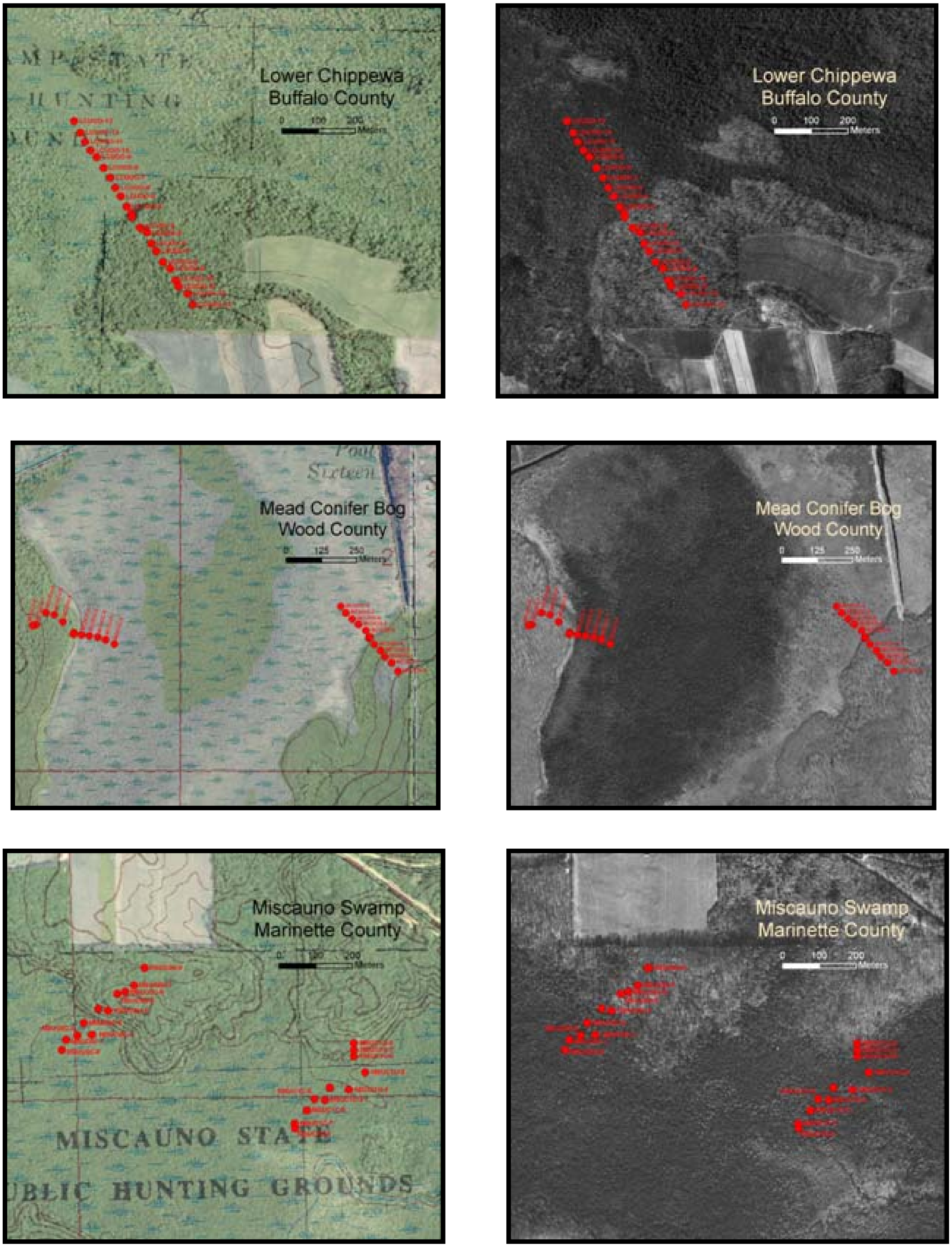
Small Mammals

Small mammals were surveyed at 12 of the 13 Intensive Sites (Figure 6); Big Bay on Madeline Island was eliminated due to access issues. Also, Bear Lake Sedge Meadow, which was paired with Pigeon Creek, was not used for small mammal surveys because adequate open and closed peatland natural communities were located within the Pigeon Creek site. The following Intensive Sites were surveyed: Belden Swamp (Figure 9a), Bibon Swamp (Figure 9b), Cedarburg Bog (Figure 9c), Dry Lake (Figure 9d), Hortonville Bog (Figure 9e), Kidrick Swamp (Figure 9f), Lower Chippewa River (Figure 9g), Mead Conifer Bog (Figure 9h), Miscauno Cedar Swamp (Figure 9i), Pigeon Creek Swamp, Quincy Bluff and Wetlands (Figure 9j), and Swanson Lake (Figure 9k).

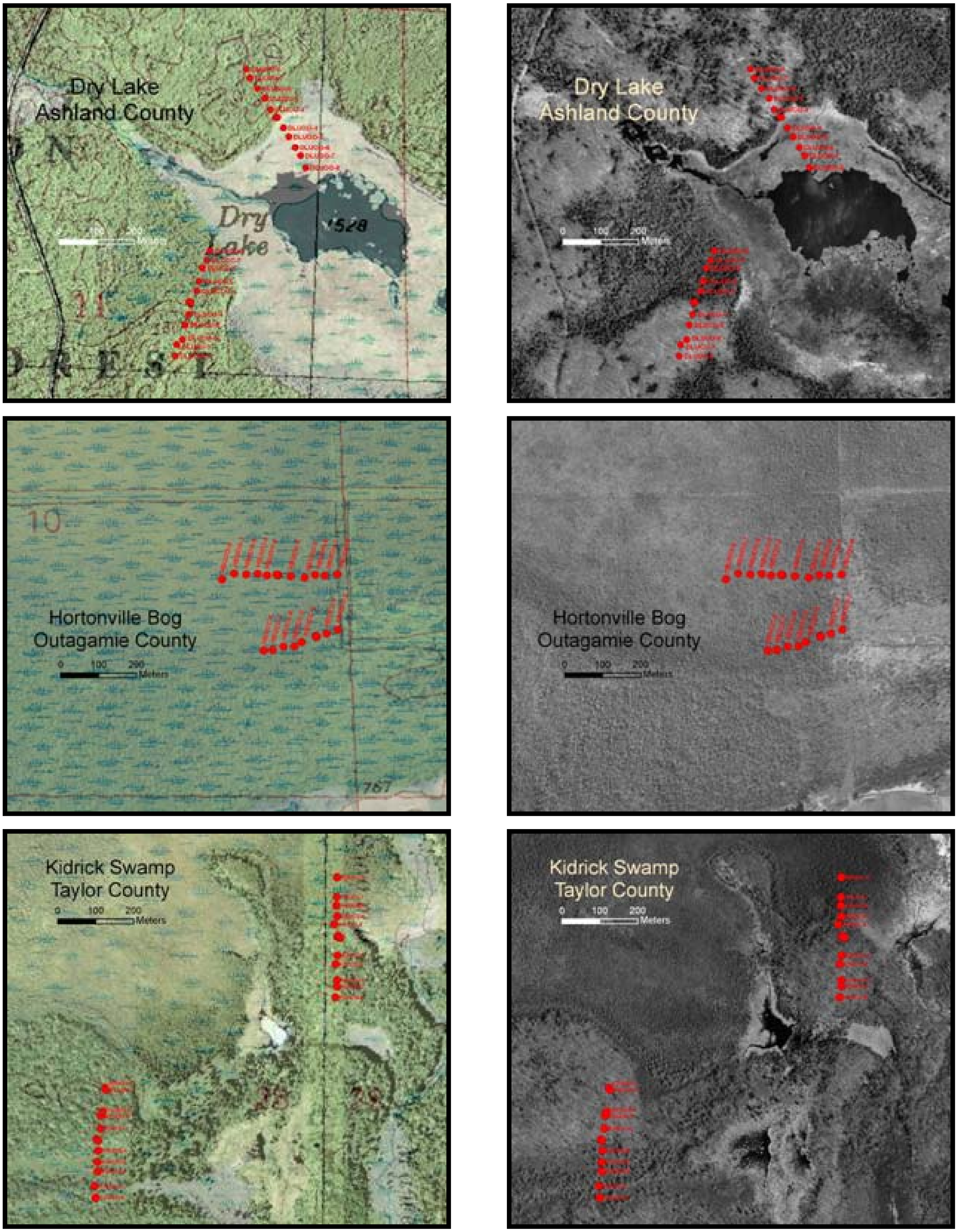
We did not survey small mammals on randomly selected Extensive Sites because the field methods and equipment required for this work could not be moved from one study site to the next site on a daily or even a weekly basis. We opted to refine our objectives and improve the temporal coverage and data collection at the Intensive Sites.



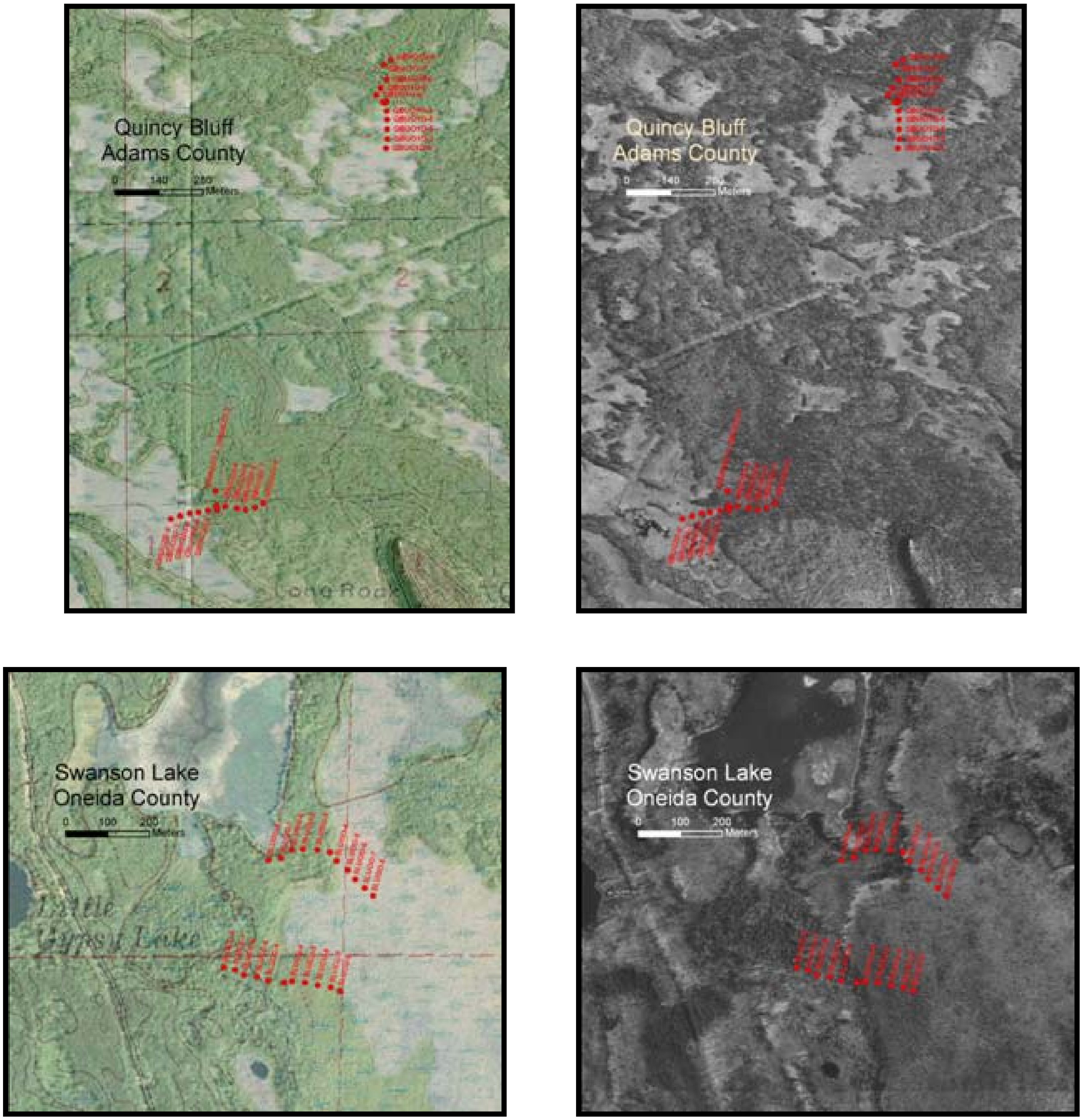
Figures 9a (top) to 9c (bottom). Amphibian and small mammal transects at Belden Swamp, Bibon Swamp, and Cedarburg Bog.



Figures 9d (top) to 9f (bottom). Amphibian and small mammal transects at Lower Chippewa, Mead Conifer Swamp, and Miscauno Swamp.



Figures 9g (top) to 9i (bottom). Amphibian and small mammal transects at Dry Lake, Hortonville Bog, and Kidrick Swamp.



Figures 9j (top) to 9k (bottom). Amphibian and small mammal transects at Quincy Bluff and Swanson Lake. Pigeon Creek is not pictured.

2004 Field Surveys

In 2004 we planned to sample small mammal populations at randomly selected point count stations within each of the 12 Intensive Sites. These were the passerine bird survey point count stations. The intent was to share habitat (vegetation) data between the two studies and to have spatially comparable "response" data (e.g., passerine and small mammal composition and abundance). The initial round of small mammal surveys was not successful: very few animals were captured despite hundreds of hours of trapping at each site. We quickly revised our methods for the opening field season and focused on the peatlands and adjacent uplands habitat of two Intensive Sites in order to obtain more basic data on small mammal species composition, distribution, and phenology. For the remaining 13 weeks of the 2004 field season we focused on the Swanson Lake in Oneida County and Mead Conifer Bogs in Wood County which provided what we felt were representative, even “classic,” examples of open and closed canopy peatlands in northern and central Wisconsin. The pilot data from this effort helped reformulate our objectives and methods in 2005-06.

2005 Field Surveys

In 2005 the 12 Intensive Sites were grouped into 6 pairs and each pair was assigned to one field technician. Technicians surveyed one site per calendar week such that each study site was surveyed biweekly for a total of 10 visits between May 24 and October 8 (Table 4). Small mammal trapping occurred along two transects at 11 of the 12 sites and one transect at the twelfth site. We attempted to place one transect across an upland-to-open peatland boundary and the other across an upland-to-forested peatland boundary at each site (Figure 7). Variations of this theme included two upland-to-open transects at Quincy Bluff and Wetlands , two upland-to-forested transects at Miscauno Cedar Swamp, an open peatland-to-forested peatland transect at both Belden Swamp and Bibon Swamp, and a single, long upland-to-open transect at Lower Chippewa River (Figures 9a-k).

Table 4. Amphibian and small survey schedule, 2005.

Site Name & Location	County	Approximate Starting Date	Approximate Ending Date	Rotation; Week #	# of Site Visits	Surveyor
Pigeon Creek	Barron	24-May-05	1-Oct-05	Even Weeks; 22-40	10	1
Dry Lake RNA	Ashland	24-May-05	1-Oct-05	Even Weeks; 22-40	10	2
Swanson Lake	Onieda	24-May-05	1-Oct-05	Even Weeks; 22-40	10	3
Kidrick Swamp RNA	Taylor	24-May-05	1-Oct-05	Even Weeks; 22-40	10	4
Mead Conifer Bogs SNA	Wood	24-May-05	1-Oct-05	Even Weeks; 22-40	10	5
Hortonville Bog SNA	Outagamie	24-May-05	1-Oct-05	Even Weeks; 22-40	10	6
Belden Swamp SNA	Douglas	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	1
Bibon Swamp State Natural Area	Bayfield	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	2
Miscauno Cedar SNA	Marinette	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	3
Lower Chippewa River SNA	Buffalo	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	4
Quincy Bluff and Wetlands SNA	Adams	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	5
Cedarburg Bog SNA	Ozaukee	1-Jun-05	8-Oct-05	Odd Weeks; 23-41	10	6

Most transects were 300 m long and were placed perpendicular to the selected habitat interface with half, or 150 m, extending into each cover type (Figure 7). Exceptions included the single transect at Lower Chippewa River which was twice the standard length (600 m; 300 m in upland and 300 m in open peatland) and one of the two transects at Hortonville Bog which had 90 m of upland transect (vice the 150 m standard). Trapping stations were positioned along each transects; the first station was located in the middle (at the boundary between the two cover types) and additional stations were placed at 30 m intervals in either direction to the ends of the transect (Figure 7). In most cases this was 5 additional stations.

We placed six pitfall traps at the transition station (upland:peatland interface), with 3 on each side of a 5 m x 23 cm plastic drift fence which ran along the edge of the two habitats (Figure 8). For data gathering, analytical and presentation purposes, three of these pitfall traps were considered to be on the peatland side of the drift fence and three were considered to be on the upland side of the drift fence. Animals caught in these traps were tallied separately, and data for each half of the transects were recorded separately as well. Pitfall traps were plastic, floral cooler buckets and measuring 20 cm in diameter by 38 cm deep. The buoyant pitfall cans were held down in saturated soils with 60 cm wire rods with hooks on both ends. Thin, black, plastic covers (30 x 30 x 0.5 cm) were elevated above each pitfall on 15 cm dowel legs to provide shade and rain cover during operation. These covers were inverted and weighted down on top of pitfall cans during periods of inactivity.

Pitfall traps and drift fences were installed in mid-May and removed in early October at the end of the field season. Pitfall trapping took place over 4 consecutive days (24 hr blocks) at each site, which resulted in 3 nights of pitfall trapping per weekly survey period. Pitfall traps were opened on Day 1 (generally a Monday) and checked for captured animals on Days 2, 3 and 4. These traps were not baited with food; animals simply blundered into them and most species could not jump or climb back out.

On Days 2-4 (2 nights total) we also placed 1 Museum Special snap trap and 1 Victor Pro-Mouse snap trap at each survey station to provide an additional method of capturing small mammals. These traps were baited with a mixture of peanut butter and instant oatmeal and re-baited on the second day, if needed. One snap trap of each type was placed on opposing sides and within 2-3 m of each pitfall trap. On alternating trap sessions the snap traps were moved 15 meters further up the transect, to the midpoint between pitfall traps, to obtain better coverage of micro-habitats along transect lines. All traps were checked once per day for 3 days. Live animals were euthanized via cervical dislocation or asphyxiation with CO_2; both methods were approved by the Animal Care and Use Protocol of the American Society of Mammalogists (Gannon et al. 2007). Specimens were given unique identification codes and labeled with information on gender, mass, species, specimen condition, study site, transect number, trap number, trap type, microhabitat, and other standardized notes prior to preservation via freezing. Data on date, time, weather and trapping effort also were routinely collected. Daily trapping effort calculations were adjusted to compensate for traps which were rendered inoperable or ineffective by inclement weather, ant and slug consumption of bait, and related problems by subtracting one-half of the daily effort, measured in hours (Beauvais and Buskirk 1999). On the final day, pitfall traps were covered and snap traps were removed and cleaned for use at the next study site.

2006 -2007 Laboratory Work

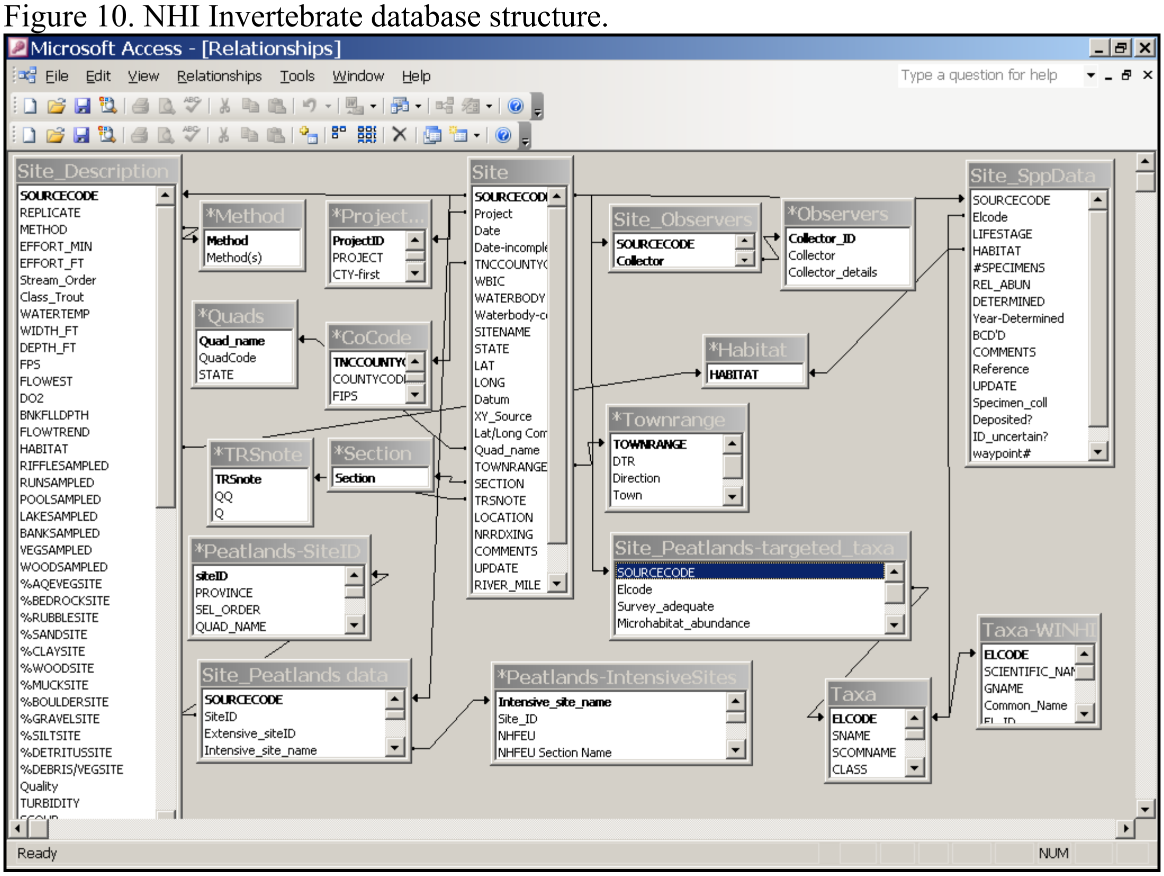
Between February 2006 and March 2007 we processed approximately 2,600 small mammals from the 2005 field surveys in our laboratory. We cross-examined data on the specimen labels with the applicable lines of field data which had been previously entered into spreadsheets. These data were in turn compared to the physical specimen to correct any mislabeling or other errors which occurred during data collection and entry. Each animal was thawed, removed from the packaging, and examined to determine the species (field technicians only provided tentative identifications). We used external morphological characteristics and dentition to determine species of each specimen except *Peromyscus* species and animal remains that were too heavily scavenged or autolyzed to identify. Samples from these specimens, including the *Peromyscus*, were sent to Marshfield Clinic Research Foundation for genetic identification. Each animal was weighed and standard museum measurements were recorded (total length, tail length, right hind foot length, ear height, etc.). Organs were removed and preserved for all specimens in satisfactory condition. We separated the heart and lungs; liver; spleen, stomach and intestine; and placenta and embryos into separate containers of 75% ethanol. Three blood samples were collected from the body cavity of each animal, and saliva samples where collected from all *Peromyscus* species using sterile cotton swabs. The former were stored at room temperature per company instructions, and the latter were placed in a snap-top vial and preserved via freezing.

Invertebrates

Data Management

Aquatic and terrestrial invertebrate data were entered into the NHI Invertebrate Atlas Database developed in Access. Additional tables and forms were added specifically for the Peatlands Project. Primary tables, fields, and their relationships are shown in Figure 10.

Figure 10. NHI Invertebrate database structure.



Terrestrial Invertebrates

Targeted terrestrial invertebrates included butterflies, moths, grasshoppers, katydids, crickets, and leafhoppers. Sites were not revisited after the 2004 field season of site reconnaissance if open areas were small or lacking. Visual searches were conducted in the habitat at each site where the species was most likely to be observed. These areas were usually the large openings in muskeg or mats surrounding bog ponds where nectar plants could be found. Some species like the Jutta Arctic and the northern wingless grasshopper are arboreal so searches were centered for those around the wooded portion of black spruce/tamarack swamps.

The most time was spent searching for adult Lepidoptera to observe the insects in flight, nectaring, resting, ovipositing, or in territorial activities. The pitcher plant moth required search inside many pitcher plant leaves, and *Catocala* moths are similarly searched for on sweet gale (*Myrica gale)* shrubs in hopes of finding the caterpillars. Open area searches followed a meandering path, and fieldwork was timed to cover the flight period for each species. Most of the bog butterflies and moths fly between mid-May and mid-June, although the coppers fly in July, and the Arctic fritillary does not begin to fly until August. The sedge butterflies fly in June and July. Lepidoptera were caught with aerial nets for identification or vouchers.

All the Orthoptera are found as adults after midsummer although the sphagnum bog cricket sings late in August. Large, long-winged Orthoptera were caught with aerial nets while short-winged and small species were collected with minnow nets or by hand. With the availability of excellent reference recordings of the calls of katydids and crickets (Walker & Moore, 2004), identification by sound was also used during the project. No static (e.g., pitfall traps) trapping methods were used for terrestrial invertebrates. For plant-dwelling insects (such as leafhoppers) sampling methods included hand-collection, removal by the use of small aspirators, beating the vegetation, and sweep netting.

<u>Documentation</u>

Audio vouchers recorded in the field and used for identification purposes have been retained by Kathryn Kirk. In most locations, voucher specimens were collected of katydids and crickets; grasshoppers were always vouchered from new sites. The specimens were preserved and mounted on insect pins with the exception of small crickets that are preserved in alcohol. Lepidoptera determinations were by Kyle Johnson and Kathryn Kirk. Orthoptera determined by Kathryn Kirk. All Orthoptera specimens are deposited in the WDNR Insect Collection. Lepidoptera specimens are deposited in the WDNR Collection or Milwaukee Public Museum.

Aquatic Invertebrate Surveys

<u>Intensive Sites</u>

For Odonata a meander search pattern was followed in open areas when other life stages were not present or could not be found using aerial nets. Frequency of coverage depended on how well other life stages were represented at that time. Flight seasons ranged from late April for *Williamsonia* species, to late August for *Aeshna*, *Somatochlora*, and *Sympetrum* species.

For other aquatic invertebrates search patterns/sampling were largely restricted to microhabitats which in peatlands was any open water extensive enough to allow sampling with a dip net or to place a bottle trap. These open water pockets may be distributed in various ways, but were found by walking a regular meander pattern. Frequency usually involved two visits per sites, the first to place bottle traps and dip, and the second (one to three days later) to retrieve the bottle trap and do additional dip netting. Most of the sampling was done in early summer or fall when water levels permitted.

Activity (bottle) traps are a very effective, efficient, and inexpensive method of sampling larger, faster, nocturnal, and scarce aquatic invertebrate taxa. A bottle trap consists of a one-quart, wide-mouthed glass jar with a relatively wide-mouthed, wide-necked funnel attached to the jar with rubber bands and paper clips. The traps were filled with water from the site and placed horizontally on the bottom of the suitable microhabitat, usually in shallow water where there is dense vegetation and/or detritus. Traps were left in place as long 5 to 7 days when water temperatures were below 10°C, but were retrieved after 2 or 3 days when water temperatures were higher; this prevented the captured animals from decaying. Retrieval of the trapped organisms was a simple procedure of pouring the contents of the jar through a fine mesh sieve and transferring the macroinvertebrates into a collecting jar. Usually, three or more traps were placed in various microhabitats throughout a given site. Dip nets were more effective in capturing certain taxa and life stages of beetles than bottle traps.

Systematic Microhabitat surveys for Odonata

On two sites an effort was made to document the precise locations that various odonate nymphs dwelt in the peatland by covering the site with parallel transects searching for exuviae. Since different species emerge at different seasons, this search patter was repeated until the emergence season was over. Each location where an exuvia was collected was marked with a numbered flag. That location was later marked using a professional grade GPS. GIS coverages were generated for each site depicting the locations and species present. The two sites surveyed in this manner were Quincy Bluff Wetlands and Empire Swamp.

Pitfall Trapping

Pitfall trapping for small mammals and herps captured a number of invertebrates, especially ground beetles, in addition to the targeted taxa. These specimens were kept for subsequent determination and analysis.

Extensive Sites

The surveyor responsible for each taxon group made an initial assessment of habitat suitability for their target taxa. Unsuitable sites were not subsequently surveyed. For each target species, the sample design was to determine presence or likely absence. A judgment of likely absence was based on three sample efforts at a site with no target specimens found. Adult Odonata were sampled with aerial nets, and aquatic life forms were sampled by bottle trapping and kick-netting. Search pattern, frequency, and seasons sampled also are as described above.

Known Element Occurrences
Sites with known occurrences of peatland obligate targets species were routinely surveyed, and the species re-documented if possible. These searches were used to determine if timing was suitable to detect target species at new sites.

Other Sources of Data
Other studies of peatland obligate invertebrates were conducted at about the same time frame and occurrence records from these studies were added to the Invertebrate Atlas as well. Dragonflies of Lake Superior coastal peatlands (DuBois et. al. 2006) and Boghaunters of Glacial Lake Wisconsin (Vogt and Purdue, 1999) were two of particular pertinence.

Documentation
With few exceptions, invertebrate presence was documented by voucher specimens. These were preserved by standard methods and identified by a taxonomist familiar with that group. Generally Odonata were determined by Robert DuBois, WDNR-Superior, or William A. Smith (Invertebrate lead investigator). All other aquatic invertebrates were determined by Dr. Kurt Schmude of UW-Superior. All specimens are deposited with the WDNR in either Superior or Madison.

Secretive Marsh Birds, Frogs, and Toads

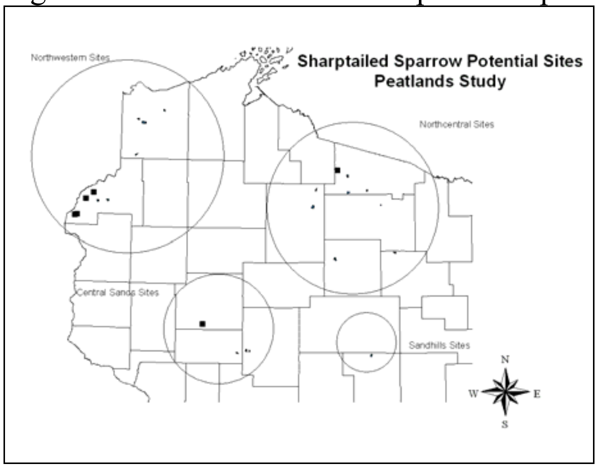
The secretive marsh birds and rare frogs and toads that were targeted can be found in Table 5. Other species of interest included Least Bittern, King Rail, Virginia Rail, Black Rail, Sora, and Common Moorhen. Any other rare marsh birds or frogs that were encountered while surveying were documented as well.

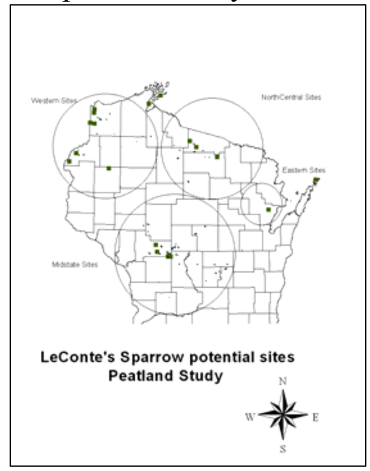
Table 5. Marsh bird and anuran target species.

Birds	**Anurans**
Yellow Rail	Bullfrog
American Bittern	Mink frog
Le Conte's Sparrow	Pickerel frog
Nelson's Sharp-tailed Sparrow	

Because Yellow Rails are strongly associated with northern sedge meadows (see Appendix A), a subset of suitable Intensive and Extensive sites were selected in northern and central Wisconsin. The central Wisconsin sites occur in the Southern Ecological Province (Figure 2). Some of the sites selected were those previously known to have Yellow Rails. The remaining sites were selected because they apparently had suitable habitat. Figures 11a and b illustrates how sites for Nelson's Sharp-tailed Sparrow and LeConte's Sparrow, respectively, were clustered.

Figure 11a and b. Nelson's Sharp-tailed Sparrow and LeConte's Sparrow survey clusters.





In 2005, 39 sites were selected and visited for the first time during daylight hours both to confirm the existence of appropriate habitat and to locate access points. If a site was determined to be unsuitable or inaccessible during that visit then it was dropped from the survey. In 2006 and 2007, only those sites that had suitable habitat and were accessible were surveyed. Also, almost all of the sites where Yellow Rails were found in 2005 were not visited in subsequent years with the exception of the three sites located on Crex Meadows Wildlife Area and the site on Fish Lake Wildlife Area.

Surveys in 2005 began on May 9 and continued through July 3. Sites that were surveyed during the first two weeks of May were revisited in June. All other sites were surveyed only once that year. In subsequent years, surveys began the last weekend in May and ended by June 30. Sites were visited only once with the exception of Powell Marsh sites in 2007, which were surveyed on the nights of May 27-28 and again on June 10. In 2007, the surveyor did not survey the sites in the Southern Ecological Province because of moving out of state. Those sites have been surveyed in 2008.

Standard survey methods as described in Conway (2004) were used. At acceptable sites, as many points as possible were placed at least 400m apart along adjacent berms or in the wetland-upland interface. For sites surveyed by boat, points were established in the wetland-open water interface. Coordinates of points were recorded using a handheld GPS unit.

Surveys were conducted between 2200 and 0300 hours. Surveys were not conducted if wind speed exceeded 25 km/h (15 mph), if there was heavy fog, if there was sustained rain, or if thunderstorms were approaching. At each survey point, surveyors would play an audio recording. Surveyors would listen passively for 5 minutes and then play the audio recording. During the initial 5-minute period, target and secondary species were recorded during 1-minute intervals. The playback period began with a 30-second broadcast of Yellow Rails followed by 30 seconds of passive listening. This procedure was repeated successively for each of the remaining target species. In addition, frog species heard during the passive and playback periods were recorded using standard amphibian call index values.

Rare Plants

Project botanists developed a list of over 80 potential rare species (Appendix B) based on querying the NHI database and other sources. The species were correlated with NHI natural community types. Queries were also made for individual Intensive and potential Extensive sites to ascertain what communities and rare plants were already known from individual sites. Aerial photographs and 7.5 minute topographic maps were examined for potential suitable habitat at each site. Field maps and photographs were annotated to reflect known and potential rare species. Reports were obtained from the site database that showed access to the site, as well as any permission that was needed from private landowners.

Survey efforts at Intensive Sites focused on the common 40 ac (16 ha) core area where the breeding passerine bird surveys were conducted. As time allowed, the site was surveyed outside of the core area. At Extensive Sites, as much of each site was surveyed as feasible.

Rare plant surveyors used a meander technique that covered areas most likely to have rare taxa, based on habitat type and the judgment of the investigator. Searches concentrated on as many likely sites as was feasible but still sampled each natural community represented in the study area. As surveyors transited to and from sites, they documented any rare species they encountered

When a rare plant was observed, GPS waypoints were taken, and the area in the vicinity was thoroughly examined to ascertain population extent and size. The reproductive state of the population was also characterized with the proportion of immature, mature but not flowering/fruiting, and mature and flowering/fruiting plants. Natural community type was noted as were the associated species. Any threats, current or potential, were also described. Other information collected for each rare plant occurrence can be found at http://www.dnr.state.wi.us/org/land/er/forms/1700-049.pdf.

Results and Discussion

Site selection results

Intensive Site Selection

Using a variety of GIS layers, manual files, and personal knowledge, we nominated 1 to 9 sites per Ecological Section. After each candidate site was evaluated in the field, the principal investigators discussed the site assessments and selected the Intensive Sites. Table 1 shows the sites evaluated and the results of our selection process. We selected a total of 13 sites distributed across 11 of the 13 ecological sections (Figure 6, Table 6). The Minnesota and Northeast Iowa Morainal ecological section is relatively small and lacked suitable sites, so we did not have an Intensive Site in that section. We also did not chose a site in the Lake Michigan ecological section due to the logistics involved with working frequently on the Grand Traverse chain of islands.

Table 6. Peatland Intensive Sites

Name	NHFEU Section Number-Name	County	Ownership
Quincy Bluff and Wetlands SNA	222R-Wisconsin Central Sands Section	Adams	DNR and TNC
Lower Chippewa River SNA	222L-North Central US Driftless and Escarpment Section	Buffalo and Pepin	DNR
Cedarburg Bog SNA	222K-Southwestern Great Lakes Morainal Section	Ozaukee	DNR and UW-Milwaukee
Hortonville Bog SNA	212Z-Green Bay-Manitowoc Upland Section	Outagamie	DNR
Miscauno Cedar Swamp SNA	212T-Northern Great Lakes Section	Marinette	DNR
Mead Conifer Bogs SNA	212Q-North Central Wisconsin Uplands Section	Wood	DNR
Bear Lake Sedge Meadow SNA Pigeon Creek	212Q-North Central Wisconsin Uplands Section	Barron and Washburn Barron	Barron County Village of Haugen Barron County
Kidrick Swamp Research Natural Area	212X-Northern Highland Section	Taylor	USFS
Swanson Lake	212X-Northern Highland Pitted Outwash Subsection	Oneida	DNR
Bibon Swamp SNA	212Y-Southwest Lake Superior Clay Plain Section	Bayfield	DNR
Dry Lake Research Natural Area	212J-Southern Superior Upland Uplands Section	Ashland	USFS

Belden Swamp SNA	212K-Western Superior Uplands Section	Douglas	Douglas County
Big Bay SNA	212I-Lake Superior Section	Ashland	DNR

Each of the remaining ecological sections had one Intensive survey site with the exception of the two largest sections, the North Central Wisconsin Uplands and the Northern Highland, where we chose two sites in order to provide greater geographic coverage. Bear Lake Sedge Meadow and Pigeon Creek Swamp are treated as a single site with Bear Lake providing the open natural communities and Pigeon Creek Swamp the closed canopy community.

Due to the efforts of State Natural Areas staff working with various partners, by the end of the field component of this project, all of the sites, except for one, were wholly or mostly on State Natural Areas. Two of the sites were also USDA-Forest Service Research Natural Areas. The only site lacking long-term protection was Pigeon Creek Swamp which is on county forest land.

We established photo plots, based on breeding passerine bird points, at each Intensive Site. Using another funding source, we were able to more accurately delineate natural communities through a combination of aerial photograph interpretation and field evaluations at all Intensive Sites. Results of that effort are in Appendix C. Additional vegetation data were collected as part of the breeding passerine bird and small mammal surveys (see above for those methodologies).

Extensive Site Selection

Using both of our grids, we evaluated 1385 grid blocks for potential Extensive Sites with a combination of GIS layers, aerial photographs, manual files, and personal knowledge. About halfway through the project, 2005 and 2006 color aerial photographs became available. The newer images allowed us to re-evaluate some of the sites we hadn't field checked yet and note any changes in land use that could negate the need for a field evaluation. Initially several project biologists evaluated grid blocks, but to improve efficiency and consistency, the botany (rare plant) staff became the primary evaluators.

We assessed 335 sites for suitability in the field and found that 223 sites met the project criteria. Using our initial WBBA grid, we found that only about 1 of 5 sites met project suitability criteria in the Southern Ecological Province. Using the 2nd grid, acceptance rate was greatly improved. Overall, we field-evaluated 197 and kept 163 Extensive Sites in the Northern Ecological Province, and kept 71 Extensive Sites of 138 evaluated in the Southern Ecological Province (Figure 12). The majority of site evaluations were completed by botany staff. Results of the field evaluations, including access information, natural community types, and details about microhabitats, were entered into the site database.

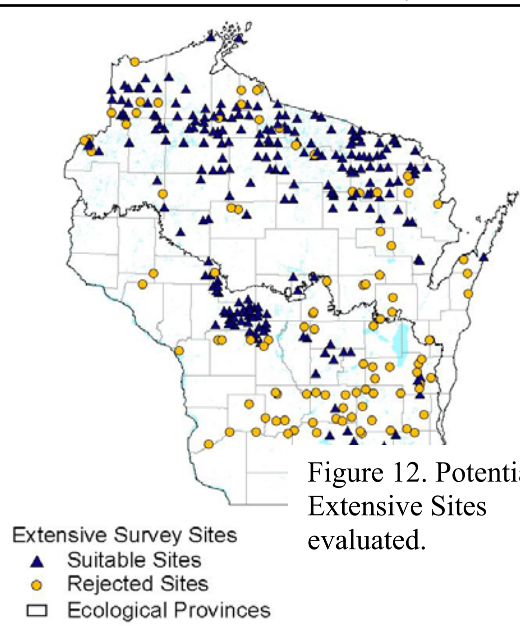


Figure 12. Potential Extensive Sites evaluated.

Landowner Contact

We had a low rate of success from the landowner contact portion of the project. In many instances, landowners did not respond to our request for permission to survey their property. Many of the responses that we did receive denied us permission. However, the landowners that did consent to survey their land were generally enthusiastic about being part of the project. In addition to conducting surveys on six properties owned wholly or partly by The Nature Conservancy (TNC), we worked on fewer than 10 Extensive Sites owned by one or more private individuals. The majority (five out of six) of TNC sites were in the Southern Ecological Province.

Taxon Groups

Biologists from the different species groups would focus their survey efforts at each site on a core area of about 40 acres but would expand their surveys beyond the core as time permitted.

Passerine Breeding Birds

Variable selection was fairly consistent with stepwise linear regression and stepwise logistic regression. Common variables in all approaches indicated that the probability of bird occurrence at peatlands increased in areas with shrub cover. Among linear and logistic regression models selected using Akaike's Information Criterion (AIC; Hurvich & Tsai 1989, Burnham & Anderson 2002), models containing the variables snags, percent cover of low shrubs and high herbs, peatland size, and percent cover of all conifer trees received the strongest empirical support. In general, the foliage height diversity at each peatland site seems to be the most important thing for supporting a wide range and abundance of species which are associated with different habitat types.

In general, little variation was observed between Intensive and Extensive Sites, but models for Intensive Sites often had stronger explanatory power. Repeated visits to Intensive Sites may be beneficial for long-term studies of presence and abundance of individual species in peatlands but a single visit to each Extensive Site was sufficient for purposes of creating habitat models to explain the relationships between birds and microhabitat components. Further and much more detailed results of the passerine bird habitat modeling can be found in Zolkowski (in prep).

Discussion

This project provides some of the first quantitative assessment of factors potentially influencing the distribution of bird species and abundance in Wisconsin peatlands. The habitat relationships of the peatland bird community that were explained using CCA and stepwise regression methods make sense ecologically compared to what is known about the natural history of these species. The models differ between species of different habitat associations and migratory guilds as well as between types of survey site by sampling intensity. Recent work has shown that many factors may influence the distribution and diversity of bird species (e.g., Terborgh et al. 1990, Wiens and Rotenberry 1981, James and Wamer 1982).

Forest-associated species were usually positively and sometimes strongly influenced by forest characteristics such as, higher basal area, percent tree cover, percent canopy closure, and understory vegetation cover. Similar results have been found in previous studies (Ross et al. 2001, Hanowski et al. 2005). Some of the stepwise logistic models for the forest-associated species at Extensive Sites in 2007 show positive correlations between species abundance and both conifer and broadleaf trees.

Models for open-shrubland species commonly included habitat characteristics such as low basal area, snag dbh, and tree cover with greater shrub cover. Modeling results for these species are in agreement with past studies (Klaus and Buehler 2001, Renfrew and Ribic 2008). Consistent with previous studies (e.g., Fairbairn and Dinsmore 2001, Riffell et al. 2006, Telleria et al. 2006) Some of the open-shrubland species in this study were positively associated with site size, such as Blue-winged Warblers, Sandhill Cranes, Yellow Warblers, and Sedge Wrens.

Shrub and moss cover were influencing factors for peatland-associated birds, such as the Palm Warbler, in all analysis methods. This is not surprising since sphagnum moss and shrubs are important components of most peatlands. Shrub cover is included as a positive influencing factor on Alder Flycatchers at Extensive Sites. Similar studies have also found shrub density and cover to be strongly associated with abundances of Alder Flycatchers (Riffell et al. 2001) and Red-winged Blackbirds (Murkin et al. 1997). Spatial heterogeneity is critical factor for abundance of peatland-associated birds (Williams 1964, Calmé and Desrochers 2000) and this is evident in the models from this study.

Characteristic nesting and breeding habitat features included in the models for most neo-tropical migrants in this study agree with previously documented habitat relationships. Sites with lower basal area and increased vegetation cover 1- and 2-m in height are typically occupied by neo-tropical migrants (Bisson and Stutchbury 2001). Habitat size was found to be positively correlated with several neo-tropical migrants in both this study and previous research, including Blue-winged Warblers, Common Yellowthroats, Eastern Wood-pewees, Lincoln's Sparrows, Palm Warblers, and Sandhill Cranes (Brenner and Berad 1998, Edwards and Otis 1999, Fauth et al. 2000). Overall in this study and others, the most important determining factor for increased neo-tropical migrant species richness is foliage height and structure diversity (Estrada and Coates-Estrada 2005).

Models from this study and research from other regions show that short-distance migrants generally utilize a greater proportion of early-successional habitats and younger forests than long-distance migrants or residents (Kirk et al. 1996, Hagan et al. 1997).

This project provides an assessment of factors potentially influencing the probability of occurrence and average abundance of three bird species at a site-level in Wisconsin peatlands. The presence and average abundance of Common Yellowthroats, Nashville warblers, and Palm Warblers were primarily influenced by understory vegetation features, especially shrubs. Combinations of vegetation layers with stratified heights seemed to be the most explanatory models of bird habitat relationships within peatlands. The vertical stratification of vegetation provides birds with a variety of opportunities for breeding, feeding and seeking shelter. In peatlands, the landscape composition and vegetation structure varies depending upon what type of peatland is being discussed. The peatlands surveyed in this study ranged from open sedge meadows to black spruce-tamarack swamps. It should be understood that there is not likely a single model that can explain the habitat relationships of all species or even groups of species since all species have their own unique niche requirements and behaviors. Additional discussion of models for these three species may be found in Zalkowski (in prep).

Results of this study are most relevant to conservation planning, which the WDNR will likely continue to implement for peatlands and other natural communities throughout Wisconsin. Bird species satisfy their needs and require an assortment of often dissimilar habitat structures in the process. Habitat preferred by one species may be avoided by another. Bird use of an area is associated more with the structure and cover pattern of the vegetation than the actual plant species that are present (Weller and Spatcher 1965, VanRees-Siewert and Dinsmore 1996).

As with most groups of organisms, no single management plan could possibly benefit all passerine bird species. Awareness of what vegetation and landscape features strongly influence bird communities of peatlands can provide some guidance as to which site characteristics to manage for and monitor. The species that are currently at the edge of their distribution range may be some of the first species to exhibit changes in their populations as a result of climate change. As time advances, the climate in the Great Lakes region may change and cause changes in vegetation trends and distributions. The predicted results of climate change could result in increased amounts of shrub cover and decreased amounts of graminoids (Weltzin et al. 2003). Bird species that are strongly and positively influenced by grasslands or areas comprised of herbaceous vegetation may shift their distributions to find suitable habitat is possible (Huntley 1991, Huntley 1994). Other organisms, such as insects and amphibians, which birds consume, may also be impacted by climate change. Bird species that are able to adapt to a changing climate will likely survive. Responses of all organisms are expected to be complex and, therefore, difficult to predict but a first step is predicting the potential response due to direct effects. That is only possible by linking large-scale models of bird distribution as a function of climate (Root and Schneider 1993).

Amphibians and Reptiles

Results

Species Richness, Relative Abundance, and Evenness

Combining all data from all techniques from the survey period, a total of 700 amphibians and reptiles were captured (Table 7). The majority of captures were of 13 amphibian species (ca. 98%). Seventeen individual reptiles of 5 different species were captured. Anurans dominated the amphibian captures ith 660 individuals (94%) of 9 species; salamanders represented 3% (n = 23, 4 species), and snakes only 2% (n = 16). One turtle, a common snapping turtle was also captured.

Relative abundance of any given species varied between the two years of the study, but several species were generally the most common (Table 7). The most common anuran was the wood frog, which comprised 33% of all captures in 2004 and 38% in 2005. Northern leopard frogs (20%, 5%), green frogs (16%, 14%), and American toads (14%, 29%) were the next most common anuran species. Six mink frogs, which are identified as a Species of Greatest Conservation Need (SGCN) in Wisconsin's Wildlife Action Plan (http://dnr.Wisconsin.gov/org/land/er/WWAP/), were also recorded. The most common salamander species was the blue spotted salamander (n =14), followed by the red-backed salamander (n = 6). Two four-toed salamanders (SGCN) and one spotted salamander were also recorded. In addition to the amphibian species, five reptile species were documented. The most common reptile was the common garter snake (n = 11) followed by the northern red-bellied snake (n = 3). One eastern milk snake, one Butler's garter snake (Wisconsin Threatened, SGCN), and one common snapping turtle were also captured.

Species richness varied greatly among the thirteen Intensive Sites (range 2 – 12; Table 8). The most species (12) were recorded at Dry Lake. The lowest species richness was at Big Bay, but much less survey effort was put into this site because it was more difficult to access (ferry boat required) than the other sites. The most individual animals were recorded at Kidrick Swamp with 104, and this site also had the highest number of amphibians (n = 99). Bibon Swamp and Mead Conifer Bogs had the next highest numbers of individuals With 96 and 94, respectively. Dry Lake had the highest salamander abundance (n = 9) followed by Quincy Bluff (n = 7). Cedarburg Bog and Dry Lake had the most individual reptile captures (n = 4 at each site), although relative to the amphibian captures, these numbers were very low.

Species evenness varied across sites (range 0.44 to 1.0), but was higher than is typical of north temperate herpetofaunal assemblages (Table 8). Evenness was lowest at Kidrick Swamp, where American toads represented 73% of the captures and at Cedarburg Bog where northern green frogs and wood frogs represented 45% and 42% of captures, respectively.

Overall, of the three survey techniques used, pitfall traps were most effective at capturing amphibians and reptiles, although at some sites, incidental observation surveys detected more individuals (Tables 9 and 10). In a total of 10,794 pitfall trap nights, 394 individuals of 15 species were captured; 386 were amphibians (11 species), and 8 were reptiles (4 species). Catch per unit effort ranged from 0.00 (0%) at

Miscauno Cedar Swamp to .09 (9%) at Lower Chippewa River, With an average of 0.04 (4%) for all trap sites (Table 10). More individuals were captured in pitfall traps located in upland habitat (n = 184) than in peatland habitat (158). The most commonly captured species in pitfall traps in peatland habitat were wood frogs (n = 81), American toads (n = 32), and northern green frogs (n = 24). These same three species were also the most commonly caught in pitfall traps in upland habitat: wood frogs (n = 79), American toads (n = 67), and northern green frogs (n = 27). Blue spotted salamanders were the only salamander species captured in pitfall traps. Eight were caught in peatland habitat and three in upland habitat. Only three snakes were caught in pitfall traps (one each of common garter snake, Butler's garter snake, and northern red-bellied snake), all in upland habitat. Mortality of captives in pitfall traps was 7% with the majority attributed to predation by small mammals. Incidental observations were successful at detecting 244 animals of which 238 were amphibians and 6 were reptiles. Visual encounter surveys only accounted for 62 individuals, 59 amphibians and 3 reptiles.

Table 7. Annual and total numbers and relative abundance of amphibians and reptiles captured in Wisconsin peatlands using pitfall traps, visual encounter surveys, and incidental observations, 2004-2005.

Species	Year				Total	
	2004		2005			
	N	Relative Abundance (%)	N	Relative Abundance (%)	N	Relative Abundance (%)
Frogs and toads (Anura)						
American toad (*Bufo americanus*)	14	13.9	171	28.5	185	26.4
Northern spring peeper (*Pseudacris crucifer crucifer*)	5	5.0	25	4.2	30	4.3
Chorus frog (*Pseudacris triseriata*)	2	2.0	2	0.3	4	0.6
Cope's gray treefrog (*Hyla chrysoscelis*)	3	3.0	5	0.8	8	1.1
Gray treefrog (*Hyla versicolor*)	5	5.0	8	1.3	13	1.9
Northern green frog (*Rana clamitans*)	16	15.8	83	13.9	99	14.1
Northern leopard frog (*Rana pipiens*)	20	19.8	32	5.3	52	7.4
Mink frog (*Rana septentrionalis*)	3	3.0	3	0.5	6	0.9
Wood frog (*Rana sylvatica*)	33	32.7	230	38.4	263	37.6
Salamanders (Caudata)						
Blue-spotted salamander (*Ambystoma laterale*)	0	0.0	14	2.3	14	2.0
Spotted salamander (*Ambystoma maculatum*)	0	0.0	1	0.2	1	0.1
Four-toed salamander (*Hemidactylium scutatum*)	0	0.0	2	0.3	2	0.3
Eastern red-backed salamander (*Plethodon cinereus*)	0	0.0	6	1.0	6	0.9
Snakes						
Eastern milksnake (*Lampropeltis triangulum triangulum*)	0	0.0	1	0.2	1	0.1
Northern red-bellied snake (*Storeria occipitomaculata occipitomaculata*)	0	0.0	3	0.5	3	0.4
Butler's gartersnake (*Thamnophis butleri*)	0	0.0	1	0.2	1	0.1
Common gartersnake (*Thamnophis sirtalis*)	0	0.0	11	1.8	11	1.6

Turtles						
Common snapping turtle (*Chelydra serpentina*)	0	0.0	1	0.2	1	0.1
All amphibians	101	100.0	582	97.2	683	97.6
All reptiles	0	0.0	17	2.8	17	2.4
Total	101	100.0	599	100.0	700	100.0

Table 8. Amphibian and reptile numbers and species richness at Wisconsin peatland sites using pitfall traps, visual encounter surveys, and incidental observations, 2004-2005.

	Belden Swamp	Bibon Swamp	Big Bay	Cedarburg Bog	Dry Lasnake	Hortonville Bog	Kidrick Swamp	Lower Chippewa River	Mead Conifer Bogs	Miscauno Cedar Swamp	Pigeon Creek Swamp/Bear lasnake Sedge Meadow	Quincy Bluff and Wetlands	Swanson Lasnake	All Sites
Frogs and toads														
American toad	7	9	0	1	11	16	76	14	23	3	10	2	13	185
Northern spring peeper	1	0	2	0	1	0	5	9	7	1	1	3	0	30
Chorus frog	1	0	0	0	2	0	0	0	0	0	0	1	0	4
Cope's gray treefrog	1	0	0	0	0	0	0	0	1	0	5	1	0	8
Gray treefrog	1	0	0	0	2	0	0	6	0	0	2	2	0	13
Northern green frog	2	13	0	35	7	1	0	4	10	1	3	17	6	99
Northern leopard frog	3	12	0	5	6	1	3	3	0	0	2	0	17	52
Mink frog	0	3	2	0	0	0	0	0	0	0	1	0	0	6
Wood frog	9	58	0	33	27	20	15	36	42	0	10	8	5	263
Salamanders														
Blue-spotted salamander	0	0	0	0	3	0	0	0	1	0	3	7	0	14
Spotted salamander	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Four-toed salamander	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Eastern red-backed salamander	0	0	0	0	5	0	1	0	0	0	0	0	0	6
snakes														
Eastern milk snake	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Northern red-bellied snake	0	0	0	1	1	0	0	0	0	0	0	1	0	3
Butler's gartersnake	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Common gartersnake	0	1	0	1	3	2	2	2	0	0	0	0	0	11
Turtles														
Common snapping turtle	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Total Amphibians	25	95	4	74	65	38	102	72	84	5	37	41	41	683
Total Reptiles	0	1	0	4	4	3	2	2	0	0	0	1	0	17

Total Amphibians and Reptiles	25	96	4	78	69	41	104	74	84	5	37	42	41	700
Species Richness	8	6	2	8	12	6	7	7	6	3	9	9	4	18
Species Diversity	1.70	1.21	0.69	0.97	1.63	1.00	0.87	1.47	1.20	0.94	1.24	1.15	1.27	1.78
Evenness	0.82	0.68	1.00	0.47	0.65	0.56	0.44	0.76	0.67	0.86	0.57	0.52	0.91	0.62

Seasonal Activity Patterns

Seasonal activity in peatlands fluctuated among species. Overall, the most individuals were captured in June (n = 200). Wood frogs, northern green frogs and leopard frogs all had the largest number of captures in June (n = 83, 27, and 19, respectively). Wood frogs were captured in every month of the season in fairly good numbers: May (n = 25), July (n = 50), August (n = 46), September (n = 42), and October (n = 16). The majority of American toads (n = 49) were captured in August, but good numbers were also captured in May (n = 22), June (n = 43), July (n = 39), and September (n = 28). Most northern green frogs were captured in June (n = 27) and July (n = 30).

Discussion

Species Richness, Relative Abundance and Evenness

Amphibian species richness declines in more northern latitudes, and in and east-west gradient within the United States, correlated with decreasing annual rainfall to the west (Kiester 1971). The actual number and particular species present in an area are the result of a variety of factors including climate, vegetation and historical influence. Overall, the Midwest, including Wisconsin, is relatively poor in amphibian and reptile species richness compared to other parts of the United States and the world. In general, species richness and evenness at our study sites were greater than in similar studies of Minnesota peatlands (Karns and Regal 1978, 1979), Maine peatlands (Stockwell and Hunter 1989), and New Hampshire forests (Rudis 1984), although we can not make direct comparisons among specific habitat types because of different methods of habitat classification used by this study.

Table 9. Number of amphibians and reptiles captured at Wisconsin peatland sites using three different survey techniques, 2004-2005.

Site Name	Pitfall* Captures	VES captures	IES captures	Total captures
Belden Swamp	8	0	17	25
Bibon Swamp	41	13	42	96
Big Bay	0	2	2	4
Cedarburg Bog	48	8	22	78
Dry Lasnake	29	7	33	69
Hortonville Bog	32	3	6	41
Kidrick Swamp	44	2	58	104
Lower Chippewa River	61	0	13	74
Mead Conifer Bogs	73	10	1	84
Miscauno Cedar Swamp	1	1	3	5
Pigeon Creek Swamp/Bear lasnake Sedge Meadow	17	3	17	37
Quincy Bluff and Wetlands	26	9	7	42
Swanson Lake	14	4	23	41
All Sites	394	62	244	700

* Includes individuals captured in unknown pitfall traps.

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Table 10. Number of species, total captures, total effort and catch per unit effort of reptiles and amphibians at Wisconsin peatland sites, 2004-2005.

	Belden Swamp	Bibon Swamp	*Big Bay	Cedarburg Bog	Dry Lasnake	Hortonville Bog	Kidrick Swamp	Lower Chippewa River	Mead Conifer Bogs	Miscauno Cedar Swamp	Pigeon Creek Swamp/Bear lasnake Sedge Meadow	Quincy Bluff and Wetlands	Swanson Lasnake	All Sites
Frogs and toads														
American toad	4	4		1	4	14	32	12	22	1	3	1	7	105
Northern spring peeper	0	0		0	1	0	1	4	3	0	0	2	0	11
Chorus frog	0	0		0	1	0	0	0	0	0	0	0	0	1
Cope's gray treefrog	0	0		0	0	0	0	0	1	0	0	0	0	1
Gray treefrog	0	0		0	0	0	0	5	0	0	0	0	0	5
Northern green frog	0	3		25	0	1	0	4	10	0	1	10	3	58
Northern leopard frog	0	4		0	0	0	0	3	0	0	1	0	2	10
Mink frog	0	2		0	0	0	0	0	0	0	0	0	0	2
Wood frog	4	28		20	20	16	8	32	36	0	9	5	2	180
Salamanders														
Blue-spotted salamander	0	0		0	1	0	0	0	1	0	3	7	0	12
Four-toed salamander	0	0		0	0	0	2	0	0	0	0	0	0	2
Snakes														
Eastern milk snake	0	0		1	0	0	0	0	0	0	0	0	0	1
Northern red-bellied snake	0	0		0	0	0	0	0	0	0	0	1	0	1
Butler's gartersnake	0	0		1	0	0	0	0	0	0	0	0	0	1
Common gartersnake	0	0		0	2	1	1	1	0	0	0	0	0	5
Number of Species	2	5		5	6	4	5	7	6	1	5	6	4	15
Total Captures	8	41		48	29	32	44	61	73	1	17	26	14	394
Total Effort	800.0	888.5		953.0	945.5	869.0	936.5	675.0	943.0	915.0	955.0	953.5	960.0	10794.0
Catch/Unit Effort	0.01	0.05		0.05	0.03	0.04	0.05	0.09	0.08	0.00	0.02	0.03	0.01	0.04

*Pitfall trapping was not done at Big Bay .

This study documented a total of 18 species, compared to 13 in Maine (Stockwell and Hunter 1989) and 11 in Minnesota (Karns and Regal 1978, 1979). Amphibians dominated the captures in all three studies (Minnesota 98.7%, Maine 98.5%, Wisconsin 98%). In all three studies, wood frogs were the most commonly captured species (Minnesota 47%, Maine 59%; Wisconsin

37.6%). American toads were the second most common species in both Minnesota (30.6%) and Wisconsin (29%). In Maine, the northern green frog was the second most common species (30%), while American toads were not even in the top five most common species. The mink frog and the Cope's gray treefrog were recorded only in Wisconsin peatlands. Maine had the greatest species richness of salamanders with five, while Wisconsin documented four species and Minnesota only one. The common garter snake was present in all three studies, but the Wisconsin study also recorded a milk snake and a Butler's garter snake. It should be noted that the range of Butler's garter snake does not include Minnesota or Maine (Conant & Collins 1998). The Minnesota and Wisconsin studies both recorded turtle species (the snapping turtle in both cases) and a western painted turtle in the Minnesota study. The low capture rate of reptiles compared to amphibians in this study is consistent with the fact that reptiles are better suited, in general, for drier habitats than amphibians; therefore, it would not be expected to find large numbers of reptiles in peatland habitats. In fact, the majority of reptiles caught in this study were captured in upland habitat, not in peatlands. Evenness is generally lower in north temperate herpetofaunal assemblages than in this study, where at many sites multiple species were fairly well-represented among all species documented using the three different survey techniques.

A variety of microclimatic conditions influence the distribution and abundance of amphibians, and in peatland habitats, temperature, moisture, and pH may be of special importance. These factors may be responsible for some of the variation in species richness (range 2–12) across the thirteen sites in this study. Big Bay had the lowest species richness (n = 2), but this is explained largely by the fact that the site is located on Madeline Island in Lake Superior. Access to this location necessitated the use of a boat, generally the scheduled passenger ferry service. Thus, this site received far fewer visits over the course of the study than other sites that were more easily accessible. In addition, fewer species are present on the island because of the limitations of colonization to islands.

The three most commonly captured amphibians, wood frogs, American toads, and northern green frogs were also much more likely to be captured in pitfall traps than other amphibian species. This is not surprising given that these species are not as likely to be able to climb out of pitfall traps as several other species (e.g., northern spring peeper, both tree frogs, and chorus frogs). Pitfall traps located at the transition between upland and peatland habitats captured more individuals than pitfall traps located completely within either peatland or upland habitat. One potential reason for this may simply be that the drift fence located at the transition zone effectively channeled more individuals into the pitfall traps. Drift fences were not used along the pitfall transects except at the transition zones. The pitfall traps associated with drift fences captured 55% of individuals. The area of habitat at the transition between upland and peatland may also serve as an important travel corridor for amphibians moving between peatlands and uplands. Several species (four-toed salamander, gray treefrog, and chorus frog) were captured only in pitfall traps associated with drift fences, which may indicate that these species are less likely to fall into a pitfall trap that is not associated with a drift fence.

Mortality of captives in pitfall traps was 7%, with the majority attributed to predation by small mammals. This is higher than reported in some other studies of pitfall trapping in peatlands (3.7%; Stockwell and Hunter 1989). However, because this study used pitfall traps with the intent of capturing both amphibians and small mammals, we took no precautions to exclude small mammals from the pitfall traps, as is often done when the sole focus is to capture amphibians (e.g., a string in bucket so mammals can climb out). Because we captured few snakes in pitfall traps (n = 3) and saw few others, predatory snakes probably posed little threat to the captive amphibians in the pitfall traps.

Seasonal Activity Patterns
Seasonal amphibian activity in peatlands fluctuated among species. The fact that wood frogs and American toads were detected throughout the survey periods, suggests that these species use peatland habitat throughout the season; whereas other species may restrict their use of peatlands to post-breeding habitat. Activity in August and September may be indicative of juvenile dispersal after metamorphosis (Mazerolle, 2001) and movement back to overwintering habitat in adjacent uplands.

Because peatland habitats are generally moist throughout the summer, the movements of amphibians in peatlands may be less restricted than in other habitats that are more seasonally moist. This may explain why amphibians were quite active on our study sites throughout the entire season. But, overall, the seasonal activity patterns found in this study were not consistent with some other studies that have reported peak activity in August (Bellis, 1959, 1962; Schroeder, 1976; Mazerolle, 2001).

Relatively low species richness at peatland sites in Wisconsin followed the general pattern for north temperate herpetofaunal assemblages. However, species richness was higher than at other north temperate peatland sites in Minnesota and Maine (Karns and Regal 1978, 1979; Stockwell and Hunter 1989). Amphibians dominated the captures, while very few reptiles were captured or observed. Of the amphibians captured, three species represented the majority (wood frogs, American toads, and northern green frogs). While peatlands are not as rich in species and do not have as great of an abundance of individuals as other habitat types in Wisconsin, they do represent an important habitat for amphibians.

Small Mammals

Results and Discussion
From late May to early October, 2005, we captured and collected 2,560 small mammals representing 17 species (Table 11a, b) on the 12 Intensive Sites. The masked shrew (*Sorex cinereus*) accounted for 50.0% of all captures and was the most common species captured at all study sites except Miscauno Cedar Swamp . The red-backed vole (*Clethrionomys gapperi*) was the second most commonly captured species overall (n=309), followed by the white-footed mouse (*Peromyscus leucopus*; n=265), northern short-tailed shrew (*Blarina brevicauda*; n=128), Arctic shrew (*S. arcticus*; n= 119), deer mouse (*P. maniculatus*; n=111), meadow vole (*Microtus pennsylvanicus*; n=104), meadow jumping mouse (*Zapus hudsonius*; n=104), and pygmy shrew (*S. hoyi*; n=59).

From there it was a significant drop in numbers for the remaining species, including southern bog lemming (*Synaptomys cooperi*; n=8), water shrew (*S. palustris*; n=6), star-nosed mole (*Condylura cristata*; n=4), southern flying squirrel (*Glaucomys volans*; n=3), eastern chipmunk (*Tamias striatus*; n=3), least chipmunk (*T. minimus*; n=2), northern flying squirrel (*G. sabrinus*; n=2), and woodland jumping mouse (*Napaeozapus insignis*; n=2).

The number of species captured at each site was fairly close, ranging from 8 to 13 species (Table 11a, b). Other than about 5 species that were more less ubiquitous, species composition varied between sites (Table 11a).

There was also considerable variation between sites. As expected from the total capture rates, masked shrews were taken in moderate to high numbers at each site (Table 11a). Others, like meadow jumping mice, were captured at all or most of the sites in low numbers. Some species, like the least chipmunk (1 site) and southern flying squirrels (3 sites), were captured at few sites, and when they were caught, they were few in number.

Table 11a. Small mammal species, capture counts, and capture rates during biweekly trapping from May 24 to October 5, 2005.

Species	Beldon Swamp SNA, Douglas Co.	Bibon Swamp SNA, Bayfield Co.	Dry Lake RNA, Ashland Co.	Swanson Lake, Oneida Co.	Miscauno Cedar Swamp SNA, Marinette Co.	Kidrick Swamp RNA, Taylor Co.	Pigeon Creek, Barron Co.	Hortonville Bog SNA, Outagamie Co.	Mead Conifer Bog SNA, Marathon Co.	Cedarburg Bog SNA, Ozaukee Co.	Lower Chippewa River SNA, Buffalo Co.	Quincy Bluff & Wetlands SNA, Adams Co.	Total
Blarina brevicauda	16	22	53	7	9	4	1		4	3	8	1	128
Sorex arcticus	20	43	14	6		4	15	3	3		8	3	119
Sorex cinereus	124	147	115	65	33	46	41	164	77	88	259	123	1282
Sorex hoyi		9	3	5		5		11	2		20	4	59
Sorex palustris	3		1			2							6
Sorex sp.		1	8			1		1	1	5	1	1	19
Condylura cristata					2						2		4
Glaucomys sabrinus					2								2
Glaucomys volans					1				1		1		3
Tamias minimus				2									2
Tamias striatus			1	1						1			3
Clethrionomys gapperi	1	9	14	97	16	6	36	41	30	18	40	1	309
Microtus pennsylvanicus	7	46	3	10	2		6	15		6	6	3	104
Peromyscus maniculatus	5	7	43		13	43							111
Peromyscus leucopus	3	2	3	10	38	24	9	18	42	41	50	25	265
Peromyscus sp.		1	2	2	4	2		1	3	4	1	5	25
Synaptomys cooperi			1	3	2		1					1	8
Napaeozapus insignis					1				1				2
Zapus hudsonius	13	3	5	3	1	4	6	4	12	4	45	4	104
Unknown species			1					2	2				5
No. of Species	9	9	12	11	12	9	8	7	9	7	10	9	17
Total Captures	192	290	267	211	124	141	115	260	178	170	441	171	2560
Total Effort	1465.5	1451.0	1551.0	1681.5	1583.5	1601.0	1730.5	1444.0	1730.5	1584.5	1393.5	1629.5	18846.0
Pitfall Effort	800.0	888.5	945.5	960.0	915.0	936.5	955.0	869.0	943.0	953.0	675.0	953.5	10794.0
Snap-trap Effort	665.5	562.5	605.5	721.5	668.5	664.5	775.5	575.0	787.5	631.5	718.5	676.0	8052.0
Capture Rate (# animals/100 traps/24 hr)	13.1	20.0	17.2	12.5	7.8	8.8	6.6	18.0	10.3	10.7	31.6	10.5	13.6

Table 11b. Small mammal capture rates (# animals/100 traps/24 hr) from May 24 to October 8, 2005.

Species	Belcon Swamp SNA, Douglas Co.	Bibon Swamp SNA, Bayfield Co.	Dry Lake RNA, Ashland Co.	Swanson Lake, Oneida Co.	Miscauno Cedar Swamp WA, Marinette Co.	Kidrick Swamp RNA, Taylor Co.	Pigeon Creek Swamp, Barron Co.	Hortonville Bog SNA, Outagamie Co.	Mead Conifer Bog SNA, Wood Co.	Cedarburg Bog SNA, Ozaukee Co.	Lower Chippewa River SNA, Buffalo Co.	Quincy Bluff & Wetlands
Blarina brevicauda	1.09	1.52	3.42	0.42	0.57	0.25	0.06		0.23	0.19	0.57	0.
Sorex arcticus	1.36	2.96	0.90	0.36		0.25	0.87	0.21	0.17		0.57	0.
Sorex cinereus	8.46	10.13	7.41	3.87	2.08	2.87	2.37	11.36	4.45	5.55	18.59	7.
Sorex hoyi		0.62	0.19	0.30		0.31		0.76	0.12		1.44	0.
Sorex palustris	0.20		0.06			0.12						
Sorex sp.		0.07	0.52			0.06		0.07	0.06	0.32	0.07	0.
Condylura cristata					0.13						0.14	
Glaucomys sabrinus					0.13							
Glaucomys volans					0.06				0.06		0.07	
Tamias minimus				0.12								
Tamias striatus			0.06	0.06						0.06		
Clethrionomys gapperi	0.07	0.62	0.90	5.77	1.01	0.37	2.08	2.84	1.73	1.14	2.87	0.
Microtus pennsylvanicus	0.48	3.17	0.19	0.59	0.13		0.35	1.04		0.38	0.43	0.
Peromyscus maniculatus	0.34	0.48	2.77		0.82	2.69						
Peromyscus leucopus	0.20	0.14	0.19	0.59	2.40	1.50	0.52	1.25	2.43	2.59	3.59	1.
Peromyscus sp.		0.07	0.13	0.12	0.25	0.12		0.07	0.17	0.25	0.07	0.
Synaptomys cooperi			0.06	0.18	0.13		0.06					0.
Napaeozapus insignis					0.06				0.06			
Zapus hudsonius	0.89	0.21	0.32	0.18	0.06	0.25	0.35	0.28	0.69	0.25	3.23	0.
Unknown species			0.06					0.14	0.12			
No. of Species	9	9	12	11	12	9	8	7	9	7	10	
Total Captures	192	290	267	211	124	141	115	260	178	170	441	1
Total Effort	1465.5	1451	1551	1681.5	1583.5	1601	1730.5	1444	1730.5	1584.5	1393.5	16
Pitfall Effort	800	888.5	945.5	960	915	936.5	955	869	943	953	675	95
Snap-trap Effort	665.5	562.5	605.5	721.5	668.5	664.5	775.5	575	787.5	631.5	718.5	6
Capture Rate (#/100 traps/24 hr)	13.10	19.99	17.21	12.55	7.83	8.81	6.65	18.01	10.29	10.73	31.65	10

Capture rates varied between sites quite a bit as well, (Table 11b), ranging from a low of about 7 up to almost 32.

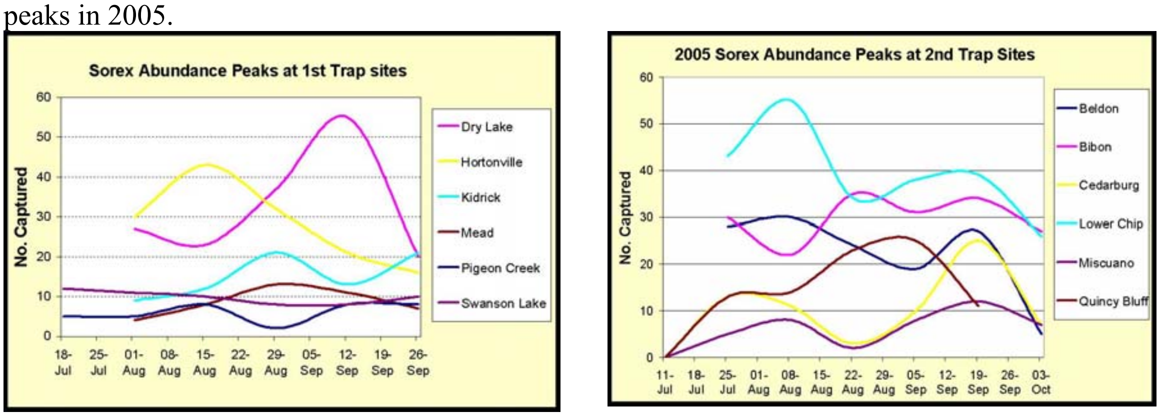
The total number of animals that were captured at individual sites varied greatly as well (Table 11a). Lower Chippewa produced the most captures with about 17% of the total. Pigeon Creek had the fewest, accounting for only about 4% of the total captures.

The number of animals captured at the individual sites (Table 12a), within each foraging category, were also variable, ranging from 298 insectivores at the most productive site (Lower Chippewa) to a low of 44 insectivores captured at Miscauno.

Capture rates were greatest for the insectivore foraging group at all of the sites except for Kidrick Swamp, Miscauno, and Swanson Lake (Table 12b). At the former two sites, the omnivore group had the highest capture rates, and at Swanson Lake the mast category had the highest capture rate.

Peak abundance of shrew (*Sorex*) species is somewhat muddled. Generally, abundances increased from the early season. However at some sites, like Swanson Lake (Figure 13a), abundances stayed relatively constant. At other sites (e.g., Lower Chippewa, Figure 13b), there was a mid-summer peak in abundance. Many sites though, like Cedarburg (Figure 13b), showed a strong late season peak that declined during the autumn.

Figure 13a and b. Shrew (*Sorex*) abundance peaks in 2005.



There are differences in the trap type and rate of successful capture between the species. Shrew species, in general, were more often captured in pitfall traps (e.g., at Cedarburg, Figure 14a), and deer mice were caught with snap traps, such as at Kidrick Swamp (Figure 14b).

Some of the variation observed between sites and within sites may, in part, be due to the size of the sites; some of the Intensive Sites, like Pigeon Creek, are small when compared to sites like Bibon Swamp and Kidrick Swamp. Also, there are habitat differences between the sites as well. The natural community types are different when comparing sites such as Cedarburg and Miscauno. Even if the peatland communities are the same at two sites, the proportions in each type likely differ at the two sites. The types and quality of the natural communities on the uplands surrounding the peatlands were not the same at each site either, and that would affect the what upland species were captured. Also, some species may be near the edge of their range, and given the distance from north to south and east to west between the 12 Intensive Sites that were surveyed it would not be expected that each species would be at all sites.

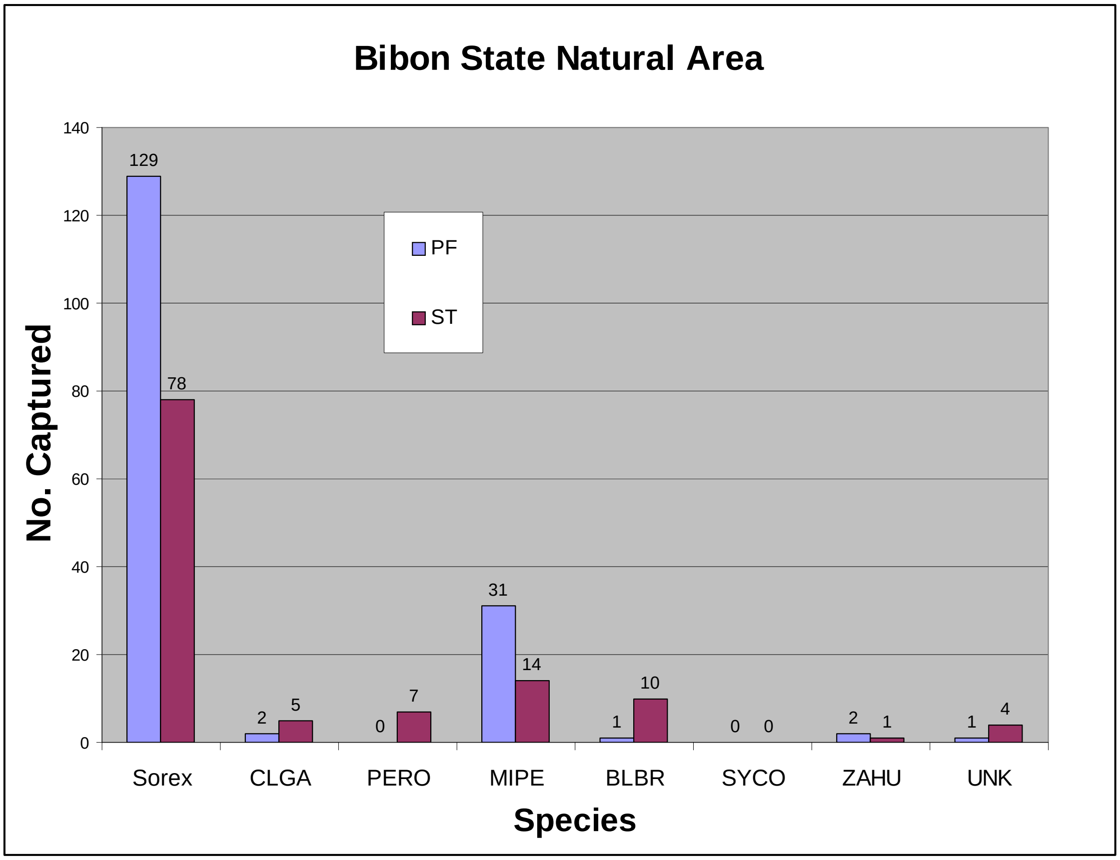


Figure 14a. Number of mammals caught by pitfall traps (in blue) and snaptraps (in purple) at Bibon Swamp. Shrews are in the genus *Sorex*.

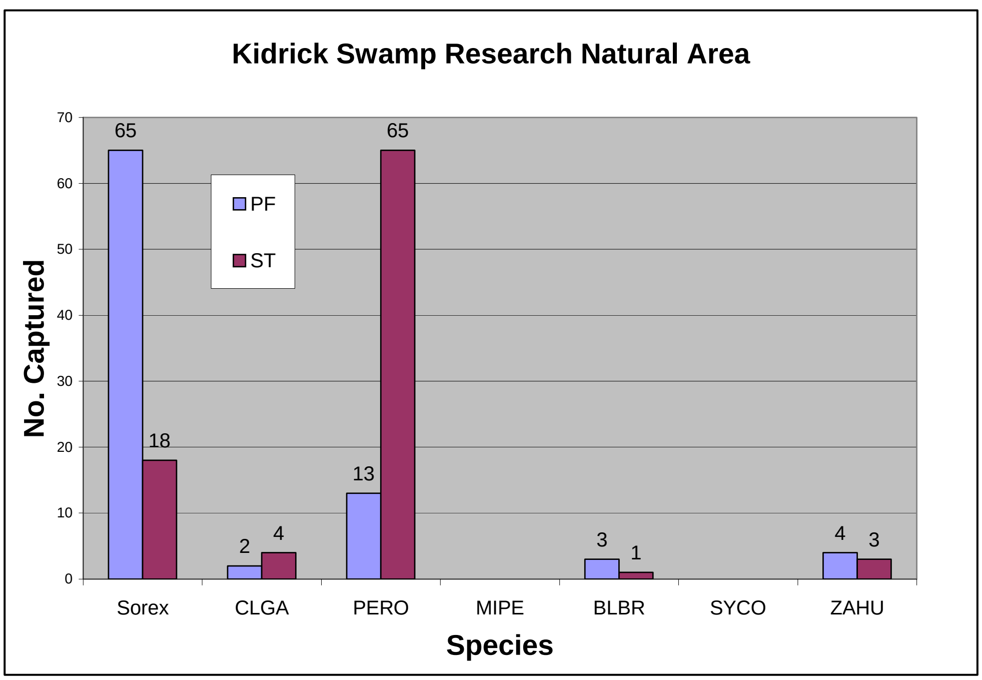


Figure 14b. Number of mammals caught by pitfall traps (in blue) and snaptraps (in purple) at Kidrick Swamp. Deer mice are labeled "PERO."

Figure 12a. Small mammal capture counts and capture rates by foraging category (insectivores, mast consumers, omnivores, and herbivores) from May 24 to October 8, 2005.

Group	Lower Chippew River SNA, Buf Co.	Bibon Swamp : Bayfield Co.	Dry Lake RNA, Ashland Co.	Hortonville Bo SNA, Outagam Co.	Beldon Swamp SNA, Douglas	Total	Quincy Bluff & Wetlands SNA, Adams Co.	Cedarburg Bog SNA, Ozaukee	Mead Conifer E SNA, Wood Co	Swanson Lake, Oneida Co.	Kidrick Swamp RNA, Taylor C	Pigeon Creek Swamp, Barron	Miscauno Ceda Swamp SNA, Marinette Co.
Insectivores	298	222	194	179	163	1617	132	96	87	83	62	57	44
Total Captures	441	290	266	258	192	2555	171	170	176	211	141	115	124
%	67.6%	76.6%	72.9%	69.4%	84.9%	63.3%	77.2%	56.5%	49.4%	39.3%	44.0%	49.6%	35.5%
Total Effort	1393.5	1451.0	1551.0	1444.0	1465.5	18846.0	1629.5	1584.5	1730.5	1681.5	1601.0	1730.5	1583.5
Catch/ Unit Effort	**21.4**	**15.3**	**12.5**	**12.4**	**11.1**	**8.6**	**8.1**	**6.1**	**5.0**	**4.9**	**3.9**	**3.3**	**2.8**

Group	Swanson Lake, Oneida Co.	Lower Chippewa River SNA, Buffalo Co.	Hortonville Bog SNA, Outagamie Co.	Pigeon Creek Swamp, Barron Co.	Mead Conifer Bog SNA, Wood Co.	Total	Miscauno Cedar Swamp SNA, Marinette Co.	Cedarburg Bog SNA, Ozaukee Co.	Dry Lake RNA, Ashland Co.	Bibon Swamp SNA, Bayfield Co.	Kidrick Swamp RNA, Taylor Co.	Beldon Swamp SNA, Douglas Co.	Quincy Bluff & Wetlands SNA, Adams Co.
Mast	100	41	41	36	31	319	19	19	15	9	6	1	[illegible]
Total Captures	211	441	258	115	176	2555	124	170	266	290	141	192	171
%	47.4%	9.3%	15.9%	31.3%	17.6%	12.5%	15.3%	11.2%	5.6%	3.1%	4.3%	0.5%	0.6%
Total Effort	1681.5	1393.5	1444.0	1730.5	1730.5	18846.0	1583.5	1584.5	1551.0	1451.0	1601.0	1465.5	1629.5
Catch/ Unit Effort	**5.9**	**2.9**	**2.8**	**2.1**	**1.8**	**1.7**	**1.2**	**1.2**	**1.0**	**0.6**	**0.4**	**0.1**	**0.1**

Group	Kidrick Swamp RNA, Taylor Co.	Lower Chippewa River SNA, Buffalo Co.	Miscauno Cedar Swamp SNA, Marinette Co.	Dry Lake RNA, Ashland Co.	Cedarburg Bog SNA, Ozaukee Co.	Mead Conifer Bog SNA, Wood Co.	Total	Quincy Bluff & Wetlands SNA, Adams Co.	Hortonville Bog SNA, Outagamie Co.	Swanson Lake, Oneida Co.	Bibon Swamp SNA, Bayfield Co.	Beldon Swamp SNA, Douglas Co.	Pigeon Creek Swamp, Barron Co.
Omnivores	69	51	55	48	45	45	401	30	19	12	10	8	9
Total Captures	141	441	124	266	170	176	2555	171	258	211	290	192	115
%	48.9%	11.6%	44.4%	18.0%	26.5%	25.6%	15.7%	17.5%	7.4%	5.7%	3.4%	4.2%	7.8%
Total Effort	1601.0	1393.5	1583.5	1551.0	1584.5	1730.5	18846.0	1629.5	1444.0	1681.5	1451.0	1465.5	1730.5
Catch/ Unit Effort	**4.3**	**3.7**	**3.5**	**3.1**	**2.8**	**2.6**	**2.1**	**1.8**	**1.3**	**0.7**	**0.7**	**0.5**	**0.5**

Group	Lower Chippewa River SNA, Buffalo Co.	Bibon Swamp SNA, Bayfield Co.	Beldon Swamp SNA, Douglas Co.	Hortonville Bog SNA, Outagamie Co.	Total	Swanson Lake, Oneida Co.	Pigeon Creek Swamp, Barron Co.	Mead Conifer Bog SNA, Wood Co.	Cedarburg Bog SNA, Ozaukee Co.	Dry Lake RNA, Ashland Co.	Quincy Bluff & Wetlands SNA, Adams Co.	Miscauno Cedar Swamp SNA, Marinette Co.	Kidrick Swamp RNA, Taylor Co.
Herbivores	51	49	20	19	218	16	13	13	10	9	8	6	4
Total Captures	441	290	192	258	2555	211	115	176	170	266	171	124	141
%	11.6%	16.9%	10.4%	7.4%	8.5%	7.6%	11.3%	7.4%	5.9%	3.4%	4.7%	4.8%	2.8%
Total Effort	1393.5	1451.0	1465.5	1444.0	18846.0	1681.5	1730.5	1730.5	1584.5	1551.0	1629.5	1583.5	1601.0
Capture Rate (#/ 100 traps/ 24 hr)	**3.7**	**3.4**	**1.4**	**1.3**	**1.2**	**1.0**	**0.8**	**0.8**	**0.6**	**0.6**	**0.5**	**0.4**	**0.2**

Table 12b. Small mammal capture counts and capture rates by foraging category from May 24 to October 8, 2005.

Species Group	Beldon Swamp SNA, Douglas Co.	Bibon Swamp SNA, Bayfield Co.	Cedarburg Bog SNA, Ozaukee Co.	Dry Lake RNA, Ashland Co.	Hortonville Bog SNA, Outagamie Co.	Kidrick Swamp RNA, Taylor Co.	Lower Chippewa River, Buffalo Co.	Mead Conifer Bog SNA, Wood Co.	Miscauno Cedar Swamp SNA, Marinette Co.	Pigeon Creek Swamp, Barron Co.	Quincy Bluff & Wetlands, Adams Co.	Swanson Lake, Oneida Co.	Total
Insectivores	163	222	96	194	179	62	298	87	44	57	132	83	1617
%	85%	77%	56%	73%	69%	44%	68%	49%	35%	50%	77%	39%	63%
Mast	1	9	19	15	41	6	41	31	19	36	1	100	319
%	1%	3%	11%	6%	16%	4%	9%	18%	15%	31%	1%	47%	12%
Omnivores	8	10	45	48	19	69	51	45	55	9	30	12	401
%	4%	3%	26%	18%	7%	49%	12%	26%	44%	8%	18%	6%	16%
Herbivores	20	49	10	9	19	4	51	13	6	13	8	16	218
%	10%	17%	6%	3%	7%	3%	12%	7%	5%	11%	5%	8%	9%
Total Captures	192	290	170	266	258	141	441	176	124	115	171	211	2555

Invertebrates

Results and Discussion

<u>Terrestrial Invertebrates</u>

The terrrestrial invertebrate research was focused on a subset of wetland Lepidoptera and Orthoptera. Butterflies are well-studied in Wisconsin, but the moth families are large and new species and information continue to be discovered. The extent of ranges of Lepidoptera in northern wetlands is limited by variables other than potential habitat as shown by the results of this study and the previous northeastern Wisconsin peatlands study of Nekola (1998). Orthopterans are not as well documented in Wisconsin. Only grasshoppers (Acrididae) have been systematically recorded (Kirk and Bomar 2005) although species lists for katydids (Tettigoniidae) and crickets (Gryllidae) are fairly complete and few additional species were expected. The other four families of Orthoptera were not addressed in this study. We had also hoped to discover more locations for two wetland leafhoppers (Homoptera: Cicadellidae) and one terrestrial mollusk (*Vertigo nylanderi*) but were not able to include those species in the field work.

Of primary interest was a group of boreal and/or Arctic taxa which reach the southern limits of their eastern North American range in the Great Lakes States (Opler and Krizek 1984). Three *Boloria* species (Frigga, Freija and Arctic fritillaries), *Erebia discoidalis* (red-disked alpine), and *Lycaena dorcas* (Dorcas copper) are taiga or tundra species that inhabit the Canadian Arctic regions and extend into the U.S. only in the northernmost states and alpine areas of the Rocky Mountains. *Boloria eunomia* (bog fritillary), *Oeneis jutta* (Jutta Arctic) and *Lycaena epixanthe* (bog copper) are boreal species that similarly reach the southern extent of their ranges in the northern Midwest.

Four bog Noctuid moths with little collection history were added to the search list. They have been recently listed as Special Concern species in the state. *Catocala coelebs* (old maid underwing moth) has been recorded from forested bogs in Ashland, Bayfield, and Door counties. *Anarta luteola* is known from seven northern counties, and *Heliothis borealis* (boreal gem) is associated with *Boloria freija, Erebia discoidalis,* and *Anarta luteola* in muskegs as well as jack pine/oak barrens. It is known from Adams, Burnett, Juneau, Oneida, and Price counties. *Exyra fax* (pitcher plant moth) is known from very few occurrences in Bayfield, Langlade and Ozaukee counties.

The Midwestern fen muckmoth, a species of genus *Hemileuca* that occurs in wetlands, was added to the list as it has been found in both the northwestern and southeastern counties of the state. Three sedge skippers, *Poanes viator* (broad-winged skipper), *Poanes massassoit* (mulberry wing) and *Euphyes bimacula* (two-spotted skipper), were included in the search in Southern Ecological Province sites. All these species are currently on the NHI Working List.

<u>*Lepidoptera*</u>

Table 13 lists the populations of target lepidopterans. Pre-peatland study numbers refer to the number of sites where the species was first observed prior to 2004. After 2004, the newly discovered populations are displayed as 2004-2007 peatland sites and 2004-2007 sites from other sources (Figure 15). The latter information is drawn primarily from the LepAlert website (2008) of Michigan Lepidopterists where interested “boggers” are willing to share information and photos of peatland butterflies, and from the season summaries of the Wisconsin Entomological Society Newsletter. Much of the new information on locations of these butterflies and moths can be attributed to Michigan native, Kyle Johnson, whose enthusiasm and graduate research has taken him to peatlands in Michigan, Wisconsin, and Minnesota in the last few years.

Boloria titania remains the least common of the bog-obligate butterflies in Wisconsin. No new sites were found for the species which barely enters the state from the northwest, and occurs at six closely clustered stations in Douglas County. Butterflies were still present at all the known sites, although they were most often found at the roadside nectaring than in the muskeg. Nekola (1998) also recorded this behavior in 1996 when unsuccessful searches were conducted in 37 muskegs in northern Wisconsin.

Two new sites have been added for *Boloria frigga* with three large populations identified in Price County and one in Douglas County. *Boloria freija* has the largest number of sites of the three tundra fritillaries and nine were added during the period of the peatlands project. However, *Boloria eunomia* is the most commonly observed of these bog fritillaries. *B. eunomia* is not confined to muskeg but also can be found in small areas of peat among black spruce stands and at the edges of bog lakes as long as cranberries are present. Three additional sites were added for *Lycaena dorcas*, 20 for *L. epixanthe*, and 24 for *Oeneis jutta*. The latter two species have been removed from Special Concern status in Wisconsin as there are 70 and 72 populations respectively and are commonly found in the right peatland habitat. The peatland project added five new counties for bog copper and three more have been added by others, bringing the total to 22 Wisconsin counties where the butterfly is probably present in healthy peatlands. In addition to the targeted species, K. Johnson searched Wisconsin muskegs in vain for the tundra butterfly, *Erebia mancinus*. He was later successful at finding the species in northern Minnesota (LepAlert 2008).

Table 13. Lepidopteran species targeted by the Peatland Project.

Scientific Name	**Common Name**	**Total**	**Before 2004**	**Peatland Study 2004-07**	**04-07 Other Sources**	**Status**	**S-rank**
Anarta luteola	A Noctuid Moth	8	0	4	4	SC/N	S2S3
Boloria chariclea	Arctic Fritillary	6	6	0	0	SC/N	S1S2
Boloria eunomia	Bog Fritillary	60	49	8	3	SC/N	S3
Boloria freija	Freija Fritillary	27	18	5	4	SC/N	S2S3
Boloria frigga	Frigga Fritillary	13	11	1	1	SC/N	S2
Catocala coelebs	Old-Maid Underwing	2	2	0	0	SC/N	S1S2
Erebia discoidalis	Red-disked Alpine	12	8	2	2	SC/N	S2
Euphyes bimacula	Two-spotted Skipper	17	17	0	1	SC/N	S3
Heliothis borealis	Boreal Gem	2**	0	1	1	SC/N	S2?
Hemileuca sp. 3	Midwest-Fen Buckmoth	10	10	0	0	SC/N	S3
Lycaena dorcas	Dorcas Copper	30	27	1	2	SC/N	S1S2
Lycaena epixanthe	Bog Copper	70	50	16	4	SC/N	S3/S4*
Oeneis jutta	Jutta Arctic	72	48	24	0	SC/N	S3/S4*
Poanes massasoit	Mulberry Wing	56	56	0	0	SC/N	S3
Poanes viator	Broad-winged Skipper	38	37	1	0	SC/N	S3
Exyra fax	Pitcher Plant Moth	3?	3?	0	0	SC/N	S2S3

* No longer tracked by NHI ** sight records only

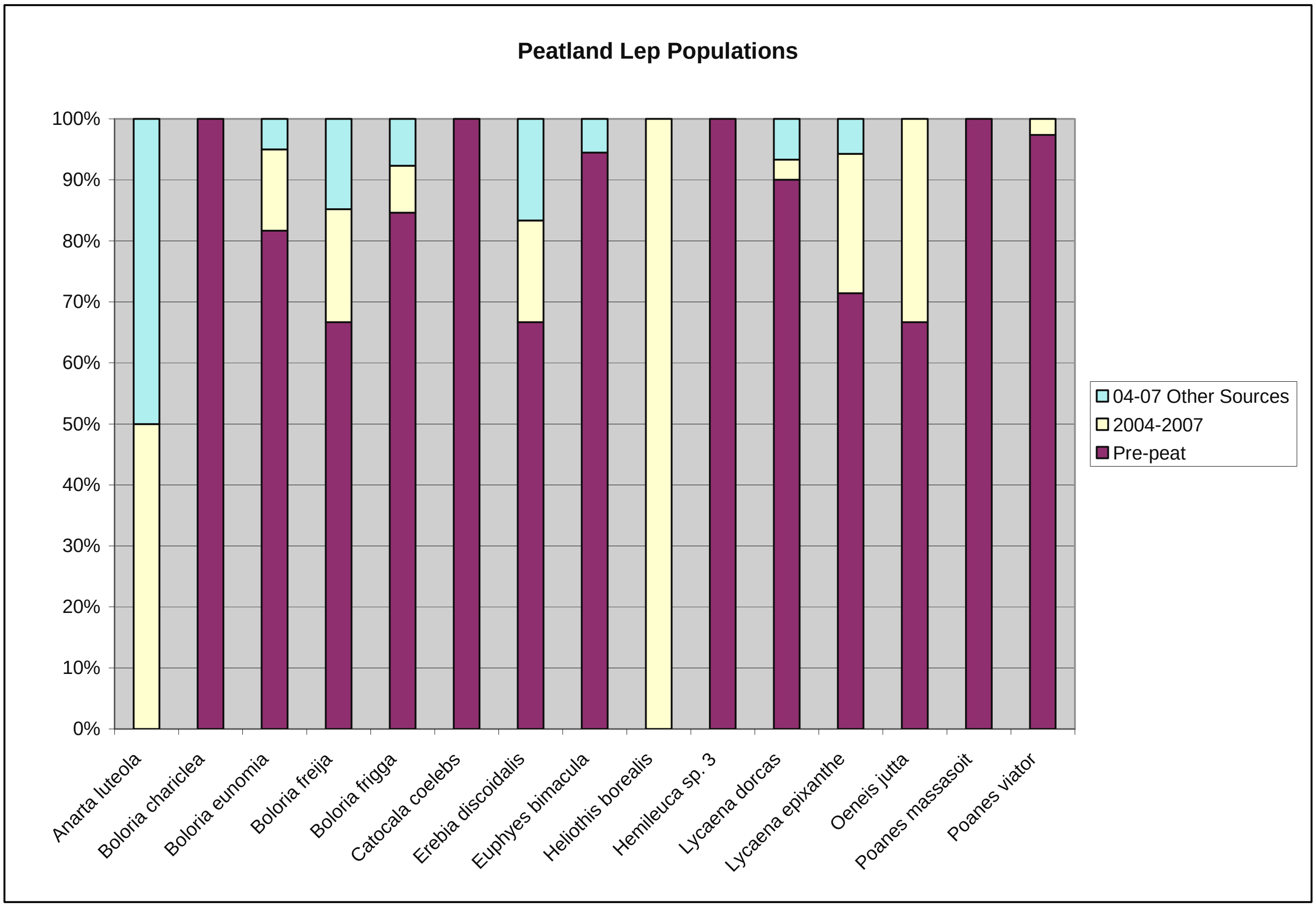


Figure 15. Source of Peatland Lepidoptera Records

Orthoptera

Very little research has included orthoptera in wetland studies. The peatland project was an opportunity to establish some baseline information on what species might be found in peatland habitats and to search for a few species of special concern (Table 14). Figure 16 shows the relative proportion of orthopterans recorded at the various peatland sites.

There are ten species of Wisconsin grasshoppers that might be expected to be found in peatlands in northern Wisconsin and five additional species that are associated with southern sedge habitats. Like the sedge butterflies mentioned above, the latter group was not recorded from the few southern peatlands that were visited during the study. None of the Oedipodinae, or banded-Winged grasshoppers, were found in peatlands as they are primarily species of open country or sandy barrens and beaches. Four Melanoplinae, or spur-throated grasshoppers, could be found in peatlands. All four are denizens of woody vegetation. *Melanoplus islandicus* is found on conifers and *M. punctulatus griseus* on young tamaracks in wet conifer forests. *M. islandicus* was recorded from the heavily wooded bog on Stockton Island, but *M. punctulatus griseus* was not seen. *Melanoplus borealis* and the wingless grasshopper, *Booneacris glacialis* (Podisminae), are found on leatherleaf in bogs. These species were recorded during the study at 12 and 9 sites, respectively, and should be included in the list of fauna of muskeg and shrubby bog.

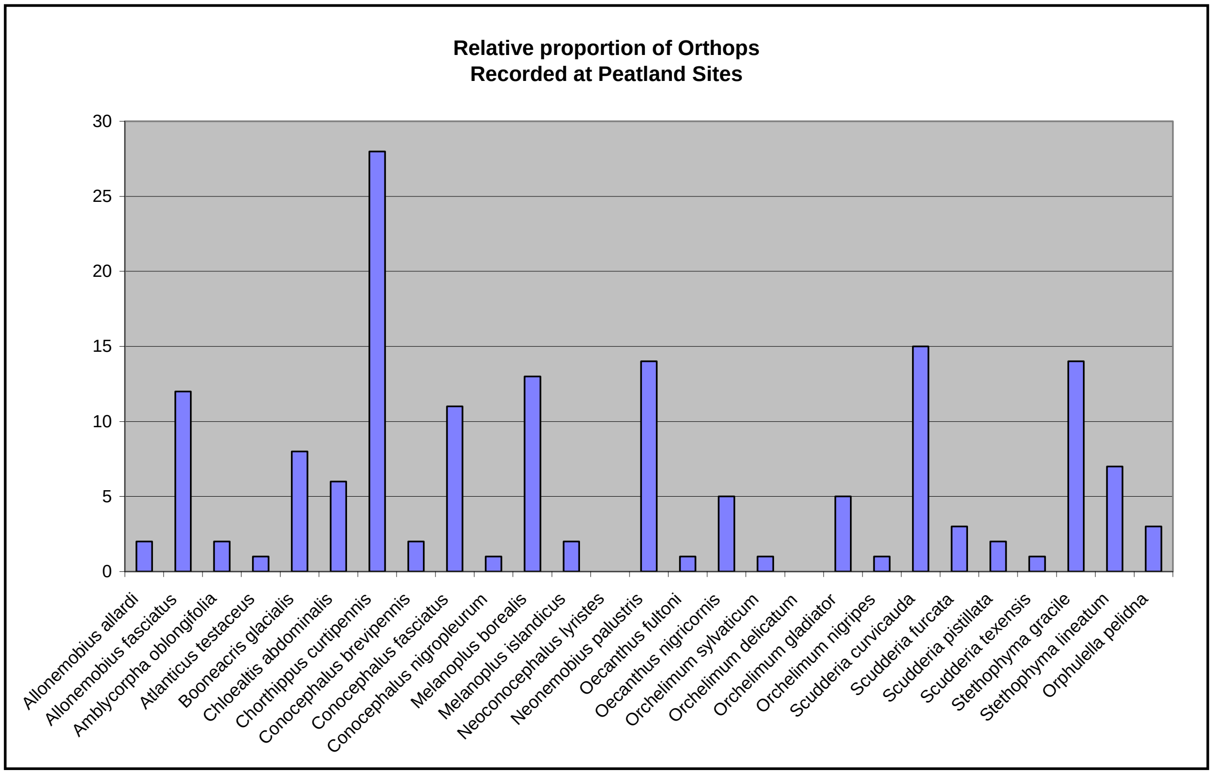
Table 14. Number of sites where orthopterans were recorded from.

Common Name	Species Name	Recorded Sites
Allard's Ground Cricket	*Allonemobius allardi*	2
Striped Ground Cricket	*Allonemobius fasciatus*	12
Oblong-winged Katydid	*Amblycorpha oblongifolia*	2
Short-legged Shield-backed Katydid	*Atlanticus testaceus*	1
Northern Wingless Grasshopper	*Booneacris glacialis*	9
Rocky Mt. Sprinkled Grasshopper	*Chloealtis abdominalis*	6
Marsh Meadow Grasshopper	*Chorthippus curtipennis*	28
Short-winged Meadow Grasshopper	*Conocephalus brevipennis*	2
Slender Meadow Grasshopper	*Conocephalus fasciatus*	11
Black-sided Meadow Katydid	*Conocephalus nigropleurum*	1
Northern Grasshopper	*Melanoplus borealis*	12
Forest Grasshopper	*Melanoplus islandicus*	2
Slender Conehead Katydid	*Neoconocephalus lyristes*	0
Marsh Ground Cricket	*Neonemobius palustris*	14
Snowy Tree Cricket	*Oecanthus fultoni*	1
Black-horned Tree Cricket	*Oecanthus nigricornis*	5
Long-spurred Meadow Katydid	*Orchelimum sylvaticum*	1
Delicate Meadow Katydid	*Orchelimum delicatum*	0
Gladiator Meadow Katydid	*Orchelimum gladiator*	5
Black-legged Meadow Katydid	*Orchelimum nigripes*	1
Curve-tailed Bush Katydid	*Scudderia curvicauda*	15
Fork-tailed Bush Katydid	*Scudderia furcata*	3
Broad-winged Bush Katydid	*Scudderia pistillata*	2
Texas Bush Katydid	*Scudderia texensis*	1
Northern Sedge Grasshopper	*Stethophyma gracile*	14
Striped Sedge Grasshopper	*Stethophyma lineatum*	7
Spotted-winged Grasshopper	*Orphulella pelidna*	2

Bold = peatland project target species

Note: A total of 43 sites visited had Orthopterans recorded from them

Figure 16. The relative proportion of orthopterans recorded at peatland sites.



Six other species are slant-faced grasshoppers (Gomphocerinae), a group that lives in grassy habitats of prairie, sand barrens, and upland meadows. *Chorthippus curtipennis* is one of the most common grasshoppers in the state and can be found in almost any wetland. *Pseudopomala brachyptera* is typically found in dry prairies and forest edges in Wisconsin but is known from wetlands in other states (Cantrall 1968, Vicsnakery and Snakevan 1985). In this project the species was discovered in a sedge meadow area at the edge of a tamarack bog in Jackson County. *Orphulella pelidna*, a fairly uncommon species, was found further into the same wetland but still outside the peat habitat. *Stethophyma gracile* and *S. lineatum* are sedge grasshoppers (Acridinae) that were known from five and four sites, respectively, in Wisconsin prior to the peatlands project. *S. lineatum* was discovered first at Thomas Wet Prairie in Iowa County in 1992 and *S. gracile* was not reported until 10 years later. As a result of this research, one or both grasshoppers can be expected to be found in most high-quality open peat habitats in the northern portion of the state where they feed on sedges. *S. lineatum* appears to range further south in the Midwest and was found in Waukesha County during this study.

Perhaps the most surprising find was a grasshopper that has been tentatively identified as *Chloealtis abdominalis*, a northern species that is reported from wood margins and forest openings. It occurs across Canada and south into the Rocky Mountains where it exists, like many boreal species, in high elevation wetlands (Otte 1981). It occurs in upper Michigan, northern Minnesota, and southeastern Ontario. It was previously reported from jack pine barrens in Wisconsin but was found on tamarack trees in northern wet forests at six sites in the peatlands study.

The ground crickets in the Gryllidae subfamily Nemobiinae are tiny species that less than about 10.3mm (less than ½ inch) in length. In sphagnum mats they can be heard but not seen, especially the 6.4 mm (¼ inch) sphagnum ground cricket, *Neonemobius palustris*, which was recorded at 14 sites in seven counties, thus establishing its position in the fauna of Wisconsin. The striped ground cricket, *Allonemobius fasciatus*, is common in wetlands across the U.S. and southern Canada and was found at 12 sites. *A. allardi* was identified by call at two sites in Lincoln and Oneida counties.

None of the meadow katydids (Conocephalinae) are specifically associated with peatlands and so were not targeted in the study. However, records of katydids in Wisconsin wetlands are rarely collected so the information is valuable to orthopterists. Three species of *Conocephalus* were encountered. *C. fasciatus* was found at 11 sites, *C. brevipennis* at two sites, and *C. nigropleurum* at a single site.

Orchelimum sylvaticum was tentatively identified by call from a site in central Wisconsin. The website, Singing Insects of North America (Walker and Moore 2008), does not indicate that the species has been found in Wisconsin. *O. gladiator* was found at five sites and appears to be amenable to life in shrubby *Chaemodaphne*-dominant bog habitats in contrast to its congenerics that are typically found in grasses at the edge of wetlands. *O. nigripes* was found at one site. *O. delicatum,* which is a Special Concern species, was not found at the peatland sites.

Of the bush katydids (Phaneropterinae), *Scudderia curvicauda* was a commonly encountered in bogs and shrubby sites. *S. texensis* was encountered at one southern peatland site, and *S. pistillata* was recorded by call in Douglas County and vouchered in Ashland County. *S. furcata* was found at three shrubby peatland sites in central Wisconsin. Although shield-back katydids (Tettigoniinae) are a highly diverse group in North America, only one species is native to Wisconsin. *Atlanticus testaceus* was encountered early in the study singing from a three-foot tall black spruce tree at Kidrick Swamp in Taylor County. The final target species was the slender coneheaded katydid, *Neoconocephalus lyristes*, known from bogs in northern Illinois, Ohio, and southern Michigan and Ontario. The species was not found in any of the southern sites.

Aquatic Invertebrates

Thirty-one sites in the Northern Ecological Province and twenty-seven Southern Province sites were systematically sampled for aquatic invertebrates by dip net or bottle trap and may or may not have additionally been searched for flying adult odonates. In both provinces the average number of target species found was five at a site. The maximum number found at a single site was ten species at Site 222-433 in Jackson County (Figure 17). Nine target species were found at Site 212-487 in Douglas County in the Northern Province (Figure 18). Total biological diversity at a site does not appear to correlate with the presence of target species on a site by site basis. Site 212-487 was reported to have 17 aquatic species via the sampling methods used during the study. Several other northern sites had three times that number. On average, those sites where six or more target species were found, had greater aquatic diversity (average 30.25 species) than the same number of sites where less than four target species were found (average 20.38 species). Biologists reported community types of the most productive sites for target species as predominantly open bog or muskeg. As shrub-carr, sedge meadow, or marsh were reported with or without open bog, the number dropped for target species found. The overall aquatic diversity also dropped presumably because sampling remained focused on the open peatland areas where target species were expected to be present.

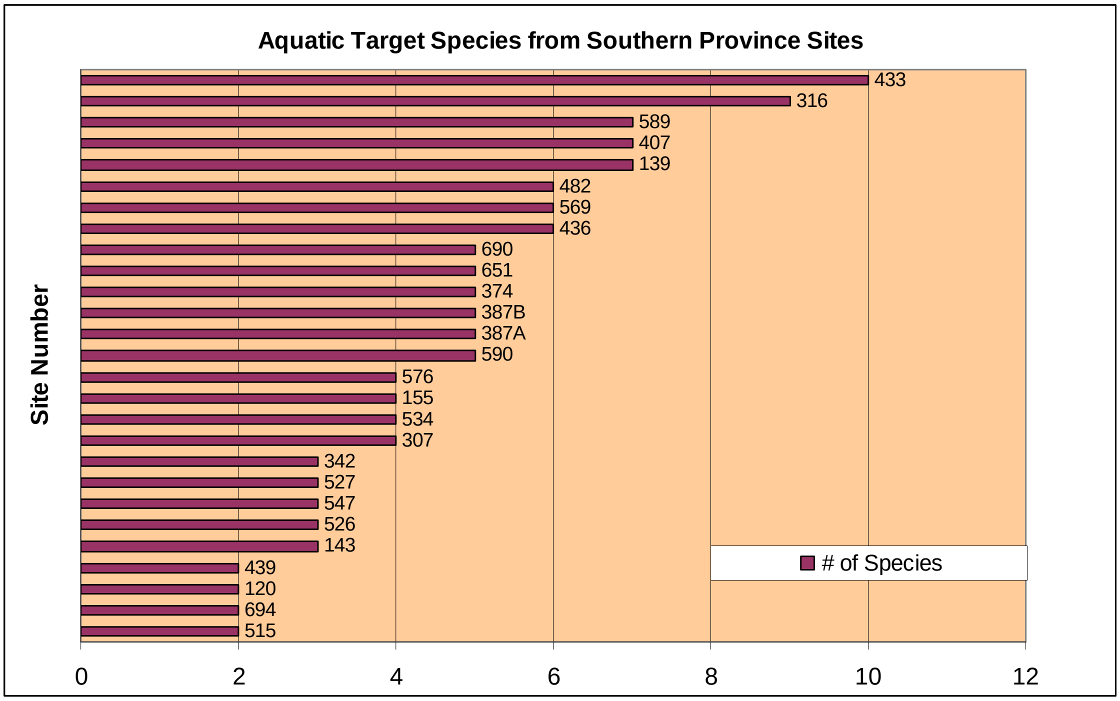


Figure 17. Number of targeted aquatic invertebrates found at individual Southern Province sites.

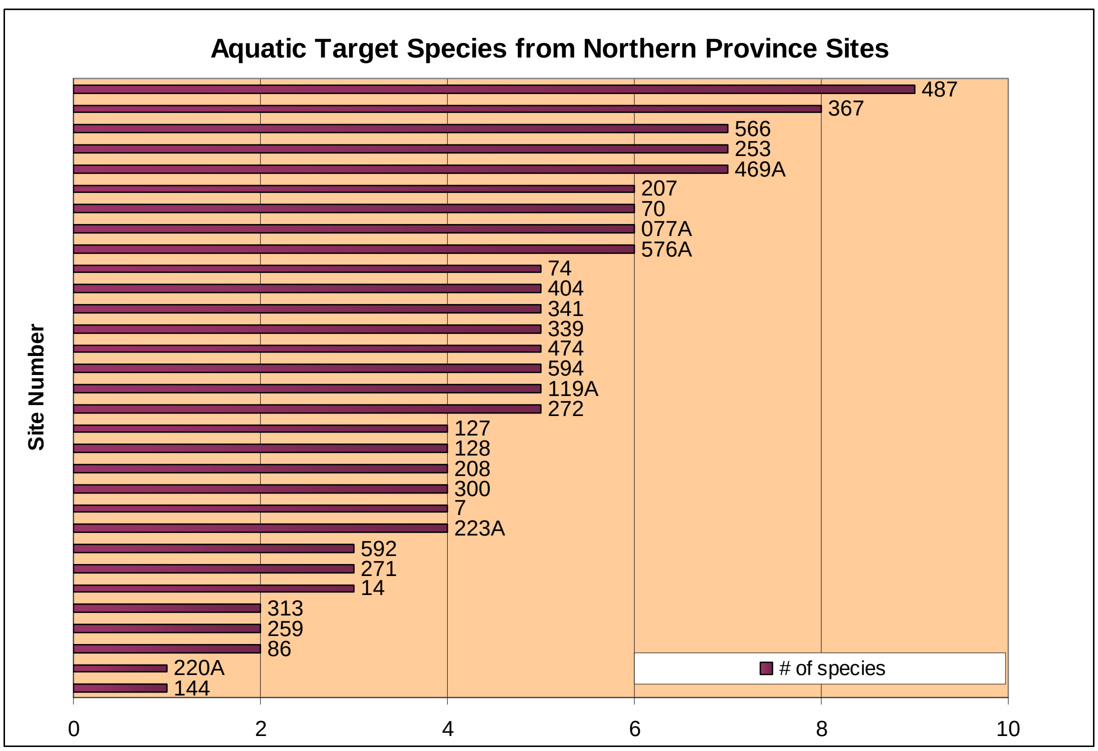


Figure 18. Number of targeted aquatic species found at individual Northern Province sites.

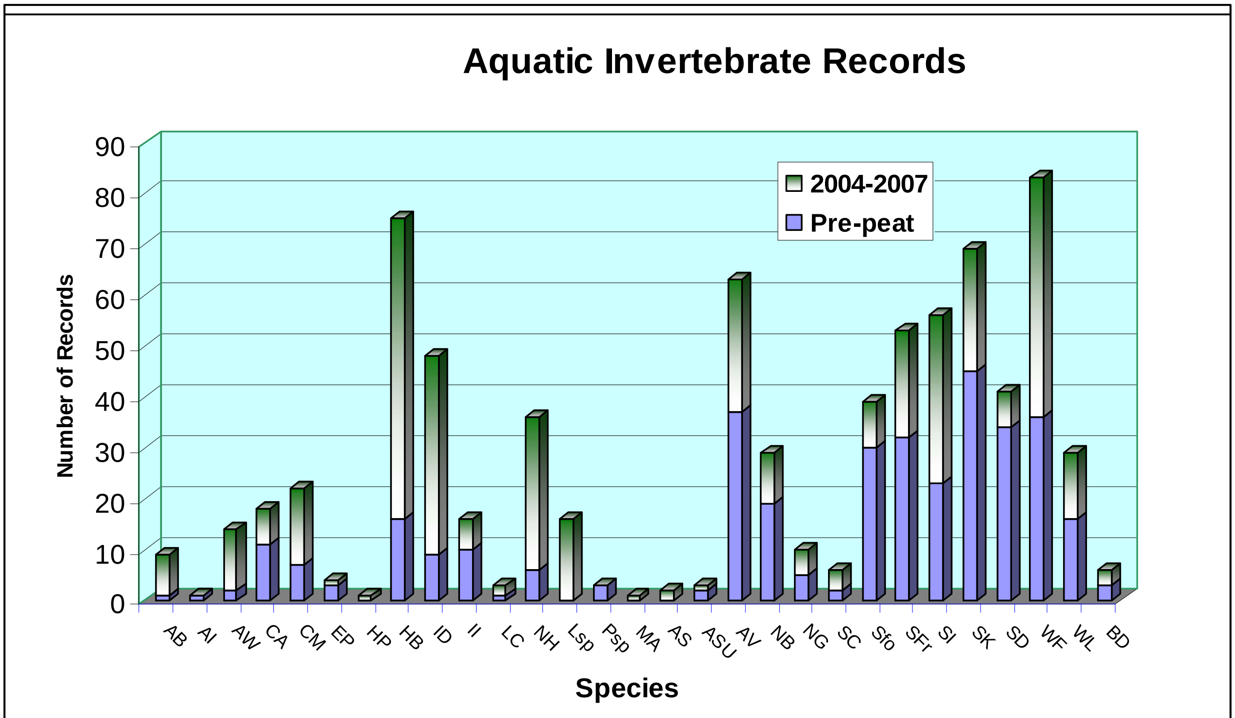
The Peatlands Project allowed Natural Heritage biologists to greatly increase the information on aquatic invertebrates in peatland habitats in Wisconsin. Twenty-nine species of Special Concern were targeted for intensive search (Table 15). One predaceous diving beetle, *Agabus inscriptus*, and one crane fly of the genus *Phalacrocera* were not encountered during the study. However, four other insects were recorded for the first time.

Table 15. Aquatic species that had survey emphasis 2004-2007.

Species Name		Common Name	Total	Pre-peat	2004-2007	Peat% of Total	Status	S-rank
		Coleoptera						
Agabus bicolor	*AB*	A Predaceous Diving Beetle	9	1	8	89	S3	SC/N
Agabus inscriptus	*AI*	A Predaceous Diving Beetle	1	1	0	0	S2/S3	SC/N
Agabus wasastjernae	*AW*	A Predaceous Diving Beetle	14	2	12	86	S2?	SC/N
Cymbiodyta acuminate	*CA*	A Water Scavenger Beetle	18	11	7	39	S3	SC/N
Cymbiodyta minima	*CM*	A Water Scavenger Beetle	22	7	15	68	S3	SC/N
Enochrus perplexus	*EP*	A Water Scavenger Beetle	4	3	1	25	S2?	SC/N
Hydrocolus persimilis	*HP*	A Predaceous Diving Beetle	1	0	1	100	SNR	SC/N
Hydroporus badiellus	*HB*	A Predaceous Diving Beetle	75	16	59	79	S3?	SC/N
Ilybius discedens	*ID*	A Predaceous Diving Beetle	48	9	39	81	S3	SC/N
Ilybius ignarus	*II*	A Predaceous Diving Beetle	16	10	6	38	S3	SC/N
Liodessus cantralli	*LC*	Cantrall's Bog Beetle	3	1	2	67	SU	SC/N
Neoscutopterus hornii	*NH*	A Predaceous Diving Beetle	36	6	30	83	S1/S3	SC/N
		Diptera						
Lasiodiamesa _sp	*Lsp*	A Midge	16	0	16	100		SC/N
Phalacrocera _sp.	*Psp*	A Crane Fly	3	3	0	0		
		Heteroptera						
Microvelia albonotata	*MA*	Broad-shouldered Water Strider	1	0	1	100	SU	SC/N
		Odonata						
Aeshna sitchensis	*AS*	Zigzag Darner	2	0	2	100	S1	SC/N
Aeshna subarctica	*ASu*	Subarctic Darner	3	2	1	33	S1	SC/N
Aeshna verticalis	*AV*	Green-striped Darner	63	37	26	41	S3	
Nannothemis bella	*NB*	Elfin Skimmer	29	19	10	35	S2/S3	SC/N
Nehalennia gracilis	*NG*	Sphagnum Sprite	10	5	5	50	S2/S3	SC/N
Somatochlora cingulata	*SC*	Lake Emerald	6	2	4	67	S1	SC/N
Somatochlora forcipata	*SFo*	Forcipate Emerald	39	30	9	23	S2	SC/N
Somatochlora franklini	*SFr*	Delicate Emerald	53	32	21	40	S2S3	SC/N
Somatochlora incurvata	*SI*	Warpaint Emerald	56	23	33	59	S2	END
Somatochlora kennedyi	*SK*	Kennedy's Emerald	69	45	24	35	S3	
Sympetrum danae	*SD*	Black Meadowhawk	41	34	7	17	S3	SC/N
Williamsonia fletcheri	*WF*	Ebony Bog Haunter	83	36	47	57	S3S4	SC/N
Williamsonia lintneri	*WL*	Ringed Boghaunter	29	16	13	45	S2	SC/N
		Trichoptera						
Banksiola dossuaria	*BD*	Giant Casemaker Caddisfly	6	3	3	33	SU	SC/N

The targeted aquatic beetles were found at many more sites than previously known (Figure 19). Of the predaceous diving beetles of concern, *Hydroporus badiellus,* a Wide-ranging boreal species (Larson, 1997), was the most commonly encountered species and the second most common was *Ilybius discedens.* Previously known from 16 and 9 sites, respectively, the beetles are now known to occur at 75 and 48 sites. *Cymbiodyta minima* was known from only 7 sites and now can be counted from 22 sites; *Cymbiodyta acuminate* from 11 and now known from 18;

Figure 19. Number of aquatic beetles records, before 2004 and from 2004-2007.



Ilybius ignarus from 10 and now known from 16 sites. *Agabus wasastjernae* and *Neoscutopterus hornii* are predaceous diving beetles for which the study produced a six-fold increase in known sites. The latter species, living exclusively in cold moss, now appears to be more secure in the state than previously thought since it can be found at three dozen sites instead of only six. *Agabus bicolor*, another boreal species found in bog pools, is now known from nine sites instead of only a single site.

The least commonly encountered beetles were those for which little information was available prior to the study. *Enochrus perplexus* is a water scavenger beetle that was only known from three sites and found at just one additional location. Cantrall's bog beetle, *Liodessus cantralli*, which was located previously at a single bog in Outagamie County, is a tiny beetle only 2 mm in length. It is now known from an additional two sites in Monroe and Marquette counties. The relatively robust beetle (up to 4mm), *Hydrocolus persimilis*, lives in cold moss and has been found for the first time in Wisconsin in a large muskeg in Price County.

Previously unknown from Wisconsin is a midge of the genus *Lasiodiamesa*. It was discovered at 16 sites. *Microvelia albonotata* is a broad-shouldered water strider of the family Veliidae. It is so rarely encountered that very little information is available on the species. The insect was found for the first time during the peatland study at a site with several small bog lakes in Forest County.

Odonata that were targeted for study were three mosaic darners (*Aeshna* species), five of the striped emeralds (*Somatochlora* species), and both *Williamsonia* species, the boghaunters. Also included were two members of the skimmer family, *Nannothemis bella,* the elfin skimmer which is the smallest dragonfly in the state, and the black meadowhawk, *Sympetrum danae.* The single damselfly targeted was the sphagnum sprite, *Nehalennia gracilis,* whose name suggests the close ties this insect has With a bog habitat. Indeed, it is confined to the peaty margins around bog ponds (DuBois 2005). It had been known from five sites in four counties and this study doubled that number to ten sites in seven counties.

Aeshna sitchensis: The zig-zag darner was added to the state fauna in 2004 when a population was discovered in a peatland on the Apostle Islands by Robert DuBois (2006). An adult was later found in Douglas County in non-breeding habitat. This species was subsequently added to the NHI Working list with a status of S1 and of state Special Concern. This species is considered a far northern taxon, and in the U.S. is limited to the northern tier of states. It is usually found in evenly vegetated sedge and sedge/moss fens in which open water is often restricted to very small, shallow puddles, often With algal mats (Cannings and Cannings 1994). This describes very well the site of the breeding population in Wisconsin. This same site also supported a large population of the state endangered peatland obligate *Somatochlora incurvata*.

Aeshna subarctica: The subarctic darner was first discovered in Wisconsin in 1998 by Robert DuBois in Douglas County in a huge peatland complex. One additional site was discovered in Price County in 2005, also in a peatland. A circumboreal species typically found in the far north (Needham, Westfall, and May 2000), these Wisconsin populations are at the extreme south edge of its range. Cannings and Cannings (1994) report that this species is restricted to deep fens dominated by moss and to sphagnum bogs.

Aeshna verticalis: The green-striped darner has been known from the state since 1907. Apparently restricted to wetlands with limited water this species is fairly frequent in open peatlands. Most populations are in the far northern part of the state with good representation in the central counties. Also scattered records occur in the southeast. As a result of this project and the discovery of many additional populations, this species was removed as a species of Special Concern in Wisconsin.

Nannothemis bella: Known populations of the elfin skimmer increased from 19 sites to 29 sites as a result of the peatlands project. Most sites are in the northern third of the state with very few in the south. Habitat typically consists of tiny shallow bog pools fringing larger bog Lakes. These peatlands typically have high alkalinity. This project added 5 counties including Walworth in the southeast.

Sympetrum danae: The black meadowhawk is another circumboreal species frequently found in peatlands as well as a variety of fens and marshes. This project located very few populations of this species.

Somatochlora kennedyi: Kennedy's emerald has a southern boreal distribution with its U.S. distribution limited to the Great Lakes region and New England (Cannings and Cannings 1994). Habitats range from sedge/rush fens to deep sedge/moss marsh. This study significantly increased the number of known populations in Wisconsin, especially in the central part of the state.

S. incurvata: The incurvata emerald is a Wisconsin Endangered species with a strong preference for the poor fens in central Wisconsin. This species ranges from the western Great Lakes east to Massachusetts and north to Maine. This study more than doubled the number of known sites (23 to 56) and added 6 counties to its known Wisconsin distribution. Also as a result of this study the previously unknown immature stage was discovered, and a description was written and published (Steffens and Smith 2007).

S. cingulata: The lake emerald is a far northern species at its extreme southern edge of its distribution in Wisconsin. While Cannings and Cannings (1995) list it as a peatland species, they acknowledge a wide range of habitats. All Wisconsin populations are in deep cool lakes in the northeast part of the state and apparently this species does not utilize peatlands this far south in its boreal range. This study located one new population.

S. forcipata: The forcipate emerald is a boreal species of central and eastern Canada, the northern Great Lakes, and New England. Immatures are very difficult to identify and some records may include the incurvata emerald. Breeding habitats range from boggy spring-fed streams, bog pools, and alder swamps. This emerald apparently is not restricted to open peatlands and may not have been detected as frequently as it occurs. Nonetheless, this study increased the number of known sites (30 to 39) and added 5 counties.

S. franklini: The delicate emerald is another *Somatochlora* having a boreal distribution with Wisconsin at the southern edge of its range. In Wisconsin there are three centers of distribution: the central counties, the extreme northeastern counties, and the extreme northwestern counties. This study increased the number of known populations from 32 to 53 and added four counties. The habitat is a variety of wetlands with mosses and low graminoids dominating (Cannings and Cannings 1995).

Williamsonia fletcheri: The ebony boghaunter is a tiny, early-flying emerald considered very rare at the onset of this study. The northern Great Lakes and New England comprise the entire range of this peatland obligate. This study more than doubled the number of known populations (36 sites to 83) and added 9 counties, including Wood and Monroe in the Southern Province. As a result of this study the ebony boghaunter was removed from as Special Concern list. Wisconsin habitats include poor fens in the central counties, coastal fens along Lake Superior, and moats around kettle bog lakes.

Williamsonia lintneri: The ringed boghaunter was not known from the state until 1994. Prior to then, the known distribution was extremely limited to northeastern U.S. bogs and fens. Wisconsin sites are limited to poor fens in the central counties where it is typically found with *W. fletcheri* and *S. incurvata*. This study increased the number of known sites from 16 to 29, but only added one new county. This species is still considered amongst the rarer of the peatland obligates.

Secretive Marsh Birds, Frogs, and Toads

The most commonly documented secretive marsh bird was the American bittern (17 sites between 2005-2007, Table 16). The next most commonly found species was the Yellow Rail at 14 sites. Nelson's Sharp-tailed Sparrow was the least documented and was only found at 4 out of 69 sites that were surveyed. While all of the target marsh bird species where found at one or more sites, other uncommon species were also documented at several sites (Table 16).

Rare frog and toad species were documented at a relatively low rate, with the most common being mink frogs (Table 16). Pickerel frogs were only recorded at one site over the course of three survey years.

Habitat quality and extent varies at each site, and there may be microhabitat differences that could account for the lack of one or more species at individual sites. All of the target marsh bird species appear to have a need for large blocks of habitat and may be sensitive to factors like site use and the succession of shrubs and trees into open communities like sedge meadows and poor fens. Based on Breeding Bird Survey data, the American bittern appears to be in decline in Wisconsin (http://www.wisconsinbirds.org/plan/species/ambi.htm), especially in southern Wisconsin. If climate change promotes the growth of woody vegetation, the spread of invasive plant species like cattails and reed canary grass, or alters the hydrology of individual wetlands, the target species may decline more. Climate change may also affect mink frogs and pickerel frogs as well. Tadpoles of species such as green frogs have a higher tolerance to warmer water and may displace mink frog tadpoles that cannot tolerate those warmer temperatures.

Table 16. Number of sites where rare marsh birds, frogs, and toads were found 2005-2007.

	Number of Sites			
Species/Year	*2005*	*2006*	*2007*	*Total*
Yellow Rail	*10*	*1*	*3*	*14*
American Bittern	*10*	*4*	*3*	*17*
Le Conte's Sparrow	*7*	*several*	*2*	*9+*
Nelson's Sharp-tailed Sparrow	*1*	*1*	*2*	*4*
Least Bittern	*0*	*0*	*2*	*2*
King Rail	*0*	*0*	*1*	*1*
Red-necked Grebe	*0*	*0*	*1*	*1*
Bullfrog	*0*	*1*	*1*	*2*
Mink Frog	*0*	*5*	*3*	*8*
Pickerel Frog	*0*	*0*	*1*	*1*

Rare Plants

Results

The botany crew surveyed all 13 Intensive Sites, several of them multiple times between 2004 and 2007. They also surveyed 211 Extensive Sites, 140 in the Northern Ecological Province and 71 in the southern province. Each Extensive Site was surveyed at least twice in a given field season. Botanists found populations of 50 different rare species (Table 17) totaling 283 rare plant occurrences at 128 sites; 178 of those were populations not previously known to exist.

During the project we also received reports of populations of these 50 species from some of our collaborators and other sources. For example, we received 17 new or updated reports for *Arethusa bulbosa* between 2004 and 2007. While these reports did not originate from our project, they help increase our understanding of certain rare plant species in Wisconsin.

When the results of our surveys are combined with contributions from our collaborators, about 30% of the rare plant species had a significant proportion of their records (20% or more) documented between 2004 and 2007 (Figure 20).

The vast majority of rare plant discoveries were peatland-associated species, but several (*Goodyera oblongifolia*, *Platanthera orbiculata*, *Deschampsia flexuosa*, and *Aster furcatus*) were upland species found while transiting to or from a project site.

Of the 50 species documented, four are listed as state Endangered, 9 as state Threatened, and 37 as Special Concern. One of the state Endangered species, *Platanthera leucophaea*, is also listed as Threatened by the federal government. The status of the individual species can be found in Table 17.

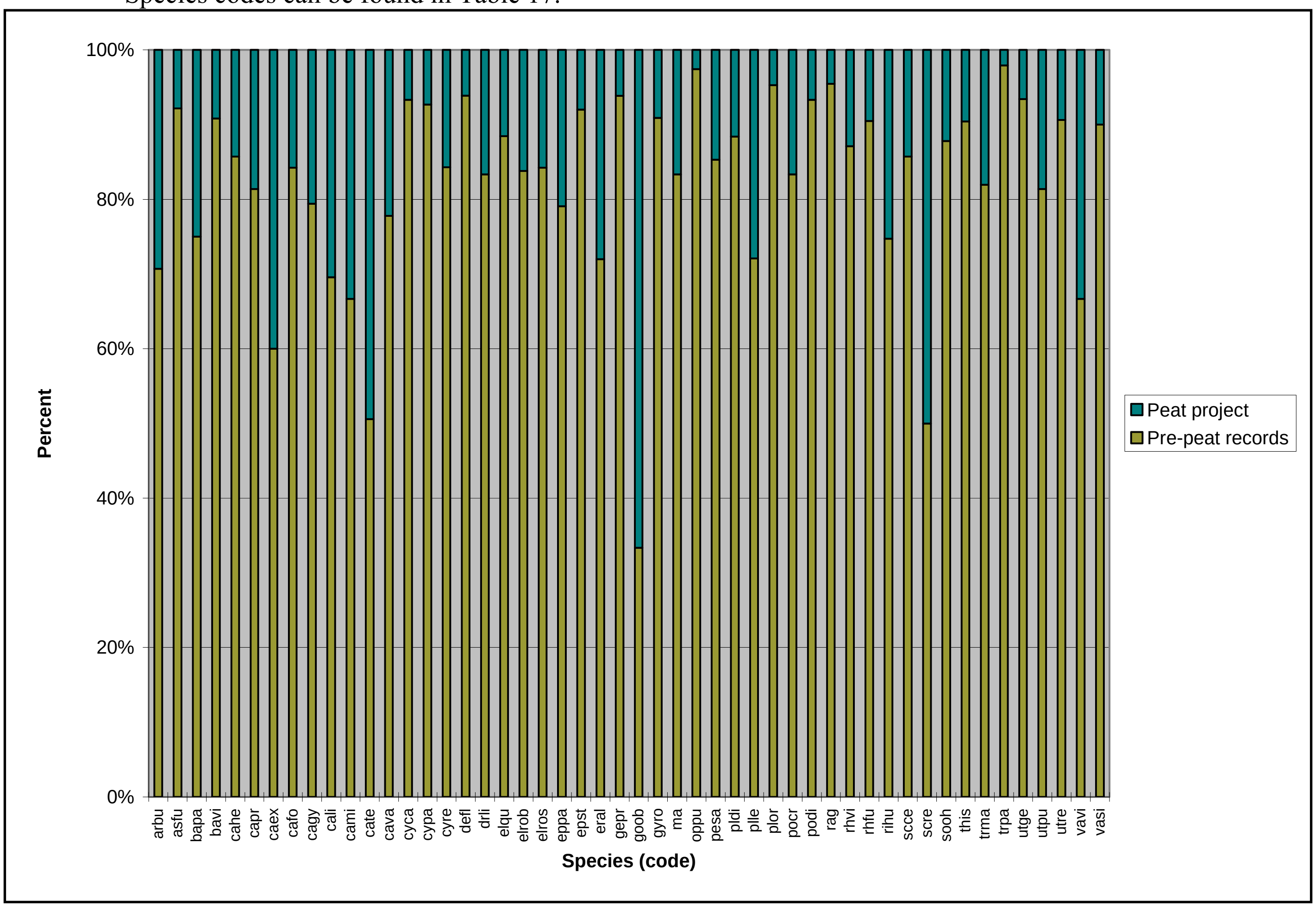
Table 17. Rare plant species found at one or more sites, 2004-2007.

Scientific Name	Species Code	Common Name	Status	S-rank
Ranunculus gmelinii	ragm	Small yellow water crowfoot	E	S2
Scleria reticularis	scre	Reticulated nutrush	E	S1
Vaccinium vitis-idaea ssp. *minus*	vavi	Mountain cranberry	E	S1
Platanthera leucophaea	plle	Prairie white-fringed orchid	E/LT	S2
Aster furcatus	asfu	Forked aster	T	S3
Carex exilis	caex	Coast sedge	T	S1
Carex michauxiana	cami	Michaux sedge	T	S2
Cypripedium candidum	cyca	Small white lady's-slipper	T	S3
Drosera linearis	drli	Slenderleaf sundew	T	S1
Eleocharis rostellata	elros	Beaked spikerush	T	S2
Petasites sagittatus	pesa	Arrow-leaved sweet-coltsfoot	T	S3
Scirpus cespitosus	scce	Tufted bulrush	T	S2
Valeriana sitchensis ssp. *uliginosa*	vasi	Marsh valerian	T	S2
Arethusa bulbosa	arbu	Swamp-pink	SC	S3
Bartonia paniculata	bapa	Twining screwstem	SC	S1
Bartonia virginica	bavi	Yellow screwstem	SC	S3
Callitriche hermaphroditica	cahe	Autumnal water-starwort	SC	S2
Cardamine pratensis	capr	Cuckooflower	SC	S3
Carex folliculata	cafo	Long sedge	SC	S3
Carex gynocrates	cagy	Northern bog sedge	SC	S3
Carex livida var. *radicaulis*	cali	Livid sedge	SC	S2
Carex tenuiflora	cate	Sparse-flowered sedge	SC	S3
Carex vaginata	cava	Sheathed sedge	SC	S3
Cypripedium parviflorum var. *makasin*	cypa	Northern yellow lady's-slipper	SC	S3
Cypripedium reginae	cyre	Showy lady's-slipper	SC	S3
Deschampsia flexuosa	defl	Crinkled hairgrass	SC	S3
Eleocharis quinqueflora	elqu	Few-flowered spikerush	SC	S2
Eleocharis robbinsii	elrob	Robbins' spikerush	SC	S3
Epilobium palustre	eppa	Marsh willow-herb	SC	S3
Epilobium strictum	epst	Downy willow-herb	SC	S2S3
Eriophorum alpinum	eral	Alpine cotton-grass	SC	S2
Gentianopsis procera	gepr	Lesser fringed orchid	SC	S3
Goodyera oblongifolia	goob	Giant rattlesnake-plantain	SC	S1
Gymnocarpium robertianum	gyro	Limestone oak fern	SC	S2
Malaxis monophyllos var. *brachypoda*	mamo	White adder's-mouth	SC	S3
Ophioglossum pusillum	oppu	Adder's-tongue	SC	S2
Platanthera dilatata	pldi	Leafy white orchis	SC	S3
Platanthera orbiculata	plor	Large roundleaf orchid	SC	S3
Polygala cruciata	pocr	Crossleaf milkwort	SC	S3
Potamogeton diversifolius	podi	Water-thread pondweed	SC	S2
Rhexia virginica	rhvi	Virginia meadow-beauty	SC	S3
Rhynchospora fusca	rhfu	Brown beakrush	SC	S2

Scientific Name	Species Code	Common Name	Status	S-rank
Ribes hudsonianum	rihu	Northern black current	SC	S3
Solidago ohioensis	sooh	Ohio goldenrod	SC	S3
Thelypteris simulata	this	Bog fern	SC	S3
Triglochin maritima	trma	Common bog arrow-grass	SC	S3
Triglochin palustris	trpa	Slender bog arrow-grass	SC	S3
Utricularia geminiscapa	utge	Hidden-fruited bladderwort	SC	S3
Utricularia purpurea	utpu	Purple bladderwort	SC	S3
Utricularia resupinata	utre	Northeastern bladderwort	SC	S3

E= state Endangered, T=state Threatened, state SC= Special Concern, LT=listed as Threatened by the federal government.

Figure 20. Proportion of records of the 50 rare species documented between 2004 and 2007. Species codes can be found in Table 17.



Discussion

The geographic breadth and intensity of this baseline study resulted in acquiring significant amounts of information about rare plants associated with peatlands in Wisconsin. Not only were we able to augment our knowledge about distribution of these 50 species (Table 17), we also learned more about the ecology of these plants.

When we examine the spatial distribution and ecology of populations of these species, it can be helpful to observe what contributions this project made. Some species show a wider, to varying degrees, range than we had previously documented. *Platanthera leucophaea*, listed as Endangered by Wisconsin and federally Threatened, was found in a new county (Green Lake) and somewhat expanded the known extant range of this plant in the state. This new population further north and west of the remainder of existing populations. While the habitat was somewhat atypical compared to other populations in the state, the orchid had been found in that type of habitat previously. New populations for the state Endangered *Vaccinium vitis-idaea* (Figure 21) also increased the known range for this cranberry-relative in Wisconsin, with new populations to the south of most of the populations. An interesting aspect of the new *V. vitis-idaea* populations is that two of the three new locations occur within the same county (Sawyer), although at opposite ends of the county. Perhaps as importantly, our comprehension of the habitat that is suitable for this species in Wisconsin is somewhat broader than before our project, with one of the sites (Douglas County) being more similar to habitat that the species occurs in further to north in Canada.

In contrast to some of these rare plants with range expansion, other species that are very rare in the state had new occurrences close to known populations. For example, *Scleria reticularis*, a state Endangered nutrush, has a very limited range in Wisconsin, having only been found in the Central Sand Plains landscape (Figure 22). While one population was found, it was within about two miles of already known populations, and the habitat and associated species were similar.

For other species there appears to be a fairly large range expansion. The known Wisconsin range of *Eriophorum alpinum* appears to have expanded quite a bit, primarily toward the west and somewhat toward the south. However, this apparent expansion may, in fact, be somewhat of a relict; this cotton-grass was only recently added to the NHI working list as Special Concern and there may be additional records we haven't recovered yet from natural community plant species lists and other sources.

For many of the species we did document, we found relatively few new populations or made few updates to known locations. However, as mentioned in the Results, for about 30% of the rare plant species a significant proportion of their records (20% or more) were either new discoveries or known occurrences that were updated during the project period (Figure 20). The proportion can be somewhat misleading however. For some species, like *Goodyera oblongifolia* and *Vaccinium vitis-idaea*, there were few populations known before the project. Hence, even the addition of only a couple of populations can weigh heavily. Five species have 40 or more records in the NHI database, and new populations or updates make up a considerable portion of the total records. Other species have a larger number of records already known. Almost 50% of the *Carex tenuiflora* records were either new or updates between 2004 and 2007. Many of the new populations came from the northwestern part of the state, with a large concentration from Douglas County.

Between 2004 and 2007, we documented a number of significant rare plant populations, including populations of four species listed as state Endangered (*Platanthera leucophaea*, *Ranunuculus gmelinii*, *Scleria reticularis*, and *Vaccinium vitis-idaea* spp *minus*), nine species listed as Threatened (e.g., *Carex exilis*, *Drosera linearis*, and *Scirpus cespitosus*), two species that are Special Concern with an S1 rank (*Bartonia paniculata* and *Goodyear oblongifolia*), and eight species that are S2-ransnaked Special Concern, including *Eriophorum alpinum* and *Rhynchospora fusca*.

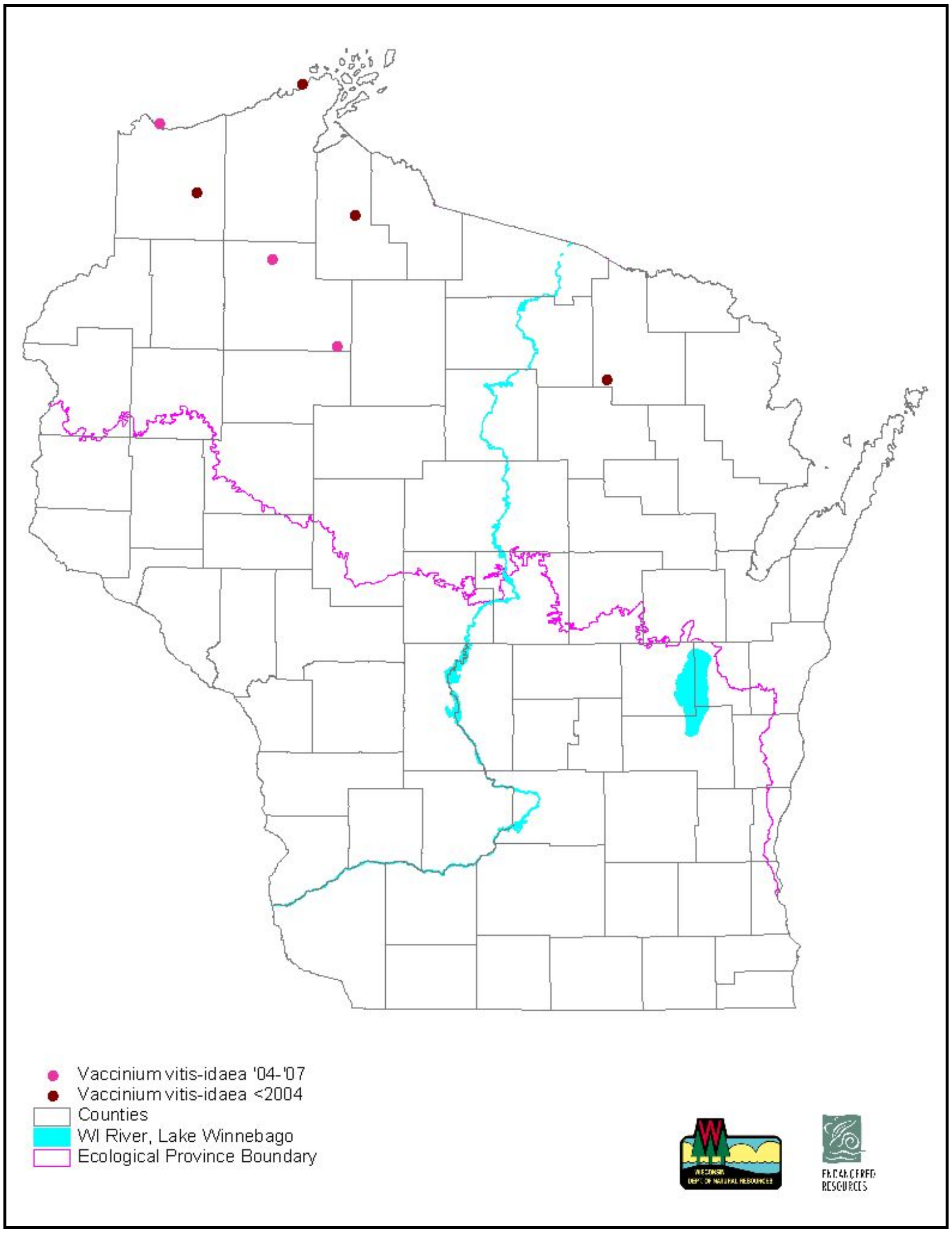


Figure 21. *Vaccinium vitis-idaea* distribution, before 2004 and currently.

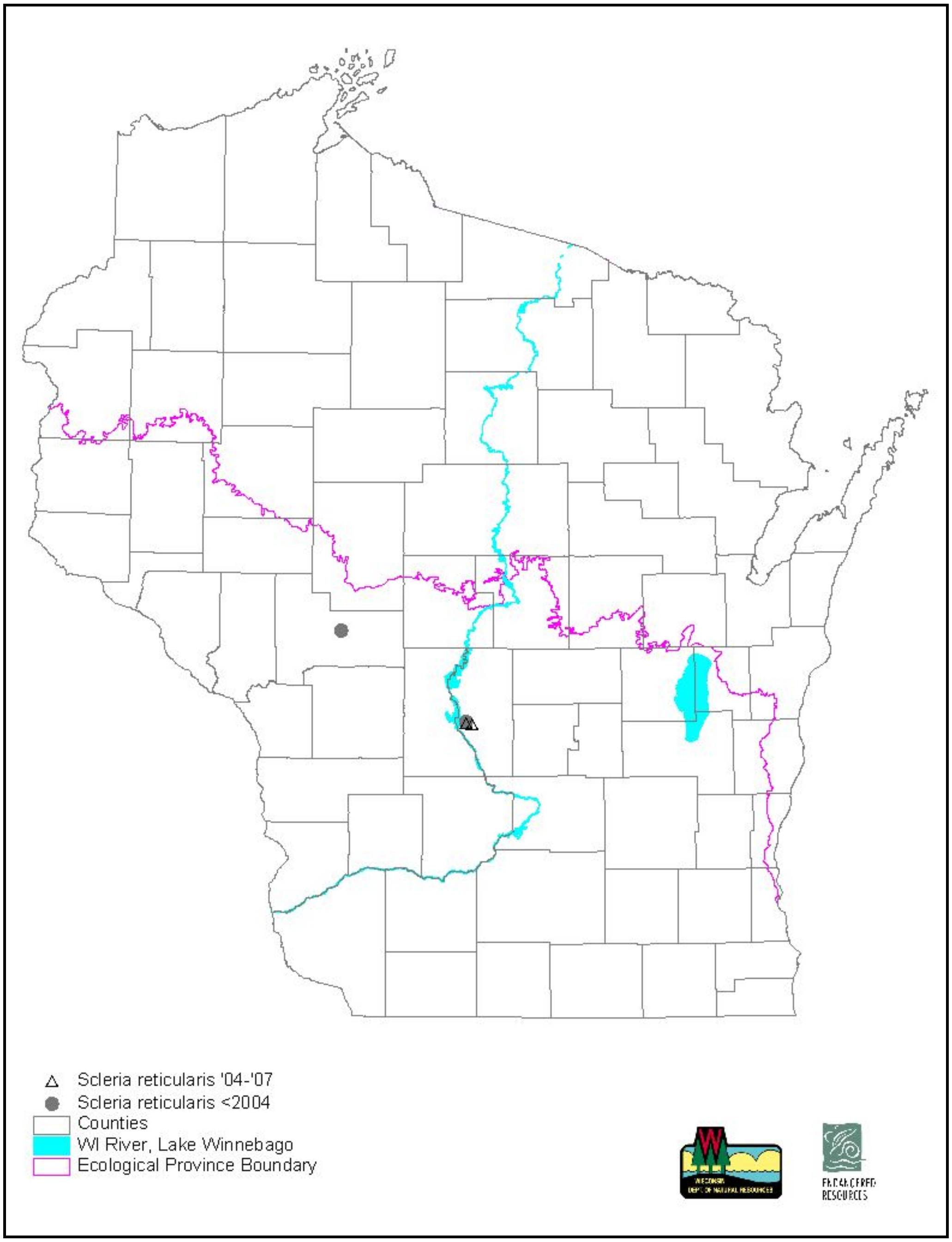
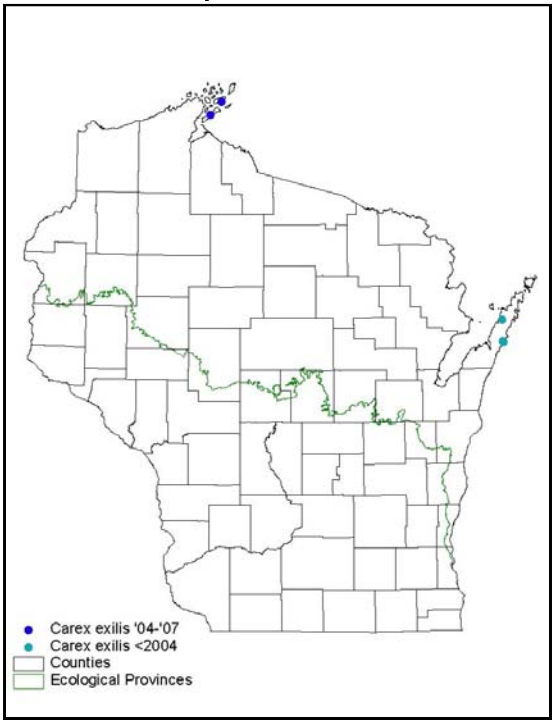
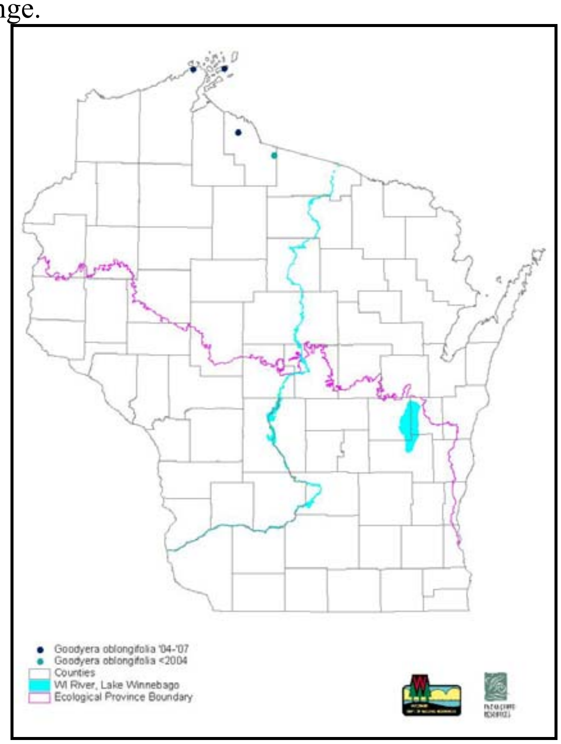


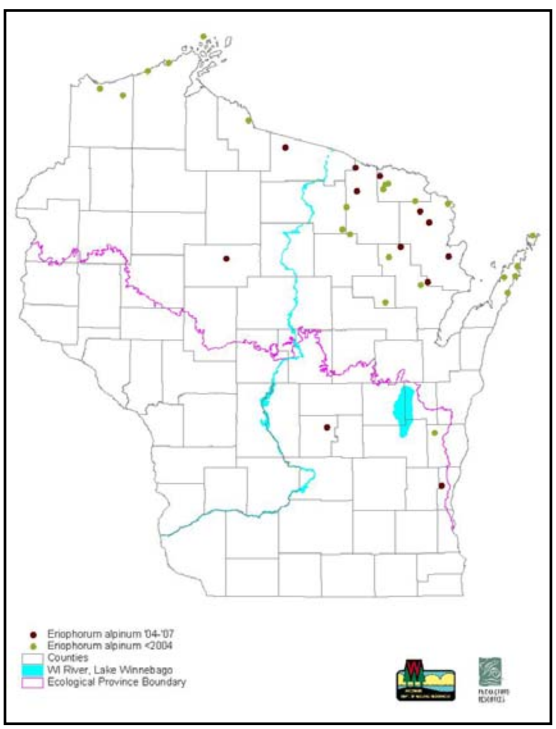
Figure 22. Distribution of *Scleria reticularis*, before 2004 and currently

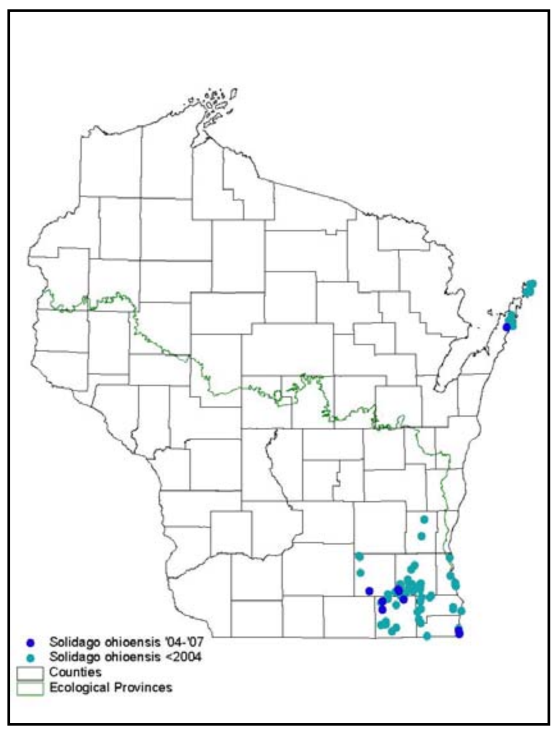
Many of the plant species we surveyed occur at the edge of their overall range, whether north, south, east, or west. A number of species barely enter into Wisconsin and have few, relatively small (in many instances) populations in specialized habitats. Depending on their ability to adapt to a changing temperature regime or precipitation patterns or their innate ability to disperse, some of these species may be especially to climate change. As such, they may be useful indicators of a changing climate. Some of the more northerly species that are very geographically limited in the state include *Carex exilis* (Figure 23), *Drosera linearis*, and *Goodyera oblongifolia* (Figure 24). Others might be more widespread across northern Wisconsin, such as *Eriophorum alpinum* (Figure 25) and *Malaxis monophyllos* var *brachypoda*, but require specific habitat and may show effects of climate change. Other species, e.g., *Cypripedium candidum* and *Solidago ohioensis* (Figure 26) are on the northern edge of their ranges but also have specific habitat requirements and therefore may be vulnerable to climate change.





Figures 23 and 24. *Carex exilis* and *Goodyera oblongifolia*.





Figures 25 and 26. *Eriophorum alpinum* and *Solidago ohioensis*.

Project Conclusions

Overall, the individual taxon groups met the major objectives outlined in the introduction. We were able to develop methods such that we, or other researchers, can replicate this study in 10-20 years and periodically thereafter. We gathered large amounts of baseline data for all of the taxon groups at the Intensive Sites. Most of the taxon groups were able to collect baseline data at a subset of the Extensive Sites. Through the efforts of the site assessors, passerine bird crew, the small mammal/amphibian crew, and the related natural community project, we obtained vegetation data that can also help researchers detect changes in the natural communitiy composition and type at individual sites. Data gathered on rare animals has already led to changes in the NHI working list, and it's anticipated that further changes will occur for animals and plants. Value-added projects, such as the habitat models that were developed for passerine birds, can be a valuable tool for natural resource professionals and may be especially useful in light of climate change.

Project Evaluation

Our project has added to the understanding of the potential effects of electrical generation and their contributions to climate change. We have collected a replicable set of baseline data for a wide range of taxon groups that may be referenced when this study is repeated in 10 to 20 years. Our survey techniques are widely used in the biological community and, with regard to equipment, are low cost. We refined our survey techniques as necessary over the course of the study to more closely answer our project objectives. Rare plant and natural community data were collected and managed according to the standards coordinated by NatureServe, an internation organization of Natural Heritage programs. Thus, it may be possible to integrate data from other members of the network for a regional perspective. We have identified some vegetation characteristics that are important to various groups of organisms that if changed will lead to increased vulnerability of a number of species.

Glossary

Anuran: any of various tailless stout-bodied amphibians with long hind limbs for leaping; semi-aquatic and terrestrial species, including toads and frogs.

Autolysis: The destruction of tissues or cells of an organism by the action of substances, such as enzymes, that are produced within the organism. Also called self-digestion. To undergo autolysis is termed *autolyze*.

Coniferous: refers to conifer trees and includes such familiar groups as pines, spruces, and cedars.

Dentition: the study of teeth

Drift fence: any fence used to control the movement of animals in a particular open area, or to collect animals for research.

Ecological Province: an upper level in the National Hierarchical Framework of Ecological Units

Ecological Section: a level in the National Hierarchical Framework of Ecological Units characterized by combinations of climate, geomorphic processes, topography, and stratigraphy.

Element Occurrence: an individual example of an element (a natural community, a rare plant population, a rare animal population, or other feature tracked by the Natural Heritage Inventory program) at a specific geographic location.

Element Occurrence Rank: provides a succinct assessment of the estimated viability (probability of persistence) of occurrences of a given species. They provide an estimation of the likelihood that, if current conditions prevail, a species occurrence will persist for a period of time.

Ericad or ericaceous: refers to the plant family Ericaceae. Species within this family include cranberries, leatherleaf, and Labrador tea and are often common components of peatlands.

Exuvia (pl. exuviae): the remains of an exoskeleton that is left after an arthropod (insect, crustacean or arachnid) has moulted. The exuvia of an animal can be important to biologists as it can often be used identify the species of the animal and even its sex.

Graminoid: grasses (family Gramineae or Poaceae) and grasslike plants such as sedges (family Cyperaceae) and rushes (family Juncaceae).

Herptile (herp): many biologists use the term "herp" or "herptiles" for all reptiles and amphibians. Also called herpetofauna.

Lepidoptera: an order of insect that includes moths and butterflies. It encompasses moths and the three superfamilies of butterflies, skipper butterflies, and moth-butterflies. Members of the order are referred to as lepidopterans or leps.

National Hierarchical Framework of Ecological Units (NHFEU): a land unit classification system developed by the U.S. Forest Service and many collaborators. As described by Avers et al (1994): “The NHFEU can provide a basis for assessing resource conditions at multiple scales. Broadly defined ecological units can be used for general planning assessments of resource capability. Intermediate scale units can be used to identify areas with similar disturbance regimes. Narrowly defined land units can be used to assess specific site conditions including: distributions of terrestrial and aquatic biota; forest growth, succession, and health; and various physical conditions.”

Natural Community: an assemblage of plants and animals, in a particular place at a particular time, interacting with one another, the abiotic environment around them, and subject to primarily natural disturbance regimes. Those assemblages that are repeated across a landscape in an observable pattern constitute a community type. No two assemblages, however, are exactly alike.

Odonata: an order of insects, encompassing dragonflies and damselflies. Odonate is a word coined to provide an English name for the group of dragonflies and damselflies.

Orthoptera: an order of insects that includes the grasshoppers, crickets and locusts.

Passerine Bird: a bird of the order Passeriformes, which includes more than half of all bird species. Sometimes known as perching birds or, less accurately, as songbirds, the passerines form one of the most diverse terrestrial vertebrate orders.

Peatland: wetlands characterized by the gradual accumulation of peat, the partially decomposed remains of plants. Open bog, muskeg, black spruce swamp, tamarack swamp and poor fen are among the common peatland natural communities.

Research Natural Area (RNA): is a network of public, largely federal, lands being protected permanently for the purposes of maintaining biological diversity, providing ecological baseline information, education, and research. Areas representing both widespread and unique ecosystems are selected for RNAs and only non-manipulative research and observation are allowed in the RNAs.

S-rank (subnational rank): the conservation status of a species or community is designated by a number from 1 to 5. The numbers have the following meaning: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure, and 5 = demonstrably widespread, abundant, and secure.

Special Concern: those species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Species of Greatest Conservation Need (SGCN): animal species that have low and/or declining populations that are in need of conservation action. They include various birds, fish, mammals, reptiles, amphibians, and invertebrates (e.g. dragonflies, butterflies, and freshwater mussels) that are already listed as threatened or endangered; at risk because of threats to their life history needs or their habitats; stable in number in Wisconsin, but declining in adjacent states or nationally.; or are of unknown status in Wisconsin and suspected to be vulnerable. These species are addressed in the Wisconsin Wildlife Action Plan (http://dnr.wi.gov/org/land/er/WWAP/)

State Natural Area (SNA): protect outstanding examples of Wisconsin's native landscape of natural communities, significant geological formations and archeological sites.

Taxon (pl. taxa): or taxonomic unit, is a name designating an organism or a group of organisms.

Wisconsin Endangered Species: any species whose continued existence as a viable component of this state's wild animals or wild plants is determined by the Wisconsin Department of Natural Resources to be in jeopardy on the basis of scientific evidence.

Wisconsin Threatened Species: any species which appears likely, within the foreseeable future, on the basis of scientific evidence to become endangered.

Wisconsin Natural Heritage Inventory (NHI) program: the program is part of an international network of NHI programs. The network is coordinated by NatureServe, an international non-profit organization. All NHI programs use a standard methodology for collecting, characterizing, and managing data, making it possible to combine data at various scales to address local, state, regional, and national issues. NHI programs focus on locating and documenting occurrences of rare species and natural communities, including state and federal endangered and threatened species. Species and natural communities tracked by the Wisconsin NHI Program can be found on the NHI Working List.

Wisconsin Natural Heritage Working List ("the working list"): contains species known or suspected to be rare in the state and natural communities native to Wisconsin. It includes species legally designated as "Endangered" or "Threatened" as well as species in the advisory "Special Concern" category.

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Appendix A. Peatland Natural Communities

Excerpted from Wisconsin Natural Heritage Inventory "Recognized Natural Communities – Working Document" Prepared by Eric Epstein, Emmet Judziewicz and Elizabeth Spencer

Alder Thicket
These wetlands are dominated by thick growths of tall shrubs, especially speckled alder (*Alnus incana*). Among the common herbaceous species are Canada bluejoint grass (*Calamagrostis canadensis*), orange jewelweed (*Impatiens capensis*), several asters (*Aster lanceolatus*, *A. puniceus*, and *A. umbellatus*), boneset (*Eupatorium perfoliatum*), rough bedstraw (*Galium asprellum*), marsh fern (*Thelypteris palustris*), arrow-leaved tearthumb (*Polygonum sagittatum*), and sensitive fern (*Onoclea sensibilis*). This type is common and widespread in northern and central Wisconsin, but also occurs in the southern part of the state.

Black Spruce Swamp (A split from Curtis' Northern Wet Forest)
An acidic conifer swamp forest characterized by a relatively closed canopy of black spruce (*Picea mariana*) and an open understory in which Labrador-tea (*Ledum groenlandicum*) and sphagnum mosses (*Sphagnum* spp.) are often prominent, along with three-leaved false Solomon's-seal (*Smilacina trifolia*), creeping snowberry (*Gaultheria hispidula*), and three-seeded sedge (*Carex trisperma*). The herbaceous understory is otherwise relatively depauperate. This community is closely related to Open Bogs and Muskegs, and sometimes referred to as Forested Bogs outside of Wisconsin.

Bog Relict

These boggy, acidic, weakly minerotrophic peatlands occur south of the Tension Zone within a matrix of "southern" vegetation. Bog relicts are isolated from the more extensive, better-developed and much more widespread stands of this community found in the northern part of the state. Acidophiles present can include sphagnum mosses (*Sphagnum* spp), sedges (e.g., few seeded sedge, *Carex oligosperma*), ericaceous shrubs, and insectivorous herbs. Tamarack (*Larix laricina*) is usually the most common tree and poison-sumac (*Toxicodendron vernix*) is often formidably abundant in the understory, especially in the moat (or "lagg") at the upland/wetland interface. Examples in southeastern Wisconsin are all somewhat alkaline and may resemble "shrub-fen" communities described in other states.

Boreal Rich Fen

Neutral to alkaline cold open peatlands of northern Wisconsin through which carbonate-rich groundwater percolates. *Sphagnum* mosses are absent or of relatively minor importance, as calciphilic species (especially the "brown" mosses) predominate. Dominant/characteristic plants include woolly sedge (*Carex lasiocarpa*), twig rush (*Cladium mariscoides*), beaked bladderwort (*Utricularia cornuta*), rushes (*Juncus* spp.), and Hudson Bay cotton-grass (*Scirpus hudsonianus*). Shrubby phases also occur, with bog birch (*Betula pumila*), sage willow (*Salix candida*), and speckled alder (*Alnus incana*) present in significant amounts.

Calcareous Fen

An open wetland found in southern Wisconsin, often underlain by a calcareous substrate, through which carbonate-rich groundwater percolates. The flora is typically diverse, with many calciphiles. Common species are several sedges (*Carex sterilis* and *C. lanuginosa*), marsh fern (*Thelypteris palustris*), shrubby cinquefoil (*Potentilla fruticosa*), shrubby St. John's-wort (*Hypericum kalmianum*), Ohio goldenrod (*Solidago ohioensis*), grass-of-parnassus (*Parnassia glauca*), twig-rush (*Cladium mariscoides*), brook lobelia (*Lobelia kalmii*), boneset (*Eupatorium perfoliatum*), swamp thistle (*Cirsium muticum*), and asters (*Aster* spp.). Some fens have significant prairie or sedge meadow components, and intergrade with those communities.

Central Poor Fen

These open, acidic, low nutrient peatlands occur within the Central Sand Plains of Wisconsin. Central poor fens are floristically depauperate and generally sedge dominated, (*Carex oligosperma*, *C. lasiocarpa*, and *C. utriculata*) Bluejoint grass (*Calamagrostis canadensis*) is a frequent associate and may co-dominate in some stands. Sphagnum spp. carpets are common but typically lack pronounced hummocks and hollows. Shrubs are present but not dominant, Hard-hack (*Spiraea tomentosa*) is the most consistent in presence, and cover of ericads is generally low. Other characteristic associates include wool grass (*Scirpus cyperinus*), cotton-grasses (*Eriophorum* spp.), swamp-candles (*Lysimachia terrestris*) and Kalm's St. John's-wort (*Hypericum kalmianum*). This community often intergrades with Tamarack (poor) Swamp. Disturbance of this community through mossing may significantly alter community composition, as recolonization by at least some of the vascular plants is very slow. Many plants characteristic of poor fen communities farther north are rare or absent in these central sands peatlands.

Coastal Plain Marsh

Sandy to peaty-mucky lakeshores, pondshores, depressions, and ditches in and around the bed of extinct glacial Lake Wisconsin may harbor assemblages of wetland species including some which are significantly disjunct from their main ranges on the Atlantic Coastal Plain. There is often a well-developed concentric zonation of vegetation. Frequent members of this community are sedges in the genera *Cyperus*, *Eleocharis*, *Fimbristyli*s, *Hemicarpha*, *Rhynchospora* and *Scirpus*; rushes (*Juncus* spp.); milkworts (*Polygala cruciata* and *P. sanguinea*), toothcup (*Rotala ramosior*), meadow-beauty (*Rhexia virginica*), grass-leaved goldenrod (*Euthamia graminifolia*), hardhack (*Spiraea tomentosa*), lance-leaved violet (*Viola lanceolata*), and yellow-eyed grass (*Xyris torta*).

Great Lakes Ridge and Swale (Formerly **Forested Ridge and Swale**)

This is a complex of semi- to fully-stabilized, often forested beach / dune ridges alternating with wet open to forested swales, found on the shores of the Great Lakes but best-developed along Lake Michigan. Both parallel the coast and offer exceptionally complex and diverse habitats for wetland, upland, and Great Lakes shoreline plants. Ridges may support assemblages similar to boreal, northern mesic, or northern dry-mesic forests. Water depth is a controlling factor in the swales, and the vegetation may run the gamut from open (emergent marsh, fen, or sedge meadow), shrub (bog birch, alder), or forested wetlands (often white cedar, black ash are prominent in these).

Interdunal Wetland

Wind-created hollows that intersect the water table within active dune fields along the Great Lakes. These maybe colonized by wetland plants, including habitat specialists that are of high conservation significance. Common members of this wetland community on Lake Superior are twig-rush (Cladium mariscoides), species of rushes (especially Juncus balticus), pipewort (Eriocaulon septangulare), the sedge (Carex viridula), ladies-tress orchids (Spiranthes sp.) and bladderworts (Utricularia cornuta and U. resupinata).

Muskeg

Muskegs are cold, acidic, sparsely wooded northern peatlands with **composition** similar to the Open Bogs (*Sphagnum* spp. mosses, *Carex* spp., and ericaceous shrubs), but with scattered stunted trees of black spruce (*Picea mariana*) and tamarack (*Larix laricina*). Plant diversity is typically low, but the community is important for a number of boreal bird and butterfly species, some of which are quite specialized and not found in other communities.

Northern Sedge Meadow

This open wetland community is dominated by sedges and grasses. There are several common subtypes: Tussock meadows, dominated by tussock sedge (*Carex stricta*) and Canada bluejoint grass (*Calamagrostis canadensis*); Broad-leaved sedge meadows, dominated by the robust sedges (*Carex lacustris* and/**or** *C.*

utriculata); and Wire-leaved sedge meadows, dominated by such species as woolly sedge (*Carex lasiocarpa*) and few-seeded sedge (*C. oligosperma*). Frequent associates include marsh bluegrass (*Poa palustris*), manna grasses (*Glyceria spp*.), panicled aster (*Aster lanceolatus*), joy-pye weed (*Eupatorium maculatum*), and the bulrushes (*Scirpus atrovirens* and *S. cyperinus*).

Northern Wet Forest (revised from Curtis, with **Black Spruce** and **Tamarack Swamps** split out)

These weakly minerotrophic conifer swamps, located in the North, are dominated by black spruce (*Picea mariana*) and tamarack (*Larix laricina*). Jack pine (*Pinus banksiana*) may be a significant canopy component in certain parts of the range of this community complex. Understories are composed mostly of sphagnum (Sphagnum spp.) mosses and ericaceous shrubs such as leatherleaf (*Chamaedaphne calyculata*), Labrador-tea (*Ledum groenlandicum*), and small cranberry (*Vaccinium oxycoccos*) and sedges such as (*Carex trisperma* and *C paupercula*). The Natural Heritage Inventory has split out two entities, identified (but not strictly defined) by the two dominant species (see **Black Spruce Swamp** and **Tamarack Swamp**).

Northern Wet-Mesic Forest (revised from Curtis, with **Northern Hardwood Swamp** split out)

This forested minerotrophic wetland is dominated by white cedar (*Thuja occidentalis*), and occurs on rich, neutral to alkaline substrates. Balsam fir (*Abies balsamea*), black ash (*Fraxinus nigra*), and spruces (*Picea glauca* and *P. mariana*) are among the many potential canopy associates. The understory is rich in sedges (such as *Carex disperma* and *C. trisperma*), orchids (e.g., *Platanthera obtusata* and *Listera cordata*), and wildflowers such as goldthread (*Coptis trifolia*), fringed polygala (*Polygala pauciflora*), and naked miterwort (*Mitella nuda*), and trailing sub-shrubs such as twinflower (*Linnaea borealis*) and creeping snowberry (*Gaultheria hispidula*). A number of rare plants occur more frequently in the cedar swamps than in any other habitat.

Open Bog

These non-forested bogs are acidic, low nutrient, northern Wisconsin peatlands dominated by Sphagnum spp. mosses that occur in deep layers, often with pronounced hummocks and hollows. Also present are a few narrow-leaved sedge species such as (*Carex oligosperma* and *C. pauciflora*), cotton-grasses (*Eriophorum* spp.), and ericaceous shrubs, especially bog laurel (*Kalmia polifolia*), leatherleaf (*Chamaedaphne calyculata*), and small cranberry (*Vaccinium oxycoccos*). Plant diversity is very low but includes characteristic and distinctive specialists. Trees are absent or achieve very low cover values as this community is closely related to and intergrades with Muskeg. When this community occurs in southern Wisconsin, it is often referred to as a **Bog Relict**.

Patterned Peatland

Very rare in Wisconsin, this wetland type can be characterized as a herb- and shrub-dominated minerotrophic peatland with alternating moss and sedge-dominated peat ridges (strings) and saturated and inundated hollows (flarks). These are oriented parallel to the contours of a slope and perpendicular to the flow of groundwater. Within a patterned peatland the peat “landforms” differ significantly in nutrient availability and pH. The flora may be quite diverse and includes many sedges of bogs and fens, along with ericads, sundews, orchids, arrow-grasses (*Triglochin* spp.), and calciphilic shrubs such as bog birch (*Betula pumila*) and shrubby cinquefoil (*Potentilla fruticosa*).

Poor Fen

This acidic, weakly minerotrophic peatland type is similar to the Open Bog, but can be differentiated by higher pH, nutrient availability, and floristics. Sphagnum (*Sphagnum* spp.) mosses are common but don’t typically occur in deep layers with pronounced hummocks. Floristic diversity is higher than in the Open Bog and may include white beak-rush (*Rhynchospora alba*), pitcher-plant (*Sarracenia purpurea*), sundews (*Drosera* spp.), pod grass (*Scheuchzeria palustris*), and the pink-flowered orchids (*Calopogon tuberosus*, *Pogonia ophioglossoides* and *Arethusa bulbosa*). Common sedges are (*Carex oligosperma*, *C. limosa*, *C. lasiocarpa*, *C. chordorrhiza*), and cotton-grasses (*Eriphorum* spp.).

Shore Fen (formerly called Coastal Fen)

This open peatland community occurs primarily along Great Lakes shorelines, especially near the mouths of estuarine streams. Along Lake Superior most stands are separated from the lake waters by a sand spit. The floating sedge mat is composed mostly of woolly sedge (*Carex lasiocarpa*); co-dominants are sweet gale (*Myrica gale*) and bogbean (*Menyanthes trifoliata*). The following herbs are common in this diverse, circumneutral, nutrient-rich community: twigrush (*Cladium mariscoides*), marsh horsetail (*Equisetum fluviatile*), a spikerush (*Eleocharis elliptica*), intermediate bladderwort (*Utricularia intermedia*), marsh bellflower (*Campanula aparinoides*), narrow-leaved willow-herb (*Epilobium leptophyllum*), water-parsnip (*Sium suave*), and bog willow (*Salix pedicellaris*). Coastal fens are distinguished from open bogs and poor fens (which may adjoin them in the same wetland complex) by the lack of Sphagnum spp. mosses, higher pH, and direct hydrologic connection to the Great Lakes. They are distinguished from rich fens by the absence of indicator species such as linear-leaved sundew (*Drosera linearis*), grass-of-parnassus (*Parnassia glauca*), false asphodel (*Tofiedia glutinosa*) and a spikerush (*Eleocharis rostellata*).

Shrub-Carr

This wetland community is dominated by tall shrubs such as red-osier dogwood (*Cornus stolonifera*), meadow-sweet (*Spiraea alba*), and various willows (*Salix discolor*, *S. bebbiana*, and *S. gracilis*). Canada bluejoint grass (*Calamagrostis canadensis*) is often very common. Associates are similar to those found in Alder Thickets and tussock-type Sedge Meadows. This type is common and widespread in southern Wisconsin but also occurs in the north.

Southern Sedge Meadow

Widespread in southern Wisconsin, this open wetland community is most typically dominated by tussock sedge (*Carex stricta*) and Canada bluejoint grass (*Calamagrostis canadensis*). Common associates are water-horehound (*Lycopus uniflorus*), panicled aster (*Aster simplex*), blue flag (*Iris virginica*), Canada goldenrod (*Solidago canadensis*), spotted joe-pye-weed (*Eupatorium maculatum*), broad-leaved cat-tail (*Typha latifolia*), and swamp milkweed (*Asclepias incarnata*). Reed canary grass (*Phalaris arundinacea*) may be dominant in grazed and/or ditched stands. Ditched stands can succeed quickly to Shrub-Carr.

Tamarack (poor) Swamp (formerly called Tamarack Swamp, this is a split from Curtis' **Northern Wet Forest**)

These weakly to moderately minerotrophic conifer swamps are dominated by a broken to closed canopy of tamarack (*Larix laricina*) and a frequently dense understory of speckled alder (*Alnus incana*). The understory is more diverse than in Black Spruce Swamps and may include more nutrient-demanding species such as winterberry holly (*Ilex verticillata*) and black ash (*Fraxinus nigra*). The bryophytes include many genera other than Sphagnum. Stands with spring seepage sometimes have marsh-marigold (*Caltha palustris*) and skunk-cabbage (*Symplocarpus foetidus*) as common understory inhabitants. These seepage stands have been separated out as a distinct type or subtype in some nearby states and provinces.

Tamarack (rich) Swamp (formerly called Tamarack Fen)

This forested wetland community type is a variant of the Tamarack Swamp, but occurs south of the Tension Zone within a matrix of "southern" vegetation types. Poison-sumac (*Toxicodendron vernix*) is often a dominant understory shrub. Successional stages and processes are not well understood but fire, wind throw, water level fluctuations, and periodic infestations of larch sawfly are among the important dynamic forces influencing this community. Groundwater seepage influences the composition of most if not all stands. Where the substrate is especially springy, skunk cabbage (*Symplocarpus foetidus*), marsh marigold (*Caltha palustris*), sedges, and a variety of mosses may carpet the forest floor. Drier, more acid stands may support an ericad and sphagnum dominated groundlayer.

White Pine - Red Maple Swamp

This swamp community is restricted to the margins of the bed of extinct glacial Lake Wisconsin in the central part of the state. It often occurs along headwaters streams and seepages in gently sloping areas. White pine (*Pinus strobus*) and red maple (*Acer rubrum*) are the dominant trees, with other species, including yellow birch (*Betula alleghiensis*), present in lesser amounts. Common understory shrubs are speckled alder (*Alnus incana*), winterberry holly (*Ilex verticillata*), and swamp dewberry (*Rubus pubescens*); characteristic herbs include skunk cabbage (*Symplocarpus foetidus*), cinnamon fern (*Osmunda cinnamomea*), gold thread (*Coptis trifolia*), and two disjuncts from the eastern United States, bog fern (*Thelypteris simulata*) and long sedge (*Carex folliculata*). Sphagnum and other mosses are common.

Appendix B. Potential Rare Plant Species for the Peatland Project

Scientific Name	Common Name
Amerorchis rotundifolia	Round-leaved orchis
Arethusa bulbosa	Swamp-pink
Bartonia paniculata	Twining screwstem
Bartonia virginica	Yellow screwstem
Calopogon oklahomensis	Oklahoma grass-pink
Calypso bulbosa	Fairy slipper
Carex capillaris	Hair-like sedge
Carex concinna	Beautiful sedge
Carex exilis	Coast sedge
Carex folliculata	Long sedge
Carex gynocrates	Northern bog sedge
Carex livida var. radicaulis	Livid sedge
Carex michauxiana	Michaux sedge
Carex pallescens var. neogaia	Pale sedge
Carex suberecta	Prairie straw sedge
Carex tenuiflora	Sparse-flowered sedge
Carex vaginata	Sheathed sedge
Clematis occidentalis	Purple clematis
Cypripedium arietinum	Ram's-head lady's-slipper
Cypripedium candidum	Small white lady's-slipper
Cypripedium parviflorum var *makasin*	Northern yellow lady's-slipper
Cypripedium reginae	Showy lady's-slipper
Drosera anglica	English sundew
Drosera linearis	Slenderleaf sundew
Eleocharis equisetoides	Horse-tail spikerush
Eleocharis mamillata	Spike-rush
Eleocharis nitida	Slender spikerush
Eleocharis olivacea	Capitate spikerush
Eleocharis quinqueflora	Few-flower spikerush
Eleocharis robbinsii	Robbins' spikerush
Eleocharis rostellata	Beaked spikerush
Epilobium palustre	Marsh horsetail
Eriophorum alpinum	Alpine cotton-grass
Eriophorum chamissonis	Russet cotton-grass
Galium brevipes	Swamp bedstraw
Galium palustre	Marsh bedstraw
Gentiana alba	Yellow gentian
Gentianopsis procera	Lesser fringed gentian
Geocaulon lividum	Northern comandra
Goodyera oblongifolia	Giant rattlesnake-plantain
Gymnocarpium robertianum	Limestone oak fern
Juncus stygius	Moor rush
Juncus vaseyi	Vasey rush
Listera convallarioides	Broad-leaved twayblade
Lonicera involucrata	Fly honeysuckle
Lycopodiella margueritae	Northern prostrate clubmoss

Malaxis monophyllos var. *brachypoda*	White adder's-mouth
Osmorhiza chilensis	Chilean sweet cicely
Parnassia palustris	Marsh grass-of-parnassus
Parnassia parviflora	Small-flower grass-of-parnassus
Petasites sagittatus	Arrow-leaved sweet-coltsfoot
Platanthera dilatata	Leafy white orchis
Platanthera flava var *herbiola*	Pale green orchid
Platanthera leucophaea	Prairie white-fringed orchid
Polemonium occidentale ssp. *lacustre*	Western Jacob's ladder
Potamogeton bicupulatus	Snail-seed pondweed
Potamogeton diversifolius	Water-thread pondweed
Polygala cruciata	Crossleaf milkwort
Pyrola minor	Lesser wintergreen
Ranunculus cymbalaria	Seaside crowfoot
Ranunculus gmelinii	Small yellow water crowfoot
Ranunculus lapponicus	Lapland buttercup
Rhexia virginica	Virginia meadow-beauty
Rhynchospora fusca	Brown beakrush
Ribes hudsonianum	Northern black current
Salix sericea	Silky Willow
Scirpus torreyi	Torrey's bulrush
Scleria triglomerata	Whip nutrush
Senecio congestus	Marsh ragwort
Sparganium glomeratum	Northern bur-reed
Tofieldia glutinosa	Sticky false-asphodel
Triglochin maritima	Common bog arrow-grass
Triglochin palustris	Slender bog arrow-grass
Utricularia geminiscapa	Hidden-fruited bladderwort
Utricularia purpurea	Purple bladderwort
Utricularia resupinata	Northeastern bladderwort
Vaccinium vitis-idaea ssp *minus*	Mountain cranberry
Valeriana sitchensis ssp *uliginosa*	Marsh valerian
Viburnum nudum var *cassinoides*	Northern wild-raisin

Appendix C. Final report of natural community mapping.

Applying the Natural Heritage Inventory Classification System to Characterize the Natural Communities in the Ongoing Peatlands Study

Final Report
30 October 2006 through 30 June 2008

Submitted to:
Wisconsin Focus on Energy
Environmental Research Program

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Background

This project complements the "Biodiversity in Selected Natural Communities Related to Global Climate Change" (Peatlands Project) grant funded by the Wisconsin Focus on Energy program. During the Peatlands Project, biologists collected composition data, including plant species lists, disturbances and threats, and cover classes for each vegetative stratum, on peatland communities. These data were collected using varying levels of survey intensity to provide a broad range of information and quantification. Intensive surveys were conducted at non-randomly selected peatlands that met specified criteria and were distributed by ecological section (Figure 1). Extensive surveys were conducted at randomly selected peatlands stratified by ecological province and distributed throughout the state (Figure 2). A proposed but unfunded component of the Peatlands Project was to characterize the natural communities for each of the peatland study sites using the NHI classification system.

This project provided a representative survey of occurrences of peatland communities as well as updated existing high quality natural community information that is housed in the NHI database, past inventory reports, and other efforts such as county surveys that have been used to identify potential State Natural Areas. This information helps to fill a crucial gap in current knowledge of the size, context, condition and overall quality of these communities.

Wisconsin peatlands provide a unique opportunity to detect changes related to global climate change in a natural system. For example, the rate of natural vegetation growth and change in forested peatlands is very slow. Black spruce, tamarack and white cedar trees have minimal growth rates in most peatland habitats, adding perhaps only fractions of an inch in diameter and perhaps several feet in height over years, even decades. Many closed peatlands contain unmerchantable timber, and harvest on some public lands (e.g., national forests) has been restricted through moratoriums.

Methods

The primary goal of this project was to collect, analyze, and incorporate baseline data on the distribution, types, and condition of Wisconsin's peatland communities in a standardized format. Natural communities were delineated using Geographic Information System according to NatureServe methodology. These data can be used for comparison in future biotic climate change studies as well as by other users of NHI data. Natural communities that are considered peatlands include Black Spruce Swamps, Bog Relicts, Boreal Rich Fens, Muskegs, Open Bogs, Poor Fens (including Central Poor Fens), Tamarack Poor Swamps, Tamarack Rich Swamps, Northern Wet-mesic Forests, Southern Sedge Meadows, and Northern Sedge Meadows (Appendix 1).

This project also included further field investigation on both Intensive and Extensive Sites, as defined in the Peatlands Project, by focusing first on a comprehensive community assessment of the 13 Intensive Sites, then on follow-up work for a portion of the 200 Extensive Sites as time and funding allowed.

Results

1. Analyzed peatlands community data collected through the "Biodiversity in Selected Natural Communities Related to Global Climate Change" grant funded by the Wisconsin Focus on Energy program
   (a) Prioritized sites for entry into the NHI database by reviewing the information collected for high quality natural community data.
   (b) Characterized the natural communities for selected peatland study sites using the NHI classification system. All of the natural communities types located on peatland study sites, including non-peatland natural communities, are listed in Table 1.
   (c) Refined natural community boundaries to reflect actual boundaries of the various peatland communities present on the priority sites and added new natural communities that were determined through field surveys.

2. Incorporated priority data for high quality peatland communities into the NHI database using standard methodology
   (a) Reviewed NHI files for data collected during the Peatlands grant, and files in regional offices that contained data related to the Peatlands study sites.
   (b) Tracked information sources in a database to aid in data processing and to maintain information about data sources.
   (c) Processed priority data into the NHI database using standardized methodology and shared results with users. Trained NHI staff interpreted the data and transcribed it onto electronic forms and into spatial representations using standardized NHI methodology. A total of 164 natural community element occurrences were mapped in the NHI database, including 58 natural community element occurrences on Intensive Sites (Table 2). All results were quality assured.

3. Performed further field investigation on both Intensive and Extensive Sites, as defined in the previous grant
   (a) Performed a comprehensive community assessment, including delineating the natural community types, of all 13 Intensive Sites and follow-up work for 18 Extensive Sites.

4. Match was provided by the Bureau of Endangered Resources in the form of maintenance and support for the NHI database and applications (e.g. NHI Data Portal)
   (a) Data development, problem resolution, patching of underlying code, and keeping the applications current with DNR's information system standards and to meet

NatureServe network standards to assure that the NHI information system functions at an optimal level, returning high quality information to users.

Discussion

This project has contributed greatly to our understanding of the range and condition of peatland natural communities throughout Wisconsin. We have been able to add many new records of natural community element occurrence to the NHI database, an important tool for researchers, community planners, and regulators. The incorporation of this data into the NHI database provides provide a valuable baseline for the evaluation of change over time related to natural community shape, extent, structure and species composition when the sites are re-visited in 10-20 years, as proposed in the Peatlands Project proposal.

At the conclusion of this project period there is still more work that can be done with data collected during the Peatlands Project. Many of the Extensive Sites that were visited have not had their information entered into the NHI database. A quick review indicates that of the 200 Extensive Sites, about 124 still have information that may potentially lead to new or updated natural community element occurrences. These data are being stored in an Access database for quick retrieval by NHI staff, but is unavailable to users of NHI data until it has been entered into the NHI database and quality controlled.

Table 1. Natural Community Element Occurrences on peatland sites.

Natural Community Element Occurrences
Alder Thicket
Black Spruce Swamp
Boreal Forest
Emergent Marsh
Forested Seep
Hardwood Swamp
Lake--Deep, Very Soft, Seepage
Lake--deep, very soft, seepage
Lake--shallow, soft, drainage
Lake--Shallow, Soft, Seepage
Muskeg
Northern Dry Forest
Northern Dry-mesic Forest
Northern Mesic Forest
Northern Sedge Meadow
Northern Wet Forest
Northern Wet-mesic Forest
Open Bog
Poor Fen
Shore Fen
Shrub-carr
Southern Sedge Meadow
Southern Tamarack Swamp (Rich)
Springs and Spring Runs, Hard
Tamarack (Poor) Swamp

Table 2. Natural Community Element Occurrences on Intensive peatland sites.

Site Name	Natural Community Type
Bear Lake Meadow	Poor Fen
Belden Swamp Complex	Alder Thicket Black Spruce Swamp Muskeg Northern Sedge Meadow Open Bog
Bibon Swamp	Alder Thicket Black Spruce Swamp Muskeg Northern Sedge Meadow Northern Wet-mesic Forest Tamarack (Poor) Swamp
Big Bay	Black Spruce Swamp Boreal Forest Northern Dry Forest Open Bog Poor Fen Shore Fen Tamarack (Poor) Swamp
Cedarburg Bog	Emergent Marsh Lake--shallow, hard, drainage Northern Mesic Forest Northern Wet-mesic Forest Patterned Peatland Shrub-carr
Dry Lake and Pines	Lake--shallow, soft, drainage Northern Wet Forest Poor Fen
Hortonville Bog	Black Spruce Swamp Northern Wet-mesic Forest Open Bog
Kidrick Swamp	Black Spruce Swamp Muskeg Northern Mesic Forest
Lower Chippewa River SNA: Bear Creek Swamp	Shrub-carr Southern Sedge Meadow Southern Tamarack Swamp (Rich)
Mead Conifer Bogs	Alder Thicket Muskeg Northern Sedge Meadow Northern Wet Forest Shrub-carr Tamarack (Poor) Swamp
Miscauno Cedar Swamp	Northern Wet-mesic Forest
Pigeon Creek Swamp	Black Spruce Swamp Northern Sedge Meadow
Quincy Bluff and Wetlands	Central Poor Fen Central Sands Pine-Oak Forest Northern Dry Forest Pine Barrens Shrub-carr Southern Tamarack Swamp (Rich)
Swanson Lake and Pines	Black Spruce Swamp Lake--deep, very soft, seepage Lake--shallow, soft, seepage Muskeg Northern Dry-mesic Forest Open Bog

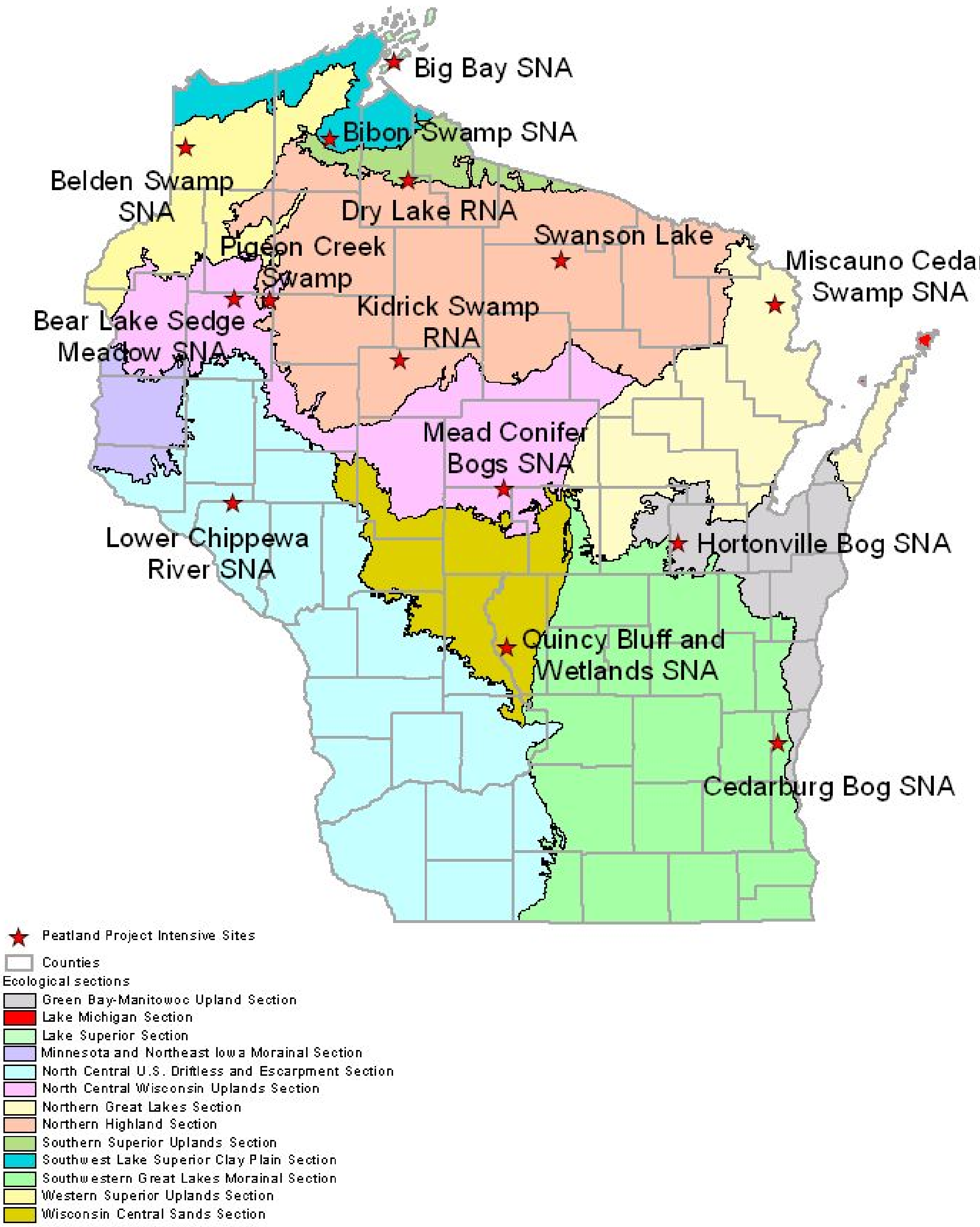

Figure 1. Peatland Intensive Sites

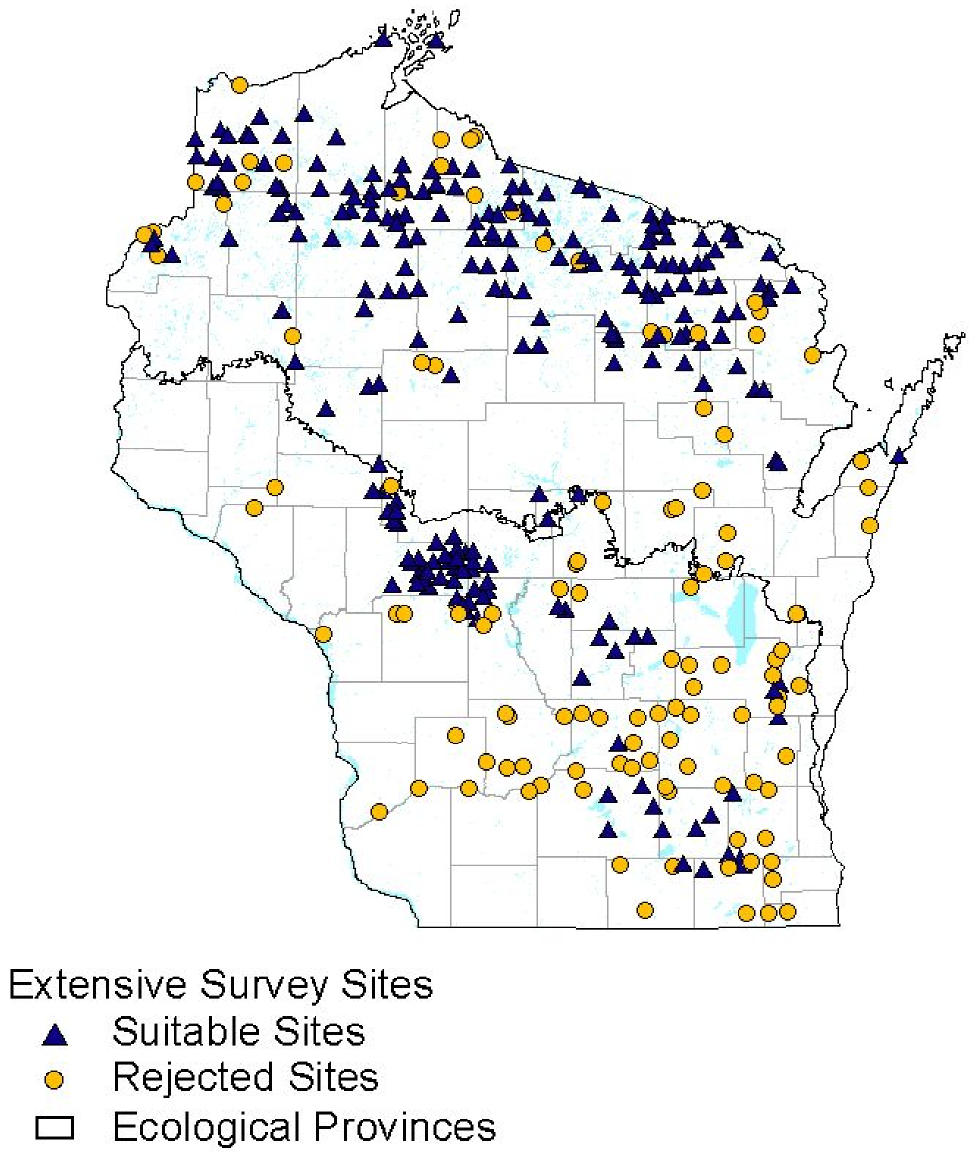

Figure 2. Peatland Extensive Sites