COWLES BOG WETLAND COMPLEX
HISTORY; INVENTORY; RESTORATION

FINAL COMPLETION REPORT
Restoration of the Biological Resource of the Cowles Bog Wetland Complex: Phase I- Design
PMIS # 60703





ON THE COVER

Top : 1916 photograph of the Cowles Bog Wetland Complex

Bottom: 2009 photograph of Charlene the last surviving pitcher plant at Cowles Bog Wetland Complex

626/160111

COWLES BOG WETLAND COMPLEX HISTORY; INVENTORY; RESTORATION

Final Completion Report for PMIS # 60703
Restoration of the Biological Resource of the Cowles Bog Wetland Complex: Phase I- Design

Daniel Mason Botanist Indiana Dunes National Lakeshore

Contributors

Noel Pavlovic Ecologist USGS Indiana Dunes National Lakeshore

Steven Broom Soil Chemistry Analyses Analytical Service Laboratory North Caroline State University

Key Agricultural Services Soil Chemistry Analyses, Macomb Illinois

John Tandarich Soil Classification Dominican University

William Crumpton Water Chemistry Analyses Iowa State University

Laura Thompson GIS – Exhibits Indiana Dunes National Lakeshore

Seasonal Staff
John Dollard
Beverly Millay
Lydia Miramontes
Matthew Otto
Carie Satkoski
Brigette Seymour
Angela Sokolowski
Adam Vaughan

TABLE OF CONTENTS

Introduction 1

Section I- History 3
Introduction 3
Phase I- Geologic Formation 3
Phase II – Early Twentieth Century 4
Phase III – Late Twentieth Century 7
Summary 11

Section II – Inventory
SII:A General Observations 15
Watershed 16
Soil Classification 17
Lake Bottom Contours 18

SII:B Vegetation 19
Introduction 19
Methods 20
Analyses 23
Results 25

SII:C Seedbank 43
Introduction 43
Methods 44
Analyses 46
Results 47

SII:D Abiotic Attributes 54
Introduction 54
Methods 54
Hydrology 54
Water Chemistry 55
Soil Chemistry 56
Results 57
Hydrology 57
Water Chemistry 58
Soil Chemistry 59

SII:E Management Experimentation 63
Introduction 63
Methods 64
Herbicide Concentration and Timing 64
Seedbank Recruitment 64
Results 66

Table of Contents (continued)

Herbicide Concentration and Timing..... 66
Seedbank Recruitment 66

Section III – Restoration..... 71
Introduction 71
Section II:A-Desired Wetland/Vegetation Types 72
Section II:B-Restoration Goals and Objectives 77
Section III:C- Restoration Tactics 81

Literature Cited 85

EXHIBITS

Exhibits A Series
Exhibit A:1 An overview of the entire Great Marsh.
Exhibit A:2 Aerial photograph of Cowles Bog Wetland Complex in 2004.
Exhibit A:3 Aerial photograph of Great Marsh in 1938.
Exhibit A:4 Aerial photograph of Great Marsh in 1954.
Exhibit A:5 Aerial photograph of Great Marsh in 2004.
Exhibit A:6 Vegetation types in Cowles Bog Wetland Complex in 1938.
Exhibit A:7 Vegetation types in Cowles Bog Wetland Complex in 1970.
Exhibit A:8 Vegetation types in Cowles Bog Wetland Complex in 1973.
Exhibit A:9 Vegetation types in Cowles Bog Wetland Complex in 1977.
Exhibit A:10 Vegetation types in Cowles Bog Wetland Complex in 1982.
Exhibit A:11 An overview of Cowles Bog Wetland Complex.
Exhibit A:12 Soil types in Cowles Bog Wetland Complex in 1944.
Exhibit A:13 Soil types at soil sample locations in Cowles Bog Wetland Complex.
Exhibit A:14 Depth to Lake Chicago sand surface in Cowles Bog Wetland Complex.

Exhibits B Series
Exhibit B:1 Vegetation sample locations in Cowles Bog Wetland Complex.
Exhibit B:2 Seedbank sample locations in Cowles Bog Wetland Complex.
Exhibit B:3 Well and staff gauge locations in Cowles Bog Wetland Complex.
Exhibit B:4 Well locations in Cowles Bog Wetland Complex that were sampled for water chemistry.
Exhibit B:5 Surface water locations in Cowles Bog Wetland Complex that were sampled for water chemistry.
Exhibit B:6 Soil sample locations in Cowles Bog Wetland Complex.

Exhibits C Series
Exhibit C:1 Legend for vegetation exhibits in Cowles Bog Wetland Complex.
Exhibit C:2 Vegetation units in Cowles Bog Wetland Complex.
Exhibit C:3 West shrub unit in Cowles Bog Wetland Complex.
Exhibit C:4 Forested swamp unit in Cowles Bog Wetland Complex.
Exhibit C:5 Fen units in Cowles Bog Wetland Complex.

Table of Contents (continued)

Exhibit C:6 East shrub unit in Cowles Bog Wetland Complex.
Exhibit C:7 Cattail stem density in Cowles Bog Wetland Complex.
Exhibit C:8 Cattail unit in Cowles Bog Wetland Complex.

Exhibit C:9 Disturbed prairie unit in Cowles Bog Wetland Complex.

Exhibit D Series
Exhibit D:1 Surface and ground water depths recorded at Cowles Bog Wetland Complex April 11, 2003.
Exhibit D:2 Surface and ground water depths recorded at Cowles Bog Wetland Complex May 2, 2003.
Exhibit D:3 Surface and ground water depths recorded at Cowles Bog Wetland Complex May 27, 2003.
Exhibit D:4 Surface and ground water depths recorded at Cowles Bog Wetland Complex June 16, 2003.
Exhibit D:5 Surface and ground water depths recorded at Cowles Bog Wetland Complex July 11, 2003.
Exhibit D:6 Surface and ground water depths recorded at Cowles Bog Wetland Complex August 12, 2003.
Exhibit D:7 Surface and ground water depths recorded at Cowles Bog Wetland Complex September 16, 2003.
Exhibit D:8 Surface and ground water depths recorded at Cowles Bog Wetland Complex October 15, 2003.
Exhibit D:9 Surface and ground water depths recorded at Cowles Bog Wetland Complex November 10, 2003.
Exhibit D:10 Surface and ground water depths recorded at Cowles Bog Wetland Complex December 9, 2003.

Exhibit E Series
Exhibit E:1 Cowles Bog Wetland Complex soil chemistry: Cation exchange capacity (cmol/kg).
Exhibit E:2 Cowles Bog Wetland Complex soil chemistry: Total cations (cmol/kg).
Exhibit E:3 Cowles Bog Wetland Complex soil chemistry: Calcium (cmol/kg).
Exhibit E:4 Cowles Bog Wetland Complex soil chemistry: Magnesium (cmol/kg).
Exhibit E:5 Cowles Bog Wetland Complex soil chemistry: pH.
Exhibit E:6 Cowles Bog Wetland Complex soil chemistry: Hydrogen (% saturation).
Exhibit E:7 Cowles Bog Wetland Complex soil chemistry: Nitrate (ug N/g soil).
Exhibit E:8 Cowles Bog Wetland Complex soil chemistry: Phosphorus (ppb).
Exhibit E:9 Cowles Bog Wetland Complex soil chemistry: Ammonium (ug N/g soil).

Table of Contents (continued)

Exhibit E:10 Cowles Bog Wetland Complex soil chemistry: Ammonium (mg N/dm³).
Exhibit E:11 Cowles Bog Wetland Complex soil chemistry: Ammonium (ug N/l).
Exhibit E:12 Cowles Bog Wetland Complex soil chemistry: Nitrate (ug N/l).
Exhibit E:13 Cowles Bog Wetland Complex soil chemistry: Nitrate (mg N/dm³).
Exhibit E:14 Cowles Bog Wetland Complex soil chemistry: Density (g/cm³).

Exhibit F Series
Exhibit F:1 Management plots and demonstration planting area in Cowles Bog Wetland Complex.

Exhibit G Series
Exhibit G:1 Desired vegetation units in Cowles Bog Wetland Complex following restoration.

APPENDIXES

Appendixes B Series
Appendix SII:B-1 Species that were observed in Cowles Bog Wetland Complex from 2002-2004..... 1
Appendix SII:B-2 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Total project area..... 11
Appendix SII:B-3 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: West shrub unit..... 18
Appendix SII:B-4 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Forested swamp unit..... 22
Appendix SII:B-5 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: East shrub unit..... 25
Appendix SII:B-6 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Raised fen unit..... 29
Appendix SII:B-7 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: North graminoid fen unit..... 33
Appendix SII:B-8 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: South graminoid fen unit..... 37
Appendix SII:B-9 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Cattail unit..... 39
Appendix SII:B-10 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Disturbed prairie unit..... 43
Appendix SII:B-11 Species that were previously observed in Cowles Bog Wetland Complex, but not observed from 2002-2004..... 45
Appendix SII:B-12 Species that were reported previously in Cowles Bog Wetland Complex, but not observed from 2002-2004..... 48
Appendix SII:B-13 Crosswalk for scientific nomenclature between Integrated Taxonomic Information System and Flora of Chicago..... 52

Table of Contents (continued)

Appendixes C Series

Appendix SII:C-1 Species detected in the seedbank of Cowles Bog Wetland Complex..... 65

Appendix SII:C-2 Species detected in the seedbank East of Mineral Springs road..... 67

Appendix SII:C-3 Species detected in the seedbank of the defined plant assemblages present in Cowles Bog Wetland Complex and East of Mineral Springs road..... 68

INTRODUCTION

Great Marsh is an inter-dunal peat base wetland in a dune-beach complex less than one-mile from Lake Michigan (Exhibit A:1). The wetland sits between two large dune systems. The southern perimeter is delineated by the Calumet Dunes, formed approximately 9,000 years ago. The Toleston Dunes and recent dunes, formed approximately 4,000 years ago, delineate Great Marsh's northern perimeter. Great Marsh is the largest inter-dunal wetland associated with Lake Michigan. Cowles-Bog Wetland Complex (CBWC), as defined in this report, represents 83 ha (205 acres) of the western terminus of Great Marsh (Exhibit A:2).

In the early 1900's, only four conifer-dominated peatlands were identified within the southern Lake Michigan dune system. Today, of these four conifer-dominated peatlands, only CBWC remains. The other three peatlands were obliterated as a side product of urban and industrial development of southern Lake Michigan. CBWC includes a 22 ha (54.3 acres) National Natural Landmark given the name Cowles Bog to memorialize Professor Henry Chandler Cowles one of the fathers of ecology in America (Exhibit A:2). CBWC provided an inspirational focal point for Professor Cowles, stimulating intellectual examination of ecological successional processes (Cook 1999). In the early 1900's, Cowles and other professional educators routinely led students on excursions to what was then referred to as Mineral Springs Quaking Bog (Cook 1999, Watts 1975). Also, Cowles led a group of visiting European scientist participating in the 1913 International Phytogeographic Excursion in America to Mineral Springs Quaking Bog (Cook 1999, Tansley 1917).

Early ecological and botanical explorers wrote of three wetland types present at CBWC (Lyons 1927). On the northern edge one would pass through Cowles Tamarack Swamp followed by Mineral Springs Quaking Bog. Beyond the quaking bog was forb-grass-sedge vegetation of the great subdunal marsh. In several scientific publications in the 1920's, the site was referenced as Cowles Tamarack Swamp (Brennan 1923, Pepoon 1927) which likely included two of Lyons' wetland types: Cowles Tamarack Swamp and Mineral Springs Quaking Bog. The first documented reference to Cowles Bog is found in the published research of a Henry Cowles' student; Herman Kurz (1923, 1928). Kurz included both of Lyons' wetland types in his reference

to Cowles Bog. Throughout the twentieth century the unique wetland types and presence of unusual plant species, being readily available for observation, provided inspiration to fledgling plant ecologists and naturalists (Cook 1999).

In 1960, the non-profit group "Save the Dunes Council" purchased 22 ha of CBWC; an area with the legal land title of "Cowles Bog". These lands included a mounded fen, forested swamp, graminoid wetland, and sand dunes. The mounded fen is one of only four mounded fens in Indiana and is unique because it is not associated with any adjacent topographic relief (personal communication, John Bacone; Division Director; Indiana Department of Natural Resources, Nature Preserve Management). On December 2, 1965, Cowles Bog was designated a National Natural Landmark and in 1966, CBWC became part of the National Park System; Indiana Dunes National Lakeshore. Today CBWC is the focal point for approximately 60 interpretive and educational programs conducted by National Park Service staff and staff of the Dunes Environmental Learning Center.

From the perspective of biological significance, CBWC's abiotic signature reveals a marvelous composition of bog, fen, swamp forest, sedge-meadow, wet-mesic prairie, shallow-marsh, and a floating mat all intertwined in a relatively small area. Historically, this richness of wetland types provided habitat for a unique assemblage of biota. Wilhelm (1990) identified 41 special floristic elements, of which, 15 of them were state listed species. At the fen of CBWC, one finds the only native stand of eastern white cedar (*Thuja occidentalis*) in Indiana. In the 1970's, the federal endangered butterfly, Mitchell's satyr (*Neonympha mitchellii mitchellii*), was observed (Texas Instruments Incorporated; Ecological Services 1976). Other documented fauna include seven species of state listed and/or park rare reptiles and amphibians (Resetar 1985, 1994). These species are spotted turtle (*Clemmys guttata*), four-toed salamander (*Hemidactylium scutatum*), northern leopard frog (*Rana pipiens*), western chorus frog (*Pseudacris triseriata*), blue-spotted salamander (*Ambystoma laterale*), and massasauga rattlesnake (*Sistrurus catenatus catenatus*). Concerning ornithological resources, the occurrence of dense cattail has resulted in declines of or prevented total use of CBWC by once commonly observed waterfowl and other species such as sedge wren (*Cistothorus platensis*), marsh hawk (*Circus cyaneus*), American bittern (*Botaurus*

lentiginosus), sora (*Porzana carolina*), Virginia rail (*Rallus limicola*) and least bittern (*Ixobrychus exilis*) (Apfelbaum et al. 1983).

This report is comprised of three sections. Section one presents a history of CBWC from its geologic formation through loss of its ecosystem resilience. Section two provides the results of inventory conducted in 2001 through 2003 and Section 3 presents restoration alternatives with associated costs necessary to thrust CBWC into an alternate stable state reflective of that documented by early twentieth century scientists and naturalists.

SECTION I- HISTORY

INTRODUCTION

Three phases of events extending from the geologic formation of CBWC through two periods of study and exposure to anthropogenic induced stressors are presented: Phase 1-Geologic Formation; Phase II-Early Twentieth Century Events; and, Phase III-Late Twentieth Century Events. During the first phase, geologic forces formed Great Marsh. The last two phases are associated with erosion of ecosystem resilience resulting in a regime shift to a biota-poor alternate stable state and investigations that documented the changing landscape. An aerial photographic presentation of the changing landscape is provided (Exhibits A:3; A:4; A:5). A summary of each phase, including scientific investigations and anthropogenic stressors that occurred during Phases II and III are provided below. Following summation of the three Phases, critical stressors responsible for the alternate stable state are discussed.

Phase 1: Geologic Formation

The geologic formation of the pre-settlement landscape of southern Lake Michigan was driven by glacial activity. The last great ice sheet experienced by Northwest Indiana was the Wisconsin glacier. Events associated with this ice sheet are responsible for present day natural landforms of Northwest Indiana extending from the Valparaiso Moraine north to Lake Michigan. The Valparaiso Moraine which extends from Northwest Indiana through Palos Hills, Illinois to Wisconsin was formed during a static phase of the Wisconsin glacier. Following this static

phase, the Wisconsin glacier moved north resulting in the formation of Lake Chicago. This event occurred approximately 14,000 years ago.

Within the approximate 14,000 year time span between Lake Chicago and present day Lake Michigan, geologist recognize twelve major phases representing expansions or contractions of the Lake (Chrzastowski and Thompson 1994). The varieties of land forms found in Northwest Indiana reflect this glacial activity. Among these landforms are the Lake Border Moraine, Glenwood dune ridge, Calumet Dune ridge, Toleston Dune ridge and recent dunes. The Great Marsh formed approximately 4000 years ago during the second Nipissing phase. The Calumet dune ridge and Lake Border Moraine are present on the southern edge of Great Marsh and the Toleston Dunes and recently formed dunes are present on the northern edge of Great Marsh. Detailed information pertaining to the glacier activities associated with the Wisconsin glacier is provided by Hansel et al. (1985), Bluckley (1974), Bartlein and Webb (1982), Thompson (1986, 1988, 1990), Thompson and Baedke (1997), and Futyma (1988).

Four thousand years ago, Great Marsh was an open water body situated between two dune systems with one outflow point to Lake Michigan. At the time of early European exploration of southern Lake Michigan, Great Marsh had evolved from a lake stage to a rich and diverse assemblage of various wetland types inclusive of, among others, conifer swamp, wet prairie, fen, bog, marsh and sedge meadow. Great Marsh, exhibiting an average width of 0.5 mile, extended west from the western edge of Michigan City for approximately 12 miles merging at its western terminus with an extensive system of riparian wetlands of over 20,000 acres associated with the Calumet River (Cook and Jackson 1978).

Phase II: Early Twentieth Century

The following summary of twentieth century anthropogenic activity in the CBWC area is based on documentation provided in Marciniak (1978) and Cook and Jackson (1978).

In the 1850's fewer than 100 residents resided within the Calumet region, a region defined by the Calumet River north to Lake Michigan. The Calumet region featured extensive wetland habitat; a region referred to by many as an area of "wet morass". Wildlife included bison, bears, wolves, fox, beaver, mink, muskrats and an abundance of waterfowl.

In 1850, all wetlands in Indiana were entitled to the state by the federal government. This entitlement was followed by aggressive efforts to drain wetlands for commercial and residential use. Commercialization of wetlands resulted in notable impacts to CBWC and to the entirety of Great Marsh. The single watershed of Great Marsh, Dunes Creek watershed, was divided into three watersheds: Dunes Creek watershed, Derby Ditch watershed, and Brown/Kinzle Ditch watershed. The eastern boundary of CBWC was established by extension of Mineral Springs Road to a newly incorporated town; Dune Acres. Lakeplain wet-mesic prairie of Great Marsh, a plant community that extended north from the Lake Border Moraine and the Calumet dune to the sedge meadow plant community of Great Marsh was extirpated. This plant community was destroyed through hydrological alterations associated with construction of transportation infrastructure such as U.S. Route 12 and railroad tracks at the base of the Calumet Dune and Lake Border Moraine and excavation of numerous ditches throughout the lakeplain wet-mesic prairie. The first action intercepted and altered the natural flow of surface and groundwater, the sustenance of the lakeplain wet-mesic prairie, while the latter action lowered the water table of the lakeplain wet-mesic prairie wetland so that row crop agriculture could be conducted. Today, lakeplain wet-mesic prairie is considered globally imperiled and is considered a Tier 1 conservation target by The Nature Conservancy (Faber-Langendoen 2001).

In CBWC two jurisdictional ditches were constructed. Samuelson ditch conveyed water west through the western portion of Great Marsh, an area known as the Bailly Town Sag, to the riparian wetlands of the Calumet River. State ditch conveyed water east under Mineral Springs Road to Dunes Creek. In the early 1920's, the town of Dune Acres drained two intradunal wetlands adjacent to CBWC, Cranberry Bog and Little Lake, into CBWC. To allow the free movement of water, several ditches were constructed across CBWC to connect water from the intradunal wetlands to jurisdictional ditches. These intradunal wetlands were drained for the purpose of golf course construction. A Native American trail was altered to provide a one-lane dirt road along the northern boundary of CBWC to gain access to the golf course. Other activities included haying of the graminoid resource, cattle grazing, removal of conifers through lumbering, and harvesting of native plants. In this latter case, plants were harvested and then sold in the Chicago market place for decorative purposes (Pepoon 1927).

During the early portion of Phase II, CBWC gained scientific recognition for its unique biota and landscape features. The tamarack swamp and quaking bog units of CBWC were routinely discussed and explored by students studying under the direction of Henry Cowles (Cook 1999, Watts 1975). Regional rare plant species that were observed by scientists participating in the 1913 Phytogeographic Excursion in America were documented (Fuller 1913) and Tansley, an excursion participate from England, wrote a descriptive interpretation of plant societies observed when visiting CBWC (Tansley 1917). Cressey (1928) included a description of Mineral Springs Quaking Bog in his book on the geology of the Indiana Dunes and Brenne considered Mineral Springs Quaking Bog to be one of the wonders of the dunes (1923). Plant species observed at the dunes of Indiana inclusive of Mineral Springs Quaking Bog/Cowles Tamarack Swamp were compiled by Lyon (1927, 1930), Pepoon (1927), and Buhl (1934, 1935).

The first quantitative studies conducted at Cowles Bog were by a student of Henry Cowles; Herman Kurz (Kurz 1923, 1928). Kurz's work demonstrated that while soils of the tamarack swamp adjacent and north of the quaking bog were slightly acidic, pH of 5.5 to 6.0, soils of the quaking bog proper were circumneutral; pH 7.0 to 7.5. In the early 1900's, the ecological community did not have a vocabulary that allowed one to distinguish between peatland types. By the mid-1900's, the ecological community routinely defined minerotrophic peatlands with an ion rich water source to be fens and peatlands with an ion poor water source to be bogs. Kurtz's investigations in the 1920's were the first documented evidence that the quaking bog may be a fen.

Phase II lasted for approximately 80 years from 1850 to 1930. Cowles Bog was named, described, species list compiled, and its significance as a natural dune feature confirmed. Kurtz's work provided the first objective data suggesting that Cowles Bog was not an acidic bog but rather, in the language of that era, a circumneutral bog. This data supported the suggestion by the 1913 phytogeographic excursion participates that the quacking bog resembled a circumneutral bog.

Overall, CBWC exhibited ecosystem resilience to Phase II anthropogenic perturbations. The exceptions were the demise of CBWC's lakeplain wet-mesic prairie and the thrusting of the tamarack dominated swamp into an accelerated successional trajectory toward greater representation by red maple (*Acer rubrum*). In the first case, CBWC's lakeplain wet-mesic prairie which was drained and farmed was colonized by red maple, black cherry (*Prunus serotina*), black locust (*Robinia pseudoacacia*), and spice bush (*Lindernia benzoin*) following cessation of agriculture. In the latter case, the acceleration of the succesional trajectory of the tamarack swamp was the byproduct, in large part, of harvesting of the coniferous resource.

During the time period from 1930 to 1960, there was a pause in scientific study of CBWC and generally new sources of anthropogenic stressors were absent. Documented observations of naturalist confirmed that CBWC retained its unique biota throughout this period. Examples of written and oral documentation are provided below.

> "One of the finest remaining stands of the small white lady's slipper (*Cypripedium candidum* Muhl.) is in Cowles Bog. The showy lady's slipper (*C. reginae* Walt.) is well represented." (Sullivan 1964, a student of Henry Cowles; neither of the above orchid species have been observed in CBWC since the early 1990's).

> "Cattail was only found in low spots such as pockets with roses and meadowsweet. Years ago, one could see across the entire wetland system because it was dominated by grasses and sedges that weren't much over shoulder height. ...It was swell and swale topography. The substrates were solid in the grass and sedge association, unlike the substrates in the present cattail association" (Apfelbaum et al. 1983; oral testimony of observations in the 1940's and 1950's by long time Dune Acre resident Louis Howes).

> "In walking the Cowles Bog area, I found two colonies of bunchberry (*Cornus canadensis*). .....The western colony is perhaps 50 plants. The eastern colony is actually two colonies close together of perhaps 200 plants." (Delano Arvin M.D. letter to Mr. Henry Jones, interpreter at Indiana Dunes National Lakeshore, May 20, 1979; bunchberry has not been observed since the late 1980's).

Phase III: Late Twentieth Century

Starting in the early 1960's and through the 1970's, stressors generated by industrial development adjacent to and west of CBWC moved CBWC over a critical threshold into an

undesirable alternate stable state. Based on interpretation of infrared aerial photography, in 1938 there were 56.4 ha of sedge-grass, 2.0 ha of cattail, 6.0 ha of shrub and 16.3 ha of forested vegetation (Exhibit A:6; Apfelbaum et al. 1983, Wilcox et al. 1984). In the 23 years between 1938 and 1961, there was little change in these vegetation types; in 1961 vegetation types present were 52.4 ha of sedge-grass, 3.5 ha of cattail, 13.3 ha of shrub and 11.5 ha of forested vegetation (Exhibit A:7). However, in the 18 years between 1961 and 1979, there was a rapid change from a diverse forb-grass-sedge plant assemblage with a diversity of fauna to one dominated by non-native cattail (narrow leaf cattail and hybrid cattail) and shrubs with limited fauna. In 1979 vegetation types present were 6.7 ha of sedge-grass, 37.7 ha of cattail, 16.1 ha of shrub and 20.2 ha of forested vegetation (Exhibits A:8; A:9; A:10).

In the 1960's, a steel manufacturing plant and an electrical power generating facility were constructed in the western portion of Great Marsh and associated dunes; resulting in extirpation of the largest dunes of southern Lake Michigan. At this time, due to fill placed in the western portion of Great Marsh, a beaver colony fled east taking up residence in CBWC adjacent to Mineral Springs Road. Beaver dam construction at the Mineral Springs Road culvert raised water levels by 38 to 45 cm causing water to flow over the road (Dune Acres Historical Commission 1997, Chesterton Tribune May 10, 1966). The Northern Indiana Public Service Company (NIPSCO) defined the southern boundary of CBWC by placement of fill in Great Marsh forming a sand berm. In addition, NIPSCO excavated wetland to the south of the sand berm converting wetland to open water. Northwest of CBWC, fly ash ponds were constructed and groundwater dewatering associated with construction of a nuclear power facility was conducted. Directly west and adjacent to CBWC, accumulated fly ash from the northwest ponds, bottom ash, limestone fragments, and miscellaneous discarded materials, were placed in an unsealed fill site (Hardy 1981).

In response to these extreme industrial actions adjacent to a national park, in 1977, Congress of the United States added language to the enabling legislation of Indiana Dunes National Lakeshore "to study and report concerning the following objectives: ... (b) preservation and restoration of the watersheds of Cowles Bog and its associated wetlands;". This authorization was, in part, to provide data to defend against any harm to INDU resulting from the above actions.

In the 1970's through the early 1980's, the United States Geological Survey (USGS) installed monitoring wells and conducted mathematical simulations to determine impacts of fly-ash ponds, and dewatering on adjacent NPS lands (Marie 1976, Meyer and Tucci 1979, Gillies and Lapham 1980, Hardy 1981, Cohen and Shedlock 1986). These studies concluded that seepage of water and toxic metals from fly ash ponds extended north into the shoreline dunes and east of the fly ash ponds for 1,000 meters (Cohen and Shedlock 1986). This footprint of negative impact to NPS lands did not include CBWC (Cohen and Shedlock 1986). However, Cohen and Shedlock (1986) neglected to consider groundwater movement into Golf Course Ditch. Groundwater from the fly ash ponds entering Golf Course Ditch would have been conveyed to CBWC. Hardy (1981) documented increased concentrations of boron, molybdenum, and potassium in the surface water of CBWC due to leaching of these chemicals from the landfill west and adjacent to CBWC.

Rosenshein and Hunn (1968) identified four geologic units present at CBWC and associated dunes. Unit 1 was a sand layer ranging in depth from 0 to 35 feet and represents an unconfined sand aquifer. Unit 2 was a clay layer ranging in thickness from 0 to 80 feet. Unit 3 was a confined sand aquifer ranging in thickness from 0 to 80 feet and Unit 4 was primarily a silt and clay layer on top of bedrock with thickness ranging from 60 to 140 feet.

In 1979 and 1980, USGS and staff from Indiana Dunes National Lakeshore's Scientific Division, installed a complex of monitoring wells on and around the raised fen of Cowles Bog National Natural Landmark. This data, the first to provide an explanation for the raised fen, suggested that there was a thinning or absence of Unit 2, the confining unit, allowing for pressured communication between the confined aquifer (Unit 3) and the raised mound (Hendrickson and Wilcox 1979, Gilles and Lapham 1980, Wilcox, Shedlock and Hendrickson 1986). This discovery exceeded significance of fulfilling only scientific curiosity because NIPSCO altered their dewatering plans for construction of the nuclear facility to include pumping directly from the confined aquifer (Unit 3). Simulations by Gillies and Lapham (1980) suggested that this action could negatively impact the hydrology of CBWC; lowering the water levels at Cowles Bog National Natural Landmark by 0.3 meters. The accuracy of Gilles and Lapham's simulations was not confirmed because NIPSCO abandoned construction of the nuclear power plant in 1981.

Kurz (1923, 1928) who reported soil pH values of 7.0 and greater at the quaking bog of Cowles Bog was the first investigator to provide scientific evidence that abiotic parameters of portions of Cowles Bog may not be consistent with those anticipated in a true bog. Additional data supporting Kurz's conclusions were accumulated throughout the 1970's and 1980's. Arihood (1975) included CBWC in a study of water chemistry at INDU and reported values of specific conductance (387 uS/cm), pH (7.4), alkalinity (176 mg/l as CaCO3), calcium (43 mg/l) and magnesium (19 mg/l). These water chemistry values are consistent with those of a rich fen.

Carter and Stottlemyer (1978) formally classified the quaking bog unit of Cowles Bog a fen. They also described vegetation, soils, and water depths at a series of points established along three transects. Boelter (1978) made detailed assessments of peat materials along one transect established by Carter and Stottlemyer. Boelter was the first investigator to describe the peat mound of Cowles Bog and demonstrate an association between groundwater flow and the peat mound. Boelter's work supported Carter and Stottlemyer's fen classification. Detailed work by the USGS and the scientific division of Indiana Dunes National Lakeshore provided final confirmation that a raised fen was present in CBWC (Hendrickson and Wilcox 1979, Gilles and Lapham 1980). As presented above, Hendrickson and Wilcox (1979) and Gilles and Lapham (1980) verified that strategic thinning of Unit 2 allowed for pressured communication between the confined aquifer (Unit 3) and the raised mound thereby providing a source of mineral rich hydrology.

Other investigations conducted during this time included baseline biological inventory inclusive of vegetation, mammals, birds, reptiles, amphibians and invertebrates (Texas instruments Ecological Services 1974-1981, Ecological Research Services, Inc. 1983). Resetar included CBWC in inventory work on state listed and park rare reptiles and amphibians (Resetar 1985, 1994). Soil profiles acquired through vibracores were evaluated for molluscan faunal changes, pollen profiles, and stratigraphy of sediment types. These studies allowed for clarification of the geologic time periods with accompanying water level and vegetation changes associated with development of Great Marsh and CBWC (Futyma 1988, Miller and Thompson 1990, Thompson 1988, Thompson 1990). In addition, evaluation of metal concentrations in a peat core from the raised fen documented increased levels of metals associated with industrial development

followed by decreasing concentrations with implementation of environmental controls (Cole et al. 1990).

The floristic composition of CBWC was documented by Wilhelm (1980, 1990). Bowles et al. (1983, 1984) and Bowles (1988, 1991) conducted surveys and monitored state listed rare, threatened, and endangered species. Wilcox et al. (1986) mapped eight vegetation types in the CBWC. In the process of developing a proposal for a prescribed burn, vegetation of the quaking bog located north and east of the raised fen was quantitatively assessed (Klick 1988). Quantitative vegetative assessments of portions of CBWC were conducted by Apfelbaum et al. (1983) and Carter and Stottlemyer (1978). The time sequence of the demise of CBWC's unique floristic resource was documented through interpretation of black and white and inferred aerial photography (Apfelbaum et al. 1983, Wilcox et al. 1984).

During Phase III, Cowles Bog revealed to investigators the "what and why" responsible for its existence. The National Park Service acted upon the Congressional directive "to study and report concerning the following objectives: ... (b) preservation and restoration of the watersheds of Cowles Bog and its associated wetlands;". At the completion of these studies, the consensus of Indiana Dunes National Lakeshore's scientific staff on the ultimate fate of CBWC may best be summed up by the final paragraph in Wilcox et al. (1984).

> "The ultimate fate of the Cowles Bog Wetland Complex appears to be the continued loss of sedge meadow. Although the loss of the sedge-grass vegetation type has slowed in recent years, the presence of cattails and shrubs within sedge meadows suggests that they will ultimately be eliminated. Effective cattail management practices are not likely to be initiated for several reasons. Alterations of pH or other water chemistry parameters (Wilcox 1982) are not likely; the status of the CBWC as a National Park Service property means that herbicide cannot be considered; and the presence of many special vegetation elements (Wilhelm 1980) means that any control method would have to be very species specific. The most successful method for controlling cattails (Beule 1979) is cutting followed by flooding. In addition to the manpower-intensive cutting effort that would be required, subsequent flooding attempts would probably not be possible because of public roads and private residential property adjacent to the wetland. Also, several portions of the cattail community have developed floating mats that could not be flooded."

SUMMARY

In the 150 years of occupation of the Calumet region by those of European heritage, landscape change of this unique ecosystem has been equivalent to landscape alterations realized by

thousands of years of passive geologic forces. Surprisingly, CBWC exhibited strong ecosystem resilience to these anthropogenic stressors until total annihilation of the western adjacent dune-wetland ecosystem in the 1960's. Critical twentieth century negative events influencing CBWC's successional trajectory are as follows:

1. Transportation infrastructure was constructed, Buffalo and Mississippi Railroad (1830-1840), South Shore Line Railroad (1906-1908) and U.S. Route 12 (1920's), at the northern edge of the Lake Border Moraine and on a portion of the Calumet Dune Beach complex.

2. Jurisdictional ditches, State Ditch and Samuelson Ditch (1880 – 1920), were constructed in CBWC.

3. Numerous ditches were constructed throughout the lakeplain wet-mesic prairie of Great Marsh (1920's); extending from the Lake Border Moraine to sedge meadow of Great Marsh.

4. The lakeplain wet-mesic prairie of Great Marsh was utilized for commercial and residential purposes (1900-present day).

5. Intra-dunal wetlands, Cranberry Bog and Little Lake, were drained for golf course construction (late 1920's). Drainage of these wetlands required the construction of additional ditches through CBWC to convey water from these intra-dunal wetlands to jurisdictional ditches.

6. A Native American trail along the northern edge of CBWC was expanded and used to gain access to the golf course (late 1920's).

7. White pine and herbaceous plants were harvested from forested areas of CBWC; cattle were pastured; graminoids were harvested for hay (early 1900's to 1950's, pasturing likely terminated in 1930's but logging of white pine reported as late as 1950's).

8. The dune-wetland ecosystem to the west of CBWC was annihilated (1961 NIPSCO plant completed; 1965 Bethlehem Steel plant completed).

9. A sand dike was constructed through Great Marsh defining the property boundary between Indiana Dunes National Lakeshore (north and east of the sand dike) and NIPSCO (south and west of the sand dike and inclusive of it; north to south dike was constructed by 1961 and the west to east dike by 1973).

10. Beaver fleeing from destruction of the western dune-wetland ecosystem take up residence at Mineral Springs Road (early 1960's).

11. Immediately south of the sand berm, wetland was excavated to form an expansive area of open water (1974).

12. Fly ash ponds were constructed and utilized throughout the 1970's; land immediately west of CBWC was used for placement of fly ash and other materials.

Events 1 through 4 altered critical hydrology supporting the lakeplain wet-mesic prairie of Great Marsh resulting in its obliteration (except for a small strip maintained by NIPSCO). By the 1950's, most crop farming had ceased and in the late 1960's the National Park Service initiated removal of homes constructed in the lakeplain wet-mesic prairie of Great Marsh. However, following cessation of crop farming, the lakeplain wet-mesic prairie was colonized by woody vegetation. The present day degraded state of this wetland prairie type is epitomized by the presence of remnant footprints of homesites, woody vegetation and a functioning ditch system. This degradation is prevalent on that portion of the lakeplain wet-mesic prairie associated with CBWC.

Events 5 through 7 are responsible for accelerated succession thrusting the conifer dominated forested swamp into a red maple dominated swamp. White pine was lumbered from CBWC and adjacent dunes and sold for profit gained (Newman and Doyle 1995). Greater canopy cover resulting from a dominance of red maple would not have been supportive of orchids and other forbs occurring in the conifer understory. Removal of attractive wild flowers from the swamp for personal and commercial use (Pepoon 1927) contributed to declines in populations of these forbs. Golf course and road construction would have provided access to the adjacent forested swamp.

Wetland drainage resulting from construction of jurisdictional ditches (Event 2), while drying the wetland sufficiently to allow for haying and grazing of its graminoid resource, was not sufficient to cause a shift from wetland vegetation to upland vegetation. Aerial photography and oral history provides evidence that wetland vegetation was not replaced by upland vegetation. However, even partial draining of muck/peat soils can result in their compression and subsidence (Snyder 2004; Ewing and Vepraskas 2006; National Engineering Handbook-Section 16). Subsidence of soils in the central portion of CBWC was substantiated by Boelter (1978) who reported a layer of aggregate organic materials one-quarter to one-half meter below the soil surface.

The annihilation of the western dune-wetland ecosystem (Event 8) in conjunction with construction of the sand berm (Event 9) prevented water flow to the west. Beaver built a dam at the culvert conveying water east under Mineral Springs Road causing water to flow over Mineral Springs Road (Event 10). These events resulted in a confined wetland with normal water level based on the elevation of Mineral Springs Road. Water from fly ash operations entered Golf Course ditch resulting in unnatural conveyance of surface water into CBWC (Event 5). Conversion of wetland to open water south of the sand berm (Event 11) resulted in a positive hydrostatic head maintaining stable water levels in the confined wetland (CBWC). Events 5, 8, 9, 10, and 11 in concert with soil subsidence, resulted in water depths that exceeded water depth tolerances of the existing forb-grass-sedge wetland plant assemblage, but provided water depths favorable for cattail growth. Narrow leaf cattail and hybrid cattail responded aggressively; rapidly colonizing denuded areas throughout the central portion of CBWC. In higher zones, conditions were favorable for colonization of shrubs and trees such as silky dogwood (*Cornus obliqua*), red maple and trembling aspen (*Populus tremuloides*). The rapid expansion of cattail and shrubs was documented through interpretation of aerial photography (Wilcox et al. 1984; Exhibits A:6 – A:10).

Within the realm of anthropogenic stressors, it is important to recognize that arrival of Europeans to North America initiated genetic communication among plant species that previously were isolated. This European facilitated genetic communication among plant species contributed to the demise of CBWC. In the 1700's, movement of goods and people from Europe to the United States transported narrow leaf cattail (*Typha angustifolia*) from Europe to northeastern United States seaports. Narrow leaf cattail was then conveyed to the Great Lakes through shipping and along highway corridors (Galatowitsch et al. 1999). Interbreeding between narrow-leaf cattail and the native broad-leaf cattail (*Typha latifolia*) resulted in a hybrid cattail (*Typha x glauca*). Hybrid cattail exhibits growth forms and growth behaviors favorable for rapid invasive expansion. Genetic testing of cattail in CBWC suggests that the cattail assemblage of CBWC is comprised of the non-native narrow-leaf cattail and hybrid cattail (Travis et al. 2009).

glauca

SECTION II – INVENTORY

INTRODUCTION

Following the final conclusions of the Park's scientific staff concerning restoration potential of CBWC (Wilcox et al. 1984; Section I), restoration of CBWC was not actively embraced by the National Park Service. Douglas Wilcox and Ronald Hiebert, the most actively involved scientists participating in CBWC investigations, left for other positions in the late 1980's. In 1994, the Park's scientific staff was disassociated from direct park management; first as the National Biological Survey and then as part of the United States Geological Survey. At this time, scientific staff members focused on upland dune ecosystem investigations with emphasis on habitat improvement of the federal listed Karner Blue Butterfly (*Lycaeides melissa samuelis Nabokov*).

Throughout the late twentieth century and continuing into the twenty-first century; investigations into natural area restoration techniques and execution of them expanded at a rapid rate. A stimulus to wetland restoration knowledge followed the Clean Water Act (1972) and the Swampbuster Provision of the Food Security Act (1985). By the late 1980's, enforcement of provisions in these Acts throughout the United States facilitated wetland creation, restoration and enhancement to compensate for commercial, agricultural and residential impacts to wetlands. In response to this new knowledge base there was renewed interest in restoring CBWC.

While much information had been collected in the late twentieth century, data were insufficient for development of a restoration plan for CBWC. Data were insufficient because (1) most efforts had been focused on the raised fen, forested swamp, and immediate adjacent zones; areas defined by property boundaries of the original real estate purchase of Save the Dunes Council; (2) throughout the late 1900's, plant communities continued to exhibit passage along a negative trajectory; and, (3) critical data such as surface and groundwater hydrology, soil chemistry, water chemistry, and seedbank were absent. In 2002 through 2004, actions were taken to inventory the resources of CBWC and to explore experimentally the response of CBWC to various management and planting protocols. Section II presents results of this inventory and investigation work. The results are presented in accordance to the major inventory and investigation themes as provided below.

Section II:A – General Observations
Section II:B – Vegetation;
Section II:C – Seedbanks;
Section II:D – Abiotic parameters: Hydrology, Water Chemistry; Soil Chemistry
Section II:E – Management Protocols.

SECTION II:A – GENERAL OBSERVATIONS

Watershed

The historic watershed of Cowles Bog Wetland Complex (CBWC) has been altered by anthropogenic modifications of the adjacent landscape. Prior to landscape modifications, the western edge of CBWC represented a watershed divide. To the west of this divide, water flowed into the Calumet River and to the east of the watershed divide water flowed into Dunes Creek. At present, all surface water flows northeast and southeast to the one culvert beneath Mineral Springs Road. This culvert represents the only outflow point from the CBWC to wetland of Great Marsh east of Mineral Springs Road (Exhibit A:11).

In 2002, surface water sources for CBWC were investigated. The CBWC's perimeter and adjacent lands were field inspected and aerial photographic maps and topographic maps evaluated. Exhibit A:11 provides an aerial overview of CBWC, the adjacent landscape, and flow patterns of surface water.

A ditch plug was placed in Golf Course Ditch in 1999. Based on visual inspection, the ditch plug has retained it structural integrity and continues to prevent unnatural flow of surface water into CBWC from the northwest. The construction of an east to west sand dike in 1973, forming the southern boundary of CBWC, prevents surface water flow from the south entering the southwestern zone of CBWC. However, the presence of seep zones at the base of the sand dike signifies that surface water from the adjacent open water body moves through the base of the dike into CBWC.

Inspection of adjacent land west and south of the open water body failed to locate culverts or landscape features that would convey surface water into the open water body from the south or west. Therefore, one must assume that water level in the open water body is driven by precipitation and groundwater from the Lake Border Moraine. Surface water from the open water

body is conveyed east to the disturbed prairie unit of CBWC (Exhibits A:11, C:x) through a connecting ditch. This ditch connects to two ditches on the west edge of the disturbed prairie unit. The ditches in the disturbed prairie unit convey surface water from the open water body into the east shrub unit of CBWC (Exhibits A:11, C:2).

Surface water from the Lake Border Moraine is captured by a ditch system south of the South Shore Railroad. The surface water is directed to a culvert that lies beneath the South Shore Railroad and Mineral Springs Road. This culvert surfaces on the east side of Mineral Springs Road. Therefore, surface water from the Lake Border Moraine is directed to a portion of Great Marsh east of Mineral Springs Road.

The watershed of CBWC is largely defined by maximum dune elevation of adjacent dunes on the western and northern boundary of CBWC and on the western, northern and eastern boundary of wetland contiguous to CBWC. This contiguous wetland to the north of CBWC is parkland belonging to the town of Dune Acres. From a non-political base this wetland is part of Great marsh and should be considered part of CBWC.

High dunes on the perimeter of CBWC comprise 38.2 hectare and the adjacent contiguous wetland 15.5 hectare. This relatively small watershed is reflected by a minimum increase in water levels following rain events. Seasonal patterns in surface water and groundwater levels are present in Section II-D.

Soil Classification

The National Resources Conservation Service identified three soil types present at CBWC (Exhibit A:12). These soil types were Houghton muck ponded, Adrian muck drained, and Maumee loamy sand representing 26.5 hectares, 10.1 hectares, and 35.1 hectares, respectively. In 2003, soil profiles were evaluated and soils classified at 32 points (Exhibit A:13). Based on this evaluation14 soil types were represented at CBWC in 2003. The most common soil type was Houghton muck which was present at 12 sample points (37.5 percent). Adrian muck was present at only three sample points (9.3 percent). Additional sampling will be necessary to determine the extent of these soil types in CBWC.

The Porter County soil survey was conducted in 1944 prior to 1960's disturbance of Great Marsh. The identification of Adrian muck drained in the southern portion of CBWC indicates that ditch construction in CBWC was successful in lowering the water table. Other differences can be attributed to the National Resources Conservation Service not including, in their soil maps, small enclosures of soil types and soil modification following landscape alterations and invasion by cattail.

Lake Bottom Contours

Ten thousand years ago the edge of Lake Chicago was defined by the present day location of South Shore Railroad to Route 12. Therefore, the soils of Great Marsh and CBWC overlay the sand based surface of historic Lake Chicago. Knowledge of the profile of Lake Chicago, will contribute to understanding other abiotic parameters and restoration direction.

In 2003, depth to sand was determined by thrusting a 4 m long probe of 1.0 cm diameter through the peat layer. At the point of probe penetration of the sand layer, measurement of the distance experienced by the probe was measured. Six hundred points along vegetation transects (Exhibit C:1) were measured. Contours representing depth to Lake Chicago were generated using Surfer® 8, a contour and surface mapping computer program. Contours were generated with Surfer's default kriging algorithm. These default settings use point type kriging, and employ a linear variogram.

The results of this analyses is provided in Exhibit A:14. Several features are notable. Depth to sand declines at the eastern boundary of CBWC. Seedbank and soil samples taken east of Mineral Springs Road reached a sand layer at depths of 20 to 30 cm suggesting that Mineral Springs Road was constructed on a submerged dune ridge. Depth to sand on the southwestern boundary of CBWC ranged from 220 to 300 cm reflecting the historic continuation of Great Marsh through the present day industrial zone. As one moves south to north there was a rapid increase in depth to sand from 220 to > 400 cm reflecting the transition from Lake Chicago's littoral zone to a zone of deeper water depths. One might speculate that the subdunal wetland mentioned by early 20th century botanical explorers developed in the littoral zone of Lake Chicago while other more unusual wetland types developed in areas of deeper water.

SECTION II:B VEGETATION

INTRODUCTION

Lyons (1927) considered CBWC to be comprised of three wetland types. On the northern edge one would pass through Cowles Tamarack Swamp followed by Mineral Springs Quaking Bog. Beyond the quaking bog was graminoid/forb vegetation of the great subdunal marsh. Bog type vegetation while common in regions north of Chicago, in the Chicago area they occurred as an isolated society of plants surrounded by more typical and common plant communities. Along Lake Michigan's southern boundary within the state of Indiana only three plant associations given the designation "bog" by early botanists were documented (Peattie 1930).

This oddity of a bog like plant association enticed early twentieth century botanical explorers to visit Cowles Bog. However, there is evidence that their exploration did not extend past the quaking bog; there was no stimulus to explore what was at that time a vast subdunal marsh of thousands of acres. Exploration of the subdunal marsh could take place through less stressful means. Therefore, species list compiled by early botanists were limited to the tamarack swamp and the quaking bog wetland types.

Investigations during phase III (see Section I) included vegetation evaluation in the forested swamp, quaking bog and subdunal marsh (Carter and Stottlemyer 1980, Apfelbaum et al. 1984). However, the subdunal marsh assessments were limited as indicated by only 28 sample points by Carter and Stottlemyer and 94 sample points by Apfelbaum. Based on quantitative assessment and field proofing, Apfelbaum et al (1983) provided a vegetation map of CBWC and vegetation change during the period from 1938 through 1982 was documented through interpretation of aerial photography (Apfelbaum et al 1983; Wilcox et al 1984). Wilcox et al (1986) mapped eight vegetation types found in the National Natural Landmark portion of CBWC and provided a species list for these vegetation types. Klick (1988) conducted vegetation evaluation along three transects in the quaking bog in preparation for a prescribed burn, however, only a list of observed species was provided in his proposal. Finally, a floristic assessment by Wilhelm (1980; 1990) and the monitoring of a limited number of permanent plots (Bowles 1984, 1985, 1988) documented the presence and status of state and park rare species in CBWC.

A list of plant species reported during vegetation exploration throughout the twentieth century but not observed during the 2002-2004 vegetation inventories is provided in Appendix SII:B-11. Appendix SII:B-12 provides the investigator that reported each of the species.

From 2002 through 2004, vegetation of CBWC was evaluated and mapped. The objective of the vegetation evaluation was to provide a detailed description of the vegetation inclusive of cattail stem densities, locations of invasive species other than cattail, rare plant locations, locations of remnant native plant assemblages, and the extent and locations of shrub and woody incursion.

METHODS

Sample Point Locations: In April of 2002, 14 south to north transects were established along CBWC's southern perimeter. Four transects were established north to south through the forested swamp along CBWC's northern perimeter. Two east to west transects were positioned along the center of the raised fen. Six lateral transects were positioned perpendicular to the westernmost central transect and three lateral transects were positioned perpendicular to the easternmost central transect. Finally, a west to east transect was located along the central portion of the north graminoid fen (quaking bog). This central transect was dissected with four north to south perpendicular lateral transects. An approximate location of transects and quadrats are provided in Exhibit C:1.

A PVC pipe, 3 m in length by 1.8 cm in diameter, was placed at 30 m intervals along each transect. The PVC pipe was marked with the appropriate transect and quadrat number. Following initiation of the vegetation survey, it was discovered that direct transition along transects from PVC pipe to PVC pipe was not possible because cattail height and density greatly reduced visibility. Therefore, wooden stakes were marked and placed at 10 m intervals between each PVC pipe.

To ensure complete coverage of CBWC, transects were positioned at approximately 90 m intervals with an element of randomness. Each transect and the first quadrat of each transect was provided with a 10 m range of potential position locations. The realized location of transects and first quadrat of each was determined through random selection of a number between 1 and 10.

Herbaceous Vegetation: Herbaceous and woody species less than 1 m in height were surveyed within 1 m square sample plots. A three-sided quadrat made of PVC pipe delineated the plots. Only species rooted within the plot were evaluated. If a plant was present at the in/out interface of the quadrat's side without a PVC pipe, a meter stick was used to provide a fourth side allowing accurate assessment of the plants location. A three-sided quadrat was used because of the great difficulty positioning a four-sided quadrat in 4 m tall cattail.

At each quadrat, a species list was compiled and the cover of each estimated using the Domin-Krajina cover-abundance scale (Mueller-Dombois and Ellenberg 1974). This cover-abundance scale was chosen because the human eye can more accurately discriminate among low cover percentages than among high cover percentages and because the scale can be converted to a more course scale such as Braun-Blanquet's scale (1965) or Daubenmire's scale (1959).

Cover-abundance scale
P = at least one individual present; percent cover minimal
+ = one or more individuals present; percent cover < 1
1 = ≥1 percent to ≤ 5 percent cover
2 = >5 percent to ≤ 10 percent cover
3 = >10 percent to ≤ 25 percent cover
4 = >25 percent to ≤ 50 percent cover
5 = >50 percent to ≤ 75 percent cover
6 = >75 percent to ≤ 95 percent cover
7 = >95 percent to ≤ 100 percent cover

In addition to cover estimates, total stem counts and sexual stem counts of cattail and a cover estimate of cattail litter were conducted. Plot surveys were conducted at 10 m intervals along transects 1 through 14 and 7N through 10N. Herbaceous vegetation was evaluated at 5 m intervals on the fen units. In total, 1,115 plots were evaluated. In 2002, surveys were conducted between July 1 and August 31. In 2003, three separate surveys were conducted. The first of these surveys targeted those plants that bloom or are otherwise apparent early in the growing season and disappear or become difficult to identify later in the growing season. This spring survey was conducted only in the portions of the wetland where spring vegetation was likely to be found (everywhere but areas of dense cattail) and occurred between May 7 and May 22.

The second survey, conducted between June 23 and July 7, focused on the sedges of CBWC. This survey was conducted across the entire wetland complex and recorded only the genus Carex. The last survey of 2003 was a complete survey of the herbs of the CBWC. It was conducted late in the season, August 25 - October 10. The 88 plots associated with transects 10 through 13 in the disturbed prairie unit were evaluated August through September 2008.

The collected data was combined into one data set. This data set represented, for each quadrat, all species observed in a growing season with a cover value reflecting the time of most favorable presence.

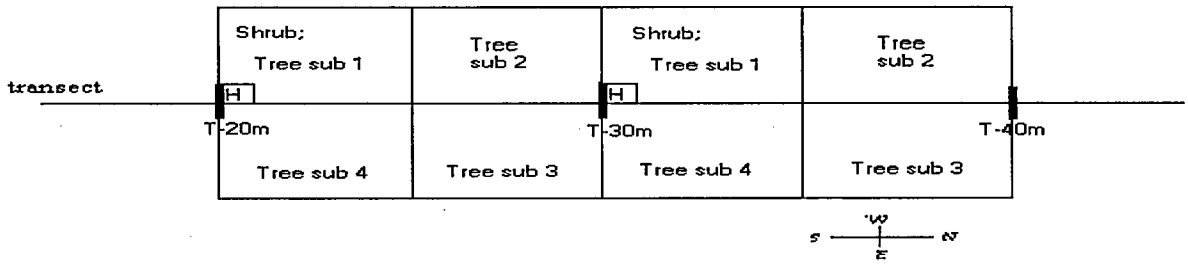
Woody Vegetation: Woody plants with a stem diameter at breast height of 7 cm or greater were considered trees. Shrubs were defined as woody plants greater than 1 m in height with a stem diameter at breast height of less than 7 cm.

Woody vegetation was surveyed in a continuous belt, 10 m wide, along each transect. The belt was subdivided into 10 x 10 m plots and four 5 x 5 m subplots. All trees rooted within each of the 5 x 5 m plots were identified by species and diameter at breast height measured. If a trunk diverged below breast height, each stem was measured. An estimate of cover over the entire 10 x 10 m plot was made for each tree species shading the plot.

Shrubs were surveyed within 5 x 5 m plots, which were delineated by two 5 m long PVC pipes arranged perpendicularly to transects being surveyed. All shrubs rooted within the plots and those that provided cover but were not rooted within the plot were identified to species and their cover estimated.

Woody vegetation of all areas except the fen units and disturbed prairie was evaluated from September 11, 2002 through October 9, 2002. The woody vegetation of the fen units was evaluated from September 2, 2003 through September 19, 2003 and that of the disturbed prairie unit from August 20 through Sept 22, 2008. A schematic representation of tree, shrub and herbaceous plots is provided below. Herbaceous plots and shrub plots were arranged on the west

side of north-south and south to north transects, and the north side of east-west transects. Tree plots straddled transects and were subdivided into four sections.



First Stage Analyses: A hierarchical agglomerative cluster analysis was conducted on tree and shrub species using presence and absence values (PC-ORD-V4 1999). A distance matrix was calculated based on the relative Sorensen method and quadrats linked through Wards method. Quadrats clustered at a value below 50 percent of information remaining were considered to represent field recognizable assemblages of woody vegetation.

For herbaceous vegetation, plant associates were investigated by developing contours of similar stem densities of cattail. These contour maps were created with Surfer® version 8 (Golden Software, Inc.2002). A Kriging algorithm was applied to the data set generating a regularly shaped grid of data over a specified area. A contour map was then generated connecting areas of an equal value. The grids for maps were generated from 1,115 data points, one for each quadrat on the vegetation transects. Vegetation of the disturbed prairie unit was not included in the analyses. Cattail presence in this vegetation unit was absent.

The cluster analysis indicated the presence of 12 recognizable woody plant assemblages. In April 2005, field mapping of woody plant assemblages was initiated. At this time, the woody assemblages identified through cluster analyses were modified in accordance to realized field conditions. For example, the tree species quaking aspen (*Populus tremuloides*) and peach-leaved willow (*Salix amygdaloides*) were cluster within the same group. However, while the understory

of each assemblage of the above two species was similar, they occurred as isolated units and were represented in the results as isolated units. Field mapping was accomplish by generating polygons by walking the perimeter of woody assemblages or acquiring point locations for individual trees and shrubs. Polygons and points were obtained using a Trimble GeoXT GPS unit.

Field evaluations were executed from April through May of 2005 and 2006. Field mapping was limited to the months of April and May. Prior to April, standing cattail litter and after May emerging cattail stems, interfered with access and necessary view distance to accurately map the woody plant assemblages. We estimate that approximately 90 percent of the woody vegetation was mapped.

Second Stage Analyses: Based on field mapping of woody vegetation, the generated contours of cattail stem densities, and CBWC's abiotic characteristics, eight vegetation units were defined. These units were provided with the following descriptors: west shrub, east shrub, forested swamp, north graminoid fen, south graminoid fen, raised fen, cattail, and disturbed prairie (Exhibits C:1 and C:2).

For each of the above units and the overall CBWC, an analysis of the collected data was conducted on each vegetation stratum: tree, shrub, and herbaceous. For the tree stratum, average density per 10 m square, average basal area per $10/m^2$, and average cover per $10/m^2$ were calculated for each species. An importance value, representing the sum of the relative value of each of the above was generated. For the shrub and herbaceous strata, average cover and frequency were calculated with importance of each species determined by the sum of relative cover and relative frequency.

RESULTS

Introduction: A list of plant species observed during the inventory work is provided in Appendix SII:B-1. Species documented by others are provided in Appendices SII:B-11 and SII:B-12. Plant species were identified based on "Plants of the Chicago Region" (1994). For the purpose of this report, species nomenclature follows the Integrated Taxonomic Information

System (ITIS). A crosswalk, inclusive of common names, between nomenclature used in the Flora of Chicago and ITIS is provided in Appendix SII:B-13. A presentation of data for the entirety of CBWC will be presented followed by that of each of the eight defined vegetation units: west shrub unit, forested swamp unit, east shrub unit, north graminoid fen, south graminoid fen, raised fen, cattail unit, and disturbed prairie unit (Exhibits C:1 and C:2).

Cowles Bog Wetland Complex: A summary of characteristics of species observed in CBWC is given in Table 1. Three hundred and five species were observed, of which 275 species (90.2 percent) were native species and 30 species (9.8 percent) were non-native species. There were 288 perennial species and only 15 annual and 2 biennial species. As anticipated, species richness was dominated by wetland species rather than upland species, 247 species (81.5 percent) and 56 species (18.5 percent), respectively. Forb was the most represented life form, 145 species, with graminoid the second most represented life form, 66 species. Within the graminoid life form there were 19 grass species, 35 sedge species (all members of the genus Carex) and 12 rush species. Other life forms represented were tree, 35 species; shrub, 43 species; vine, 7 species; fern, 8 species; and fern ally, 1 species.

Table 1: Characteristics of Species Observed in the Cowles Bog Wetland Complex (three growth forms of graminoid species are provided).

Total Species	Quantity	Wetland Status	Quantity	Growth Form	Quantity
Native species	275	OBL-FAC	247	Fern	8
Non-native species	30	FAC- to UPL	56	Fern Ally	1
Total	**305**	No indicator	2	Forb	145
		Class	**Quantity**	Graminoid	66
Life Cycle	**Quantity**	Dicot	210	Grass	19
Annual	15	Equisetinae	1	Rush	12
Biennial	2	Filicinae	8	Sedge	35
Perennial	288	Gymnosperm	4	Shrub	43
		Monocot	82	Tree	35
				Vine	7

Nineteen shrub species and 11 tree species representing 1,121 points were field mapped using GPS (Table 2). The most common isolated shrub species, representing 765 points, was poison sumac (*Rhus vernix*). Red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*) and quacking aspen representing 52 points, 27 points and 23 points, respectively, were the most common isolated tree species.

Sixteen shrub assemblages and eight tree assemblages were identified and 221 assemblages representing them were mapped using GPS (Table 2). The most common shrub assemblage, based on the number and size of polygons, were silky dogwood (*Cornus obliqua*), winterberry (*Ilex verticillata*) and swamp rose (*Rosa palustris*) representing 38 assemblages, 30 assemblages and 29 assemblages, respectively. The most common tree assemblage, quacking aspen, was represented by 16 polygons.

Table 2: The Number of Individual Species (points) and Plant Assemblages (polygons) mapped in the Cowles Bog Wetland Complex.

Scientific Name	Total points	Total polygons	Scientific Name	Total Points	Total Polygons
Shrubs			**Trees**		
Cephalanthus occidentalis	20	15	Acer rubrum	52	2
Cornus obliqua	35	38	Acer/Betula	0	5
Cornus racemosa	3	6	Alnus rugosa	2	3
Cornus stolonifera	3	6	Betula alleghaniensis	27	0
Diverse shrub	0	7	Larix laricina	9	3
Fraxinus pennsylvanica	4	0	Pinus strobus	7	0
Ilex verticillata	23	30	Populus tremuloides	23	16
Ligustrum vulgare	2	0	Prunus serotina	4	0
Lindera benzoin	2	3	Salix amygdaloides	15	5
Lonicera tatarica	5	0	Salix nigra	10	2
Morus alba	1	0	Thuja occidentalis	12	1
Photinia floribunda	2	0	Ulmus rubra	6	0
Rhus vernix	765	12	**Total trees**	**167**	**37**
Rosa multiflora	3	1			
Rosa palustris	43	29	**Others**		
Salix discolor	22	7	Carex stricta	0	1
Salix eriocephala	3	9	Carex atherodes	1	0
Salix interior	1	4	Carex lacustris	0	1
Sambucus canadensis	4	0	Carex utriculata	1	0
Spiraea alba	0	3	Phragmites australis	0	9
Viburnum lentago	13	8	Saxifrage pennsylvanica	1	0
Vitis labrusca	0	6	**Total**	**3**	**11**
Total	**954**	**184**			

Eleven plant assemblages representing herbaceous species were mapped. Species dominating these assemblages were common reed (*Phragmites australis*), nine polygons, tussock sedge (*Carex stricta*), one polygon, and lake sedge (*Carex lacustris*), one polygon.

Dominant tree species of CBWC were red maple and yellow birch. Red maple with an importance value of 139 was more common than yellow birch with an importance value of 30.1 (Table 3). The shrub and woody vine stratum was dominated by five species: spice bush

(*Lindera benzoin*), winterberry, poison sumac, fox grape (*Vitis labrusca*), and red-osier dogwood (*Cornus sericea*). The high importance value of spice bush reflects its high abundance at the disturbed prairie unit.

Table 3: Dominant Species Present in the Cowles Bog Wetland Complex (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Acer rubrum	0.6	244.8	7.4	138.9
Betula alleghaniensis	0.2	29.7	1.5	30.1
Total	**1.5**	**541.5**	**14.1**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**	**Importance**	
Lindera benzoin	6.8	19.3	46.8	
Ilex verticillata	2.3	10.5	18.6	
Toxicodendron vernix	1.0	17.7	17.1	
Vitis labrusca	1.1	9.9	12.4	
Cornus sericea	0.9	10.9	12.0	
Total	**20.3**			
HERBACEOUS				
Typha spp.	22.1	76.4	41.5	
Impatiens capensis	5.4	50.5	14.2	
Symplocarpus foetidus	7.6	24.4	14.1	
Pilea fontana	4.5	54.6	13.5	
Onoclea sensibilis	2.2	17.8	5.4	
Lindera benzoin	1.7	16.8	4.7	
Eupatorium maculatum	1.6	18.8	4.7	
Thelypteris palustris	1.3	20.4	4.5	
Total	**69.7**			

Eight species dominated the herbaceous layer (Table 3). As expected, the most common of these species was cattail. Two of the dominant species, spotted touch-me-not (*Impatiens capensis*) and clear weed (*Pilea fontana*), were commonly found scattered in the understory of cattail. The other dominate species, skunk cabbage (*Symplocarpus foetidus*), sensitive fen (*Onoclea sensibilis*), marsh shield fern (*Thelypteris palustris*), and spotted joe pye weed (*Eupatorium maculatum*), were most common in the northern one-third of CBWC and in the remnant sedge meadow located in the southeast corner. A presentation of all species encountered during the quantitative assessment with cover, frequency and importance is provided in Appendix SII:B-2.

The red maple/yellow birch tree assemblage comprising 5.1 ha occupied the largest area of the eight tree assemblages (Table 4). This assemblage occurred exclusively on the northern portion of CBWC and was most common in the forested swamp unit. The disturbed prairie unit was not

included in the evaluation of tree assemblages, given that this unit is dominated by red maple, inclusion of the disturbed prairie unit would have elevated the dominance of the red maple assemblage at CBWC.

The most common shrub assemblages were diverse shrub, silky dogwood, and winter berry representing 3.6 ha, 2.9 ha, and 2.2 ha respectively. Diverse shrub had sufficient diversity of shrub species to prevent assignment of the assemblage to a specific species. As was the case with trees, and, as reflected in the high importance value of spice bush, if the disturbed prairie unit had been included in the analyses, spice bush would have been the most common shrub assemblage.

The estimated number of trees in CBWC was 12,893 trees representing 34 species (Table 5). Red maple accounted for 48.8 percent of trees (6,288 trees) and yellow birch accounted for 16.2 percent of trees (2,094 trees). Red maple occurrences were concentrated in the west shrub unit, 1,127 trees, forested swamp unit, 2,779 trees, and disturbed prairie unit, 2,191 trees. Collectively, willow (*Salix spp.*) represented 5.9 percent of trees (761 trees). The most common willow was pussy willow (Salix discolor) represent by 308 trees followed by peach-leaved willow (*Salix amygdaloides*), 181 trees, and black willow (*Salix nigra*), 116 trees. There were 821 trees of black cherry (*Prunus serotina*). Most black cherry trees, 798 trees, were present in the disturbed prairie unit.

West Shrub Unit: The west shrub unit (Exhibit C:3) represented 13.2 ha (15.9 percent) of CBWC (Table 6). There were 142 species detected during the vegetation surveys (Table 7). Forbs, shrubs and trees were the most common life forms and perennial species represented the most common growth form. There were 135 native species and seven non-native species (Table 7). Detailed information on species observed in the west shrub unit during the quantitative vegetation survey is provided in Appendix SII:B-3.

Table 4: Size (Ha) of Shrub and Tree Assemblages in each Vegetation Unit (South Fen= South Graminoid Fen Unit; Raised Fen= Raised Fen Unit; North Fen= North Graminoid Fen Unit, * shrub and tree assemblages were not mapped in the disturbed prairie unit).

Trees	West Shrub	Forested Swamp	South Fen	Raised Fen	North Fen	East Shrub	Cattail	Disturb Prairie*	Total
Acer rubrum	0.10	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Acer rubrum/Betula alleghaniensis	0.01	5.10	0.00	0.00	0.00	0.00	0.00	0.00	5.11
Alnus incana	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
Larix laricina	0.05	0.00	0.01	0.00	0.28	0.00	0.00	0.00	0.33
Populus tremuloides	0.28	0.00	0.00	0.00	0.00	0.78	0.04	0.00	1.11
Salix amygdaloides	0.03	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.16
Salix nigra	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33
Thuja occidentalis	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.51
Shrubs									
Cephalanthus occidentalis	0.01	0.00	0.00	0.00	0.00	0.35	0.02	0.00	0.38
Cornus obliqua	0.00	0.92	0.00	0.00	0.00	1.97	0.05	0.00	2.94
Cornus racemosa	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.18
Cornus stolonifera	0.00	0.00	0.00	0.00	0.00	0.19	0.02	0.00	0.21
Diverse shrub	2.86	0.41	0.00	0.00	0.21	0.16	0.00	0.00	3.63
Ilex verticillata	2.14	0.06	0.00	0.00	0.00	0.00	0.00	0.00	2.20
Lindera benzoin	0.00	0.14	0.00	0.43	0.00	0.00	0.00	0.00	0.56
Rosa multiflora	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
Rosa palustris	0.36	0.00	0.00	0.00	0.00	0.89	0.00	0.00	1.25
Salix discolor	0.06	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.08
Salix eriocephala	0.12	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.27
Salix interior	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.41
Spiraea alba	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.14
Toxicodendron vernix	0.67	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.08
Viburnum lentago	0.05	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.09
Vitis labrusca	0.05	0.18	0.00	0.00	0.00	0.15	0.00	0.00	0.38
Total Hectare	**7.48**	**7.11**	**0.00**	**0.94**	**0.48**	**6.29**	**0.15**	**0.00**	**22.47**

Table 5: Estimated Number of Trees for Cowles Bog Wetland Complex (total) and Vegetation Units (tree number = tree density/10 m^2 * 100 * unit size; N.G. Fen= North Graminoid Fen; S.G. Fen=South Graminoid Fen; *= estimate is suspected to be flawed due to know patterns of clustering and/or other observations).

Scientific Name	West Shrub	Forested Swamp	Raised Fen	S.G. Fen	N.G. Fen	East Shrub	Hybrid Cattail	Disturb Prairie	Total
Acer rubrum	1127	2779	121	0	0	53	17	2191	**6288**
Acer saccharum*	0	0	0	0	0	0	0	*22	**22**
Alnus incana	61	200	0	0	0	0	0	0	**261**
Betula alleghaniensis	690	1330	36	0	29	9	0	0	**2094**
Betula papyrifera	145	0	0	0	0	0	0	0	**145**
Cephalanthus occidentalis	81	0	2	0	0	9	0	0	**92**
Fraxinus americana	0	0	65	0	4	0	0	0	**69**
Fraxinus nigra	0	12	2	0	21	9	0	0	**44**
Fraxinus pennsylvanica	10	71	0	0	0	0	0	0	**81**
Larix laricina	20	24	10	0	39	0	0	0	**93**
Lindernia benzoin	0	0	0	0	0	0	0	56	**56**
Morus alba	8	0	2	0	0	0	0	0	**10**
Nyssa sylvatica	0	24	0	0	0	0	0	101	**125**
Pinus strobus	0	24	7	0	4	0	0	0	**35**
Populus deltoides	16	0	0	0	0	0	0	56	**72**
Populus tremuloides	91	0	2	0	0	289	139	34	**555**
Prunus serotina	0	0	5	0	0	18	0	798	**821**
Quercus alba	0	0	0	0	0	0	0	56	**56**
Quercus palustris	0	0	0	0	0	9	0	11	**20**
Quercus rubra	0	0	0	0	0	0	0	22	**22**
Quercus velutina	8	0	0	0	0	0	0	8	**8**
Robinia pseudoacacia	0	0	0	0	0	0	0	247	**247**
Salix amygdaloides	0	35	0	0	0	140	6	0	**181**
Salix discolor	71	35	12	0	33	140	17	0	**308**
Salix eriocephala	30	0	0	0	12	0	0	0	**42**
Salix fragilis	0	0	0	0	0	61	0	0	**61**
Salix glaucophylloides	0	0	0	0	0	53	0	0	**53**
Salix nigra	20	0	0	0	0	79	17	0	**116**
Sassafras albidum	0	0	0	0	0	0	0	78	**78**
Toxicodendron vernix	10	0	48	0	8	0	0	0	**66**
Thuja occidentalis*	0	35	*186	0	0	0	0	0	**221**
Ulmus americana	10	0	0	0	0	0	9	22	**41**
Ulmus rubra	81	247	10	0	41	26	26	26	**457**
Viburnum lentago	0	0	19	0	0	0	0	34	**53**
Total	**2479**	**4816**	**527**	**0**	**191**	**895**	**231**	**3754**	**12893**

Numerous isolated shrubs and trees were present in the Unit's southwest quarter. The most common of these scattered shrub species was poison sumac. Cattail stem densities ranged from 0 to 30 stems/m^2. Several pockets of cattail with stem density greater than 30 stems/m^2 were present.

Table 8: Dominant Species Present in the Cowles Bog Wetland Complex – West Shrub Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Acer rubrum	0.85	131.82	6.12	131.85
Betula alleghaniensis	0.52	48.40	2.40	59.91
Total	**2.0**	**314.8**	**12.8**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**		**Frequency**	**Importance**
Ilex verticillata	9.32		40.46	38.93
Toxicodendron vernix	3.63		53.44	26.47
Alnus rugosa	4.84		22.90	20.79
Vitis labrusca	3.53		30.53	19.29
Total	**34.7**			
HERBACEOUS				
Typha spp.	14.40		79.85	25.55
Symplocarpus foetidus	10.14		45.52	17.02
Pilea fontana	5.87		74.63	14.23
Onoclea sensibilis	6.96		46.27	13.04
Impatiens capensis	3.50		55.97	9.53
Dryopteris thelypteris	3.06		41.79	7.69
Osmunda cinnamomea	4.28		14.93	6.79
Scutellaria epilobiifolia	1.96		32.09	5.40
Lycopus uniflorus	1.25		35.07	4.77
Total	**78.6**			

Red maple and yellow birch were the dominant tree species (Table 8). There were 1,127 red maple trees and 690 yellow birch trees (Table 5). Other tree species commonly observed were Slippery elm (*Ulmus rubra*), pussy willow, quaking aspen, button bush (*Cephalanthus occidentalis*), and paper birch (*Betula papyrifera*). Concerning this last species, its presence was restricted to a west to east narrow strip on the Unit's northern edge. Average tree cover was 12.6 percent/10 m^2.

There were 23 shrub species of which four of them, winterberry, poison sumac, speckled alder, and fox grape were dominants (Table 8). Average shrub cover was 34.7 percent/5 m^2.

Table 6: Vegetation Unit Size (ha) and estimated extent (ha) of Cattail Stem Densities.			
Realized Vegetation Units	**Area**	**Cattail Stem Density (stems/m^2)**	**Area**
West Shrub Unit	13.2	0 – 10	18.3
East Shrub Unit	16.9	11 – 20	15.5
Forested Swamp Unit	7.3	21 – 30	12.5
Raised Fen	2.9	31 – 40	14.1
South Graminoid Fen	0.9	41 – 50	10.4
North Graminoid Fen	1.4	51 – 60	0.4
Cattail Unit	31.1	61 – 70	1.5
Disturbed prairie Unit	9.3	**Total Area**	**72.7 Hectares**
Total Area	**83 Hectares**		

There were six tree assemblages and nine shrub assemblages mapped at the west shrub unit (Table 4). Speckled alder (*Alnus incana spp. rugosa*) and quaking aspen, representing a collective 1 ha, were the most common tree assemblages. Other tree assemblages were red maple, 0.1 ha, tamarack (*Larix laricina*), 0.05 ha, peach-leaved willow, 0.03 ha, and red maple/yellow birch, 0.01 ha.

Table 7: Species Characteristics For Vegetation Units in the CBWC

	UNITS							
	West Shrub	**Forested Swamp**	**East Shrub**	**Raised Fen**	**North Graminoid Fen**	**South Graminoid Fen**	**Cattail**	**Disturb Prairie**
Total Species	142	122	146	150	133	77	136	58
Native	135	117	133	136	122	73	128	52
Non-native	7	5	13	14	11	4	8	6
Life Forms								
Annual	9	6	6	6	6	5	8	2
Biennial	1	1	1	1	2	1	1	0
Perennial	132	115	139	143	125	71	127	56
Growth Forms								
Trees	16	14	16	13	9	1	9	15
Shrubs	23	20	25	20	18	16	23	12
Woody Vines	4	5	4	7	6	1	3	2
Herbaceous Vines	5	4	6	5	5	3	4	0
Forbs	71	59	67	78	70	44	72	11
Sedges	11	6	12	12	10	3	10	5
Grasses	6	7	6	10	10	4	7	6
Rushes	2	1	5	2	2	2	4	1
Ferns	4	6	5	3	3	3	4	6

Diverse shrub and winterberry representing 5.0 ha were the most common shrub assemblages. An additional seven shrub assemblages representing 1.3 ha were present. In total, 7.5 ha (56.6 percent) of the west shrub unit was comprised of tree assemblages, 1.2 ha, and shrub assemblages, 6.3 ha.

The herbaceous layer was represented by 99 species of which 76 percent were forbs. There were nine dominant species: cattail, skunk cabbage, clear weed, sensitive fern (*Onoclea sensibilis*), spotted touch-me-not, marsh shield fern, cinnamon fern (*Osmunda cinnamomea*), marsh skullcap (*Scutellaria epilobiifolia*), and northern bugle weed (*Lycopus uniflorus*). The average cover of the herbaceous layer was 78.6 percent/m^2.

Forested Swamp Unit: Adjacent and east of the west shrub unit was forested swamp (Exhibit C:4). The forested swamp unit represented 7.3 ha (8.8 percent) of CBWC. One hundred and twenty-two species were observed in the forested swamp (Table 7). Data from the quantitative assessment of the forested swamp is provided in Appendix SII:B-4.

A large assemblage of mix occurrence of red maple and yellow birch representing 5.1 hectare and 0.3 ha of red maple forest comprised 74 percent of the forested swamp unit (Table 4). Scattered within the treed assemblages were five shrub assemblages representing 1.7 ha. The largest of these assemblages was dominated by silky dogwood. The three smallest assemblages were dominated by fox grape, spice bush, and winterberry. The fourth assemblage was comprised of diverse shrub.

There were over twice as many red maple trees (2,779 trees) as yellow birch trees (1,330 trees; Table 5). Other commonly observed trees included speckled alder, slippery elm, and green ash. In total, 16 tree species were present (Table 7). Average cover was 51.9 percent/10m^2 (Table 8).

Twenty shrub species were present, of these species, three species, winterberry, speckled alder, and spice bush dominated the shrub stratum. Average shrub cover was 43.7 percent/5 m^2.

In spring, skunk cabbage and marsh marigold (*Caltha palustris*) dominated the herbaceous stratum (Table 9). Following leaf-out of the woody canopy, spotted touch-me-not, cinnamon fern, rice cut grass, clear weed, purple stem tickseed (*Bidens connata*), sensitive fern, and false nettle (*Boehmeria cylindrica*) were the most commonly observed species. Average cover of the herbaceous layer was 58.9 percent/m^2.

Table 9: Dominant Species Present in the Cowles Bog Wetland Complex –Forested Swamp Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Acer rubrum	3.81	845.77	30.48	178.03
Betula alleghaniensis	1.82	265.71	13.81	73.61
Total	**6.6**	**1376.6**	**51.9**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**	**Importance**	
Ilex verticillata	14.40	55.38	50.07	
Alnus incana	9.52	26.15	29.85	
Lindera benzoin	5.20	52.31	28.08	
Total	**43.7**			
HERBACEOUS				
Symplocarpus foetidus	16.16	63.01	33.28	
Impatiens capensis	3.64	65.75	12.27	
Caltha palustris	3.37	41.10	9.54	
Osmunda cinnamomea	4.16	21.92	9.09	
Leersia oryzoides	2.88	42.47	8.82	
Pilea fontana	1.14	60.27	7.53	
Bidens connata	2.09	42.47	7.48	
Onoclea sensibilis	2.64	30.14	7.27	
Boehmeria cylindrica	2.06	34.25	6.67	
Total	**58.9**			

Traversing the Cowles Bog Trail in mid-summer, the forested swamp appears dark and forbidden with greater tree cover than reported here. There are three factors contributing to the contrast between the observed cover and the reported cover of 51.9 percent/10 m^2; 1) The woody survey was conducted in September, a time when leaf cover starts to diminish; 2) At scattered points, shrubs diminished the occurrence of trees; and, 3) Annual tree fall due to storm events generates gaps in the tree canopy.

East Shrub Unit: The east shrub unit comprised of 16.9 ha (Table 3), represented 20.4 percent of CBWC (Exhibit C:6) This unit extended from the eastern edge of the forested swamp to the eastern terminus of the projects footprint. The unit extended south adjacent to Mineral Springs Road to the disturbed prairie unit and then west for a small distance along the CBWC's southern boundary (Exhibit C:2). The east shrub unit is inclusive of a small sedge remnant located at its southeast corner. Detailed summary data collected during the quantitative vegetation survey are provided in Appendix SII:B-5.

One hundred and forty-six species, of which, 133 were native species and 13 species were non-native species, were observed (Table 7). Similar to other wetland units, the majority of species were perennial forbs (Table 7).

The woody component was less than that documented at the west shrub unit and was comprised of different species assemblages than present at the west shrub unit. Tree assemblages were quaking aspen, black willow, and peach-leaved willow. As a group, these assemblages comprised 1.3 ha (Table 4).

The shrub vegetation consisted of 14 assemblages. The most common shrub assemblage, representing 2.0 ha, was dominated by silky dogwood. Other shrub assemblages were button bush, gray dogwood (*Cornus racemosa*), red-osier dogwood (*Cornus stolonifera*), diverse shrub, multiflora rose (*Rosa multiflora*), swamp rose (*Rosa palustris*), fox grape, nanny berry (*Viburnum lentago*), meadowsweet (*Spiraea alba*), sandbar willow (*Salix interior*), heart-leaved willow (*Salix eriocephala*), pussy willow, and poison sumac. In total, there were 5.15 ha of shrub assemblages.

Collectively, of a total of 895 trees, willow trees represented 61.7 percent of trees (473 trees) present in the east shrub unit (Table 5). The most common willow species were peach-leaved willow and pussy willow. Other willow species present were black willow, crack willow (*Salix fragilis*), and blue-leaved willow (*Salix myricoides*). Quaking aspen with 289 trees (32.3 percent) was the most the most common tree species.

Sixteen tree species were observed (Table 7), and of these, two species, quaking aspen and peach-leaved willow, dominated the tree stratum (Table 10). Average tree cover was 5.7 percent/10 m^2. There were 25 shrub species with the dominant species being silky dogwood, buttonbush, and swamp rose. The average shrub cover was 16.1 percent/5 m^2.

Table 10: Dominant Species Present in the Cowles Bog Wetland Complex – East Shrub Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Populus tremuloides	0.17	60.68	1.67	92.19
Salix amygdaloides	0.08	92.57	1.60	90.40
Total	**0.5**	**198.9**	**5.7**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**		**Frequency**	**Importance**
Cornus obliqua	3.60		16.49	36.37
Cephalanthus occidentalis	3.60		14.95	35.05
Rosa palustris	2.45		22.68	34.47
Total	**16.1**			
HERBACEOUS				
Typha spp.	22.06		87.32	41.25
Impatiens capensis	3.91		61.95	12.58
Onoclea sensibilis	6.21		28.78	12.08
Pilea fontana	2.81		60.98	10.91
Calamagrostis canadensis	2.39		37.07	7.59
Carex stricta	3.19		18.54	6.63
Eupatorium maculatum	2.50		24.39	6.32
Carex aquatilis	3.00		14.63	5.91
Total	**70.4**			

The inclusion of the southeastern sedge remnant in this unit enhanced diversity of the herbaceous layer. Two groupings of the eight dominant species were recognized. Cattail, spotted touch-me-not, and clear weed dominated areas with high cattail stem densities. Aquatic sedge (*Carex aquatilis*), tussock sedge, spotted joe pye weed (*Eupatorium maculatum*), blue joint grass (*Calamagrostis canadensis*), and sensitive fern were common in areas with low cattail stem densities. The average herbaceous cover was 70.4 percent/m^2.

Raised Fen Unit: The fen units of CBWC were given positive recognition for their floristic uniqueness during exploration of CBWC in the early 20th century. Based on topography and position, three fen units were recognized: raised fen; north graminoid fen, and south graminoid fen (Exhibit C:2). The surface elevation of the raised Fen was approximately 1.3 m higher than that of the surrounding wetland. The raised fen's artesian water moves laterally north and south generating adjacent fen habitat. The boundaries of the fen units were estimated based on vegetation, soil chemistry and water chemistry. Detailed quantitative data pertaining to the raised fen is provided in Appendix SII:B-6

The raised fen is 2.9 ha. The western and eastern portions of the raised fen exhibited uniquely different vegetation; the western portion being forested and the eastern half dominated by cattail and common reed. A ditch, constructed in the 1920's separated the western half of the raised fen from the eastern half of the raised fen. One hundred and fifty species were observed on the raised fen; 13 tree species, 20 shrub species, 7 woody vines, and 110 herbaceous species (Table 7). The western portion exhibited a tree assemblage dominated by white cedar (*Thuja occidentalis*; 0.51 ha) and a shrub assemblage dominated by spice bush (0.43 ha; Table 5).

A scattering of isolated red maple trees throughout the raised fen was reflected in co-dominance of this species with white cedar (Table 11). Average tree cover was 17.1 percent/10 m^2. There were an estimated 186 white cedar trees and 121 red maple trees (Table 6). Other tree species present were 36 yellow birch, 65 white ash, 10 tamarack, 10 slippery elm, 19 nannyberry, 7 white pine (*Pinus strobus*), 48 poison sumac, and 12 pussy willow (Table 6).

Table 11: Dominant Species Present in the Cowles Bog Wetland Complex – Raised Fen Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Thuja occidentalis	0.64	185.26	4.34	93.61
Acer rubrum	0.42	186.64	5.16	86.31
Total	**1.8**	**186.6**	**17.1**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**	**Importance**	
Lindera benzoin	13.54	40.00	83.71	
Toxicodendron vernix	2.26	27.50	27.33	
Total	**23.3**			
HERBACEOUS				
Symplocarpus foetidus	25.10	60.64	31.57	
Typha ssp.	12.54	71.49	19.88	
Impatiens capensis	12.24	57.43	18.18	
Pilea fontana	10.65	69.08	17.72	
Lindera benzoin	5.64	40.96	9.82	
Eupatorium maculatum	4.03	34.54	7.54	
Total	**98.3**			

Dominant Shrub species were spice bush and poison sumac (Table 11). Average shrub cover was 23.3 percent/5 m^2. Herbaceous dominants reflected the western and eastern portions of the raised mound. Skunk cabbage and small individuals of spice bush were common on the western half of the raised fen. Cattail, spotted touch-me-not, clear weed, and spotted joe pye weed were

common on the eastern half of the raised fen. The average cover of the herbaceous stratum was 98.3 percent/m^2.

North Graminoid Fen Unit: The north graminoid fen unit was 1.4 ha (Table 6). The Unit extended north from the raised fen unit, interfacing with the forested swamp unit on the north and west. The eastern edge transitioned into the east shrub unit. Nine tree species, 18 shrub species and 106 herbaceous species were observed (Table 7). Detailed information on species detected in the unit during the quantitative vegetation survey is provided in Appendix SII:B-7.

A 0.28 ha assemblage of tamarack was present on the southern boundary. The only other mapped woody assemblage was an area of diverse shrub representing 0.21 ha (Table 4). Tree quantities include an estimated 39 tamarack trees, 29 yellow birch trees, 21 black ash trees, 41 slippery elm trees, 12 heart-leaved willow trees, 33 pussy willow trees, 8 poison sumac trees, 4 white pine trees, and 4 white ash trees. The tree stratum was dominated by tamarack and slippery elm. The average tree cover was 10.6 percent/10 m^2 (Table 12).

The shrub layer was dominated by red-osier dogwood, poison sumac, and pussy willow. The average cover was 11.1 percent/5 m^2. There were 12 dominant herbaceous species. Cattail, as suggested by it frequency of 84.4 percent, was common throughout the north graminoid fen; however, there was significant pockets of species richness. Other herbaceous plant dominants were skunk cabbage, marsh shield fern, clear weed, rice cut grass, swamp goldenrod (*Solidago patula*), false nettle, side flowering aster (*Symphyotrichum lateriflorum*), spotted joe pye weed, violet (*Viola spp*), and spotted touch-me-not. The average cover of the herbaceous layer was 76.2 percent/m^2.

South Graminoid Fen Unit: The South Graminoid Fen Unit was comprised of 0.9 ha. Seventy-seven species were observed (Table 7) which was fewer species than observed at the other two fen units. One tree species, 16 shrub species and 60 herbaceous species were present. There were no tree or shrub assemblages mapped in this unit. Detailed information on species detected in the unit during the quantitative vegetation survey is provided in Appendix SII:B-8.

Table 12: Dominant Species Present in the Cowles Bog Wetland Complex – North Graminoid Fen Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Larix laricina	0.85	303.58	6.18	174.94
Ulmus rubra	0.29	31.36	0.99	31.97
Total	**1.9**	**418.3**	**10.6**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**		**Importance**
Cornus stolonifera	3.81	59.38		54.40
Toxicodendron vernix	1.77	65.63		38.07
Salix discolor	0.89	25.00		16.46
Total	**11.1**			
HERBACEOUS				
Typha spp.	21.14	84.44		35.35
Symplocarpus foetidus	4.57	27.78		8.51
Thelypteris palustris	3.35	41.11		8.11
Pilea fontana	2.03	52.22		7.38
Leersia oryzoides	3.18	27.78		6.68
Solidago patula	2.81	32.22		6.60
Boehmeria cylindrica	3.30	24.44		6.54
Aster lateriflorus	1.62	34.44		5.24
Eupatorium maculatum	1.62	32.22		5.03
Eleocharis rostellata	2.32	16.67		4.55
Viola spp.	0.99	34.44		4.41
Impatiens capensis	1.37	28.89		4.40
Total	**76.2**			

South Graminoid Fen Unit: The South Graminoid Fen Unit was comprised of 0.9 ha. Seventy-seven species were observed (Table 7) which was fewer species than observed at the other two fen units. One tree species, 16 shrub species and 60 herbaceous species were present. There were no tree or shrub assemblages mapped in this unit. Detailed information on species detected in the unit during the quantitative vegetation survey is provided in Appendix SII:B-8.

There were no trees present in the evaluated vegetation plots (Table 13). Red-osier dogwood and poison sumac were the dominant shrub species. Average shrub cover was 5.7 percent/5 m^2. As indicated by the presence of two invasive co-dominant species, cattail and common reed and only four other co-dominant species, spotted touch-me-not, clear weed, skunk cabbage, and spotted joe-pye-weed, this fen unit was more degraded than either of the other two fen units (Table 13). The average herbaceous cover was 66.3 percent/m^2.

Table 13: Dominant Species Present in the Cowles Bog Wetland Complex – South Graminoid Fen Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
No trees				
SHRUBS & WOODY VINES				
Scientific Name	**Cover**		**Frequency**	**Importance**
Cornus stolonifera	3.57		28.57	87.50
Toxicodendron vernix	0.93		42.86	53.75
Total	**5.7**			
HERBACEOUS				
Typha spp.	13.54		96.00	30.46
Impatiens capensis	11.48		68.00	24.43
Pilea fontana	9.74		64.00	21.38
Symplocarpus foetidus	6.80		24.00	12.77
Phragmites australis	3.20		40.00	9.01
Eupatorium maculatum	1.74		36.00	6.39
Total	**66.3**			

Cattail Unit: The southern edge of the west shrub unit and fen units and the western edge of the east shrub unit transitioned into a vast expanse of wetland dominated by cattail. The cattail unit at 31.1 ha (37.5 percent) was the largest vegetation unit of CBWC. DNA testing failed to locate native cattail (*Typha latifolia*, Travis et al. 2009). In short all cattail at CBWC is non-native cattail: narrow-leaf cattail (*Typha angustifolia*) or hybrid cattail (*Typha X glauca*).

Nine tree species, 23 shrub species, and 104 herbaceous species were observed (Table 7). Detailed information on species documented during the quantitative vegetation survey is provided in Appendix SII:B-9.

There was one tree assemblage; quaking aspen 0.4 ha, and several shrub assemblages dominated by button bush, silky dogwood, red-osier dogwood, and nannyberry which comprised 0.11 hectare (Table 4). Quaking aspen and peach-leaved willow were the dominant tree species (Table 14). The average cover of the tree stratum was 0.6 percent/10 m^2.

The dominant shrub species were red-osier dogwood, speckled alder, poison sumac, winterberry. Average shrub cover was 2.7 percent/5 m^2. As anticipated, species diversity was very low in the cattail unit. The vegetation was dominated by cattail and spotted touch-me-not. The average cover was 61.5 percent/m^2.

Table 14: Dominant Species Present in the Cowles Bog Wetland Complex – Cattail Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Populus tremuloides	0.04	5.82	0.22	111.48
Salix amygdaloides	0.01	20.08	0.17	103.03
Total	**0.1**	**36.1**	**0.6**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**	**Importance**	
Cornus stolonifera	0.52	6.34	33.19	
Alnus rugosa	0.59	3.86	30.42	
Toxicodendron vernix	0.25	8.82	28.98	
Ilex verticillata	0.32	2.20	16.64	
Total	**2.7**			
HERBACEOUS				
Typha spp.	40.32	97.51	86.75	
Impatiens capensis	4.60	50.62	18.49	
Total	**61.5**			

Approximately 24 ha of this unit exhibited cattail stem densities of 31 to 70 stems/m^2, and 1.5 ha exhibited very dense cattail occurrence of 61 to 70 stems/m^2 (Exhibit C:7; Table 6). Assuming an average stem density of 65 stems/m^2, the above zone would realize close to 1,000,000 cattail stems.

Disturbed Prairie Unit: The disturbed prairie unit extended from the northern edge of a utility right-of-way south to the southern edge of the remnant sedge meadow present within the east shrub unit (Exhibits C:2 and C:9). The disturbed prairie represented 9.3 ha of CBWC.

Assignment of the woody and shrub vegetation to a defined assemblage was not conducted. However the quantitative survey (Appendix SII:B-10) confirmed that the tree canopy is dominated by red maple . There were 2,191 red maple trees (Table 5) generating 45.3 percent cover/10 m^2 (Table 15). Other common trees were black cherry, 798, and black locust (*Robinia pseudoacacia*), 247.

The shrub layer was dominated by spice bush. Spice bush provided 52.7 percent cover/ 5 m^2 (84.2 percent of total shrub cover). The herbaceous layer was very sparse exhibiting only 12.3 percent cover/m^2. The dominate species were small spice bush individuals and fowl manna grass

(*Glyceria striata*). The absence of a herbaceous layer is reflected in species observed of which out of 58 species only 29 (50 percent) of them were herbaceous (Table 7).

Table 15: Dominant Species Present in the Cowles Bog Wetland Complex – Disturbed Prairie Unit (tree values-10 m^{-2}; shrubs–10 m^{-2}; herbaceous – 10 m^{-2}; total represents the grand sum of all species present in the stratum).

TREES				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Acer rubrum	2.19	1678.3	45.34	179.08
Total	**4.4**	**3114**	**60.1**	
SHRUBS & WOODY VINES				
Scientific Name	**Cover**	**Frequency**	**Importance**	
Lindernia benzoin	52.37	96.70	135.42	
Total	**62.1**			
HERBACEOUS				
Lindera benzoin	7.36	64.77	91.52	
Glyceria striata	2.19	15.91	25.56	
Total	**12.3**			

Observations providing evidence that the disturbed prairie unit historically was lake plain wet-mesic prairie are as follows:

- The soil type is Maumee Silty Clay Loam, a soil type that is known to have developed under wet-mesic prairie influence.
- Aerial photography from the 1930's shows a landscape being utilized for agricultural crops.
- Extensive ditch system was constructed in the late 19th century to drain the land. This ditch system, in part, continues to maintain an artificial low water table.
- A forb layer reflecting a natural forest community was absent.
- The southern edge of the disturbed prairie unit is adjacent to a utility right-of-way in which woody vegetation is removed. This utility-right-of-way provides habitat for many conservative species reflecting lake plain wet-mesic prairie

SECTION II:C SEEDBANK

INTRODUCTION

Species recruitment is an important ecosystem function contributing to vegetation resilience in wetlands that have encountered vegetation altering forcing functions (van der Valk and Davis 1978; van der Valk 1981). Restoration of Cowles Bog Wetland Complex (CBWC) will require the replacement of the current invasive plant assemblage with a native plant assemblage. This native plant assemblage can be derived from natural recruitment, anthropogenic induced recruitment, or a combination of both actions. Natural sources of species recruitment fall into two general classes: (1) exogenous sources such as seed carried by flood waters from upstream, water fowl, and other animals, or wind; and (2) endogenous sources such as seed banks. At CBWC exogenous sources of propagules would be limited to windblown seed. This is because CBWC represents the western terminus of Great Marsh and, therefore, remains isolated from overland flow from other wetlands. The dense occurrence of cattail also minimizes waterfowl use of the area, further limiting the capacity for exogenous seed dispersal. Therefore, following removal of the invasive plant assemblage, endogenous recruitment from the seedbank represents the main source of natural species recruitment.

Species recruitment to the seedbank and persistence in the seedbank is species specific and can be influenced by environmental exposure and predation (Roberts 1972; Schafer and Chilcote 1970; Baker 1989). Some species are members of a transient seedbank, persisting for durations of one year or less (Thompson and Grime 1979). Often a wetland designated for restoration or enhancement actions has been compromised by anthropogenic induced drivers such as draining, grazing, flooding, or nutrient loading. These forcing functions may result in altered vegetation and adversely impact the seedbank (Weinhold and van der Valk, 1989; Middleton 1999; Zedler 2000). Therefore, species currently or historically present in the vegetation may not be represented in the seedbank.

Throughout the 20th century, CBWC has been exposed to direct anthropogenic stressors such as ditching, grazing, haying, and impacts to its watershed through road and railroad construction. In the last half of the 20th century, CBWC was reduced in size through wetland fill, its hydrology was altered and it was exposed to chemicals from fly ash ponds and atmospheric deposition.

Due to these changes, the graminoid/forb plant assemblage present up to the early 1960's has been replaced by an invasive assemblage of shrubs, cattail, and common reed.

Given that CBWC has been exposed to many intense negative stressors, and that the vegetation has been negatively altered, it is likely that the seedbank has also been negatively impacted. Knowledge of seedbank species and seedbank seed quantity will assist in restoration planning. This information will allow for development of a customized species list; species that must be reintroduced via seed dispersal and plant propagation actions. In addition, information concerning the quantity of invasive species seed in the seedbank will provide insight into restoration actions necessary to counter establishment of invasive species from the seedbank. The objectives of the seedbank study were as follows:

1. Identify species and seed quantity presently in the seedbank;
2. Determine spatial variation of species with the seedbank;
3. Determine the impact of cattail presence from a time perspective on the seedbank.

METHODS

Introduction: The seedling emergence method (Simpson et al. 1989) in which soil samples are exposed to a favorable environment allowing germination of seed in the soil was used to examine the seed bank of CBWC. Samples representing five vegetation types of CBWC (raised fen, north graminoid fen, forested swamp, cattail, remnant sedge meadow) and two sedge meadow types in an adjacent wetland east of Mineral Springs Road (lake sedge and tussock sedge) were sampled (Exhibit B-2). Cattail sample points were taken from stands of cattail ranging in age from 30 to 80 years. In total, soil samples were taken from 74 sample points. Methodologically, this study consisted of four components: soil extraction, soil containerization/hydration, seedling evaluation, and analyses.

Extraction: Seventy-four points were selected for seedbank sampling. Points were selected at random along portions of vegetation transects present within the vegetation types given above. Sampling of Mineral Springs Road East (MSRE) wetland was executed at random points along transects established through the center of each vegetation type. At each sample point, 12 soil cores were extracted. Cores were obtained with a golf-hole cutter and were 10cm diameter and

10 cm in depth. The 12 cores came from points randomly scattered within a 5 m radius of the sample point. Cores were placed in labeled plastic bags for transport out of the wetland.

Throughout the extraction process, special care was employed to ensure that no contamination occurred. The golf hole cutter and the knives used to obtain a soil sample from a sample point were rinsed with water and cleaned prior to soil extraction from a new sample point. In addition, hands were rinsed and cleaned between each sample point. Extraction occurred during the first two weeks of May 2002.

Containerization/Hydration: Immediately after collection, any existing rhizomes were removed and each sample, consisting of 12 cores, was hand homogenized. Following homogenization, each sample was split into 6 buckets. The buckets had a capacity of 5.5 liters with wire handles, and had sides that were pierced with four 3 mm holes, about 2.5 cm from their bottoms. The buckets were 20 cm in diameter and 17 cm in length. Half of the sample was kept at saturation and half kept inundated. Therefore, the two treatments, saturated and inundated, had three replicates each. Buckets were kept in a greenhouse to facilitate germination.

Portions of the sample put into buckets for saturated treatment were spread into a 3 cm layer atop 0.5 liters of sterilized topsoil (~2cm in depth) which was placed on top of 2.5 liters of sand (~9 cm in depth). The upper surface of the seedbank sample was approximately 2.5 cm below the rim of the bucket. Samples receiving the inundated treatment were spread into a 3 cm layer atop 0.25 liters of topsoil (~1cm) followed by 1.25 liters of sand (~5 cm). The surface of these samples was approximately 8 cm below the bucket's rim.

Buckets were placed into water-filled germination bins. The bins were constructed out of lumber and lined with plastic pond liner. Each bin was supplied with water by a system of pipes and nozzles, and each had its own water outlet. The system allowed a desired water level to be maintained while providing enough water circulation to avoid stagnation. Germination bins were designated to either saturated or inundated samples; replicates were kept in separate bins. The bins were located along the sides of the greenhouse, away from air vents, to reduce possible recruitment of airborne seeds from outside. An elevated grate at the bottom of each bin allowed

water to flow freely around and under the buckets. The water level of saturated treatments was kept at or just below the sample surface. Inundated samples were covered by four to five centimeters of water.

Evaluation: Evaluation began in June 2002, and was completed in June of 2004. As seedlings were identified, they were counted, removed, and recorded. A knife or other fine tool was used to cut and remove roots; special care was taken not to disturb the soil surface while extracting seedlings. Unknown plants were left in place, or extracted, labeled, and preserved in a plant press for identification.

Analyses: Seed germination in saturation and inundated treatments were compared. There were no species in which seed germination was specific to the inundated treatment. Further, in all cases where a species exhibited germination in both, saturated and inundated treatments, seed germination was more prolific under the saturated treatment. Therefore, all summary data and analyses were conducted using data generated through the saturated treatment.

For each species, total seedlings present at each sample point represented the average of the three replications. Average seedling quantity for each species at each sample point was derived by multiplying the quantity present by 31.8 (100,000 cm^2 divided by 31.4 cm^{-2} where 31.4 cm^{-2} represents bucket surface area). Seed banks are known to exhibit high spatial variability (Bigwood and Inouye 1988); therefore, frequency of species occurrence at sample points was included for consideration of dominant seedbank species. The importance value for each species, sum of relative seed quantity and relative frequency, was calculated. Dominant seedbank species were those species with high importance values representing at least 50 percent of total importance.

Differences among plant assemblages and among cattail stand ages in species richness, total seed quantity, cattail seed quantity and forb-sedge-grass seed quantity were evaluated. In both cases, plant assemblages and cattail stand ages, One-way Anova was conducted followed by Student-Newman-Keuls tests. All testing was conducted using natural logarithm transformed values. Homogeneity of variance was confirmed using Levene's test.

RESULTS

Density, frequency and importance of seedbank species detected in CBWC and MSRE are provided in Appendices SII:C-1 and SII:C-2, respectively. Density, frequency and importance of seedbank species detected in the five plant assemblages within CBWC, the two plant assemblages within MSRE and at cattail stands of increasing age are provided in appendices SII:C-3.

Mean seed quantity in the seedbank of CBWC was 1487 seeds/m^2 (Table 16). Mean seed quantity in the seedbank of MSRE was similar; 1268 seeds/m^2. In total, 90 species were identified (Table 16). Of the identified species, 84 species (93.3 percent) were native species and 6 species (6.7 percent) were non-native species (Table 16). There were 67 perennial species, 22 annual species and one biennial species. The majority of seedbank species were forbs; 50 species (54.3 percent). In addition to the forb species, there were 15 sedge species, 11 rush species, 10 grass species, 4 shrub species and 2 vine species. Trees were not represented in the seedbank. Eighty-two seedbank species were wetland species (as defined by wetland indicator categories FAC to OBL) and eight species were upland species (as defined by wetland indicator categories FAC- to UPL). Seventy-five seedbank species were present in the realized vegetation while 15 seedbank species were not represented in the realized vegetation.

Table 16: Characteristics of Species Detected in the Seedbanks of CBWC and MSRE.

Species Present		Life Forms		Wetland Indicators	
ID to Species	90	Annual	22	OBL	53
ID to Genus only	2	Biennial	1	FACW+	9
Total	92	Perennial	67	FACW	10
				FACW-	3
				FAC+	2
Native species	84	Forb	50	FAC	5
non-native species	6	Grass	10	FAC-	2
Species present/absent in the		Rush	11	FACU+	2
realized vegetation		Sedge	15	FACU	2
Present	75	Shrub	4	FACU-	0
Absent	15	Vine	2	UPL	2
	Cowles Bog Wetland Complex			**Mineral Springs Road East**	
Total Seed m^{-2}	1487 +- 870.4			1268 +- 1040.0	
Total Species	87			44	

Eighty-seven species were present in the seedbank of CBWC, but species diversity was low, as reflected by 84 percent of seedbank species present in ten or fewer sample points and 80 percent

of seed quantity represented by only three species (see Appendix B-1). Forty-four species were present in the seedbank of MSRE. As was the case with CBWC, overall seedbank species diversity was not high as suggested by 75 percent of species present in 40 percent or fewer sample points and 78 percent of seed being represented by five species (see Appendix B-2).

Three species dominated the seed bank of CBWC (Table 17). These species were cattail (*Typha x glauca; Typha angustifolia*), wool grass (*Scirpus cyperinus*), and soft rush (*Juncus effusus*). Five species dominated the seedbank of MSRE. These species included marsh purslane (*Ludwigia palustris*) and monkey flower (*Mimulus ringens*), as well as the three dominant species of CBWC. Cattail seed was present at all points sampled in CBWC and MSRE and exhibited approximately three times as much seed/m^2 in CBWC, 994 seed/m^2, than in MSRE, 265 seed/m^2.

Wool grass and soft rush were more common and more widely distributed in MSRE than in CBWC with seed quantity and frequency of 266 seeds/m^2 and 100 percent versus 118 seeds/m^2 and 88 percent , respectively, for wool grass, and 275 seeds/m^2 and 50 percent frequency versus 79 seeds/m^2 and 31 percent frequency, respectively, for soft rush.

Table 17: Dominant species present in the seedbank of Cowles Bog Wetland Complex and Mineral Springs Road East. (Importance equals relative seed quantity plus relative frequency)

Scientific Name	Seed Quantity(m^{-2})	Frequency (%)	Importance
Cowles Bog Wetland Complex (sample points =64)			
Typha spp.	994	100	77.4
Scirpus cyperinus	118	88	17.2
Juncus effusus	79	31	8.6
Wetland East of Mineral Springs Road (sample points = 10)			
Typha spp.	265	100	29.0
Scirpus cyperinus	226	100	25.9
Juncus effusus	275	50	25.7
Ludwigia palustris	129	50	14.2
Mimulus ringens	84	50	10.7

Except for the north graminoid fen where cattail was the only dominant seedbank species, cattail and wool grass were dominant seedbank species in all plant assemblages (Table 18). At the north graminoid fen, wool grass was the second most common species but did not qualify as a dominant species. At plant assemblages located on peripheral zones, remnant sedge meadow and forested swamp, and in the two plant assemblages of MSRE, there were three to four co-

dominant species. Two co-dominant species were present at the raised fen and one co-dominant species was present at the hybrid cattail assemblage.

In addition to wool grass and cattail, seedbank co-dominants of the lake sedge plant assemblage were soft rush, monkey flower and marsh purslane and seedbank co-dominants of the tussock sedge plant assemblage were panicle aster (*Aster simplex*) and tussock sedge. At CBWC the following species were co-dominants: remnant sedge meadow – soft rush and blue vervain (*Verbena hastata*); raised fen – fowl manna grass (*Glyceria stricta*); forested swamp – fowl manna grass and Pennsylvania bitter cress (*Cardamine pensylvanica*).

Table 18: Dominant species present in the seedbank of plant assemblages (Importance represents relative seed quantity plus relative frequency).

Scientific Name	Seed Quantity(m^{-2})	Frequency (%)	Importance
Carex lacustris dominated wetland east of Mineral Springs Road (sample points = 5)			
Juncus effusus	550	100	32.0
Scirpus cyperinus	413	100	25.7
Typha spp.	382	100	24.3
Ludwigia palustris	252	80	16.9
Mimulus ringens	168	100	14.3
Carex stricta dominated wetland east of Mineral Springs Road (sample points =5)			
Typha spp.	148	100	50.0
Aster simplex	51	80	22.0
Scirpus cyperinus	38	100	20.8
Carex stricta	25	60	13.1
Remnant Sedge Meadow of Cowles Bog Wetland Complex (sample points = 9)			
Typha spp.	440	100	39.5
Juncus effusus	415	100	37.6
Scirpus cyperinus	179	100	20.5
Verbena hastata	66	89	11.5
Raised Fen of Cowles Bog (sample points = 8)			
Typha spp.	432	100	72.4
Scirpus cyperinus	54	75	16.7
Glyceria striata	49	75	15.9
North Graminoid Fen of Cowles Bog (sample points = 5)			
Typha spp.	1047	100	102.2
Forested Swamp of Cowles Bog Wetland Complex (sample points = 6)			
Typha spp.	311	100	37.3
Scirpus cyperinus	182	100	25.6
Cardamine pensylvanica	127	83	19.1
Glyceria striata	110	100	19.0
Cattail unit of Cowles Bog Wetland Complex (sample points = 34)			
Typha spp.	1435	100	88.8
Scirpus cyperinus	115	88	16.0

Seedbanks of the plant assemblages differed in species richness, species diversity, cattail seed, forb-sedge-grass seed, and total seed (Table 19). Species richness was greatest in the cattail seedbank, 73 species, and least in the north graminoid fen, 16 species. There were 40 species present in the seedbank of the remnant sedge meadow. The other four plant assemblages exhibited similar species richness ranging from 25 species at the forested swamp and tussock sedge assemblage, 27 species at the raised fen, and 31 species in the lake sedge assemblage.

Seedbank species diversity, as measured by the number of species/m^2, did not reflect species richness except at the north graminoid fen, which had fewer species than other plant assemblages and a species diversity of only 5 species/m^2. Lake sedge and remnant sedge meadow plant assemblages exhibited the greatest species diversity; 15 species/m^2 and 13 species/m^2, respectively. Species diversity at other plant assemblages was similar and ranged from 11 species/m^2 at the forested swamp to 8 species/m^2 at the raised fen. The greatest numbers of seedbank species were detected in the hybrid cattail assemblage, but this assemblage had species diversity of only 9 species/m^2.

Table 19: Results of one-way-ANOVA for differences among plant assemblages in species diversity, total seed, hybrid cattail seed and forb-sedge-grass seed. Tests of homogeneity of variance (Levene), one-way-Anova and Student-Newman-Keuls (alpha=0.05) for difference among groupings were conducted on LN transformed values. Non-transformed values (mean (standard deviation)) are provided in the table. Assemblages designated with the same letter were not significantly different.

Plant Group	Sample Points	Species Number	Species Diversity	Total Seed	Hybrid Cattail Seed	Forb-Sedge-Grass Seed
1	5	31	15d (1.3)	2160a (378.5)	382bc (72.8)	1778a (407.6)
2	5	25	9abc(0.9)	377d (29.9)	148c (18.9)	229b (26.1)
3	8	27	8ab (0.9)	717cd(54.3)	432b (54.2)	285b (36.3)
4	5	16	5a (1.2)	1251c (372.9)	1047a (300.3)	204b (85.7)
5	7	40	13cd (0.5)	1375bc (180.2)	440b (111.2)	935c (101.9)
6	6	25	11bc (1.3)	1104c (128.4)	311bc (48.9)	793c (144.3)
7	36	73	9abc (0.6)	1735ab (159.4)	1307a (148.0)	428b (82.4)
Levene's Test			0.14	0.075	0.162	0.51
ANOVA			F=6.1; P=0.000	F=8.9; P=0.000	F=10.8; P=0.000	F=10.0; P=0.000

Plant assemblage: 1= lake sedge; 2= tussock sedge; 3= raised fen; 4= north graminoid fen; 5= remnant sedge meadow; 6= forested swamp; 7= cattail.

Total seed quantity ranged from a high of 2160 seeds/m^2 at the lake shore sedge assemblage and 1735 seeds/m^2 at the cattail assemblage to a low of 377 seeds/m^2 in the tussock sedge

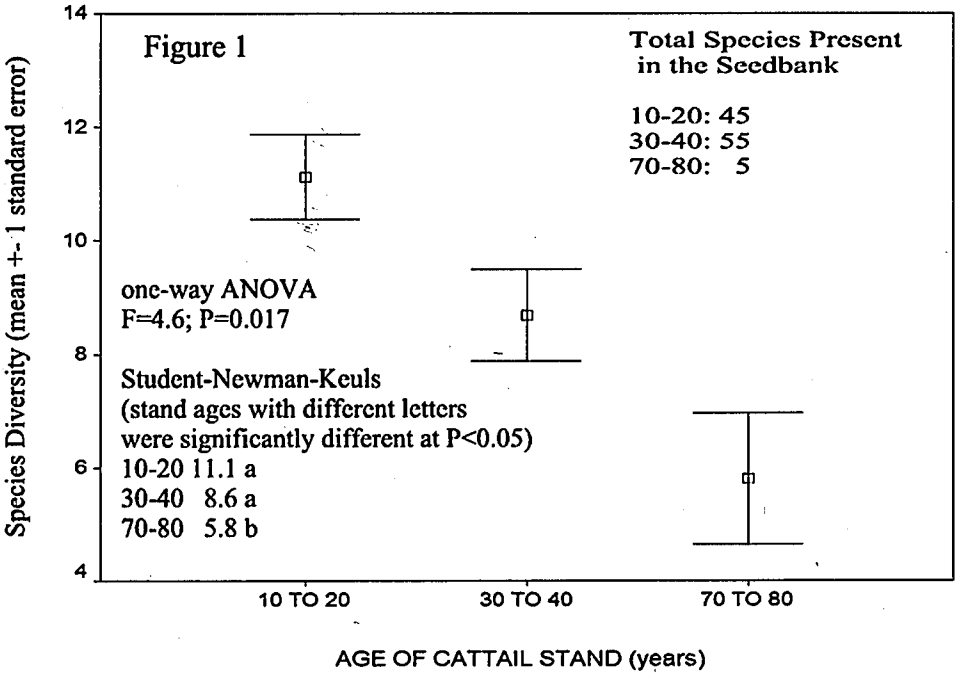
assemblage. Total seed at other plant assemblages was similar and ranged from 1,375 seeds/m^2 at the remnant sedge meadow to 717 seeds/m^2 at the raised fen.
Cattail seed quantity was similar and greatest at the cattail assemblage and north graminoid fen unit, 1307 seeds/m^2 and 1251 seeds/m^2, respectively. The least amount of cattail seed was present at the tussock sedge plant assemblage, 148 seeds/m^2. Cattail seed at other assemblages ranged from 440 seeds/m^2 at the remnant sedge meadow to 311 seeds/m^2 at the forested swamp.

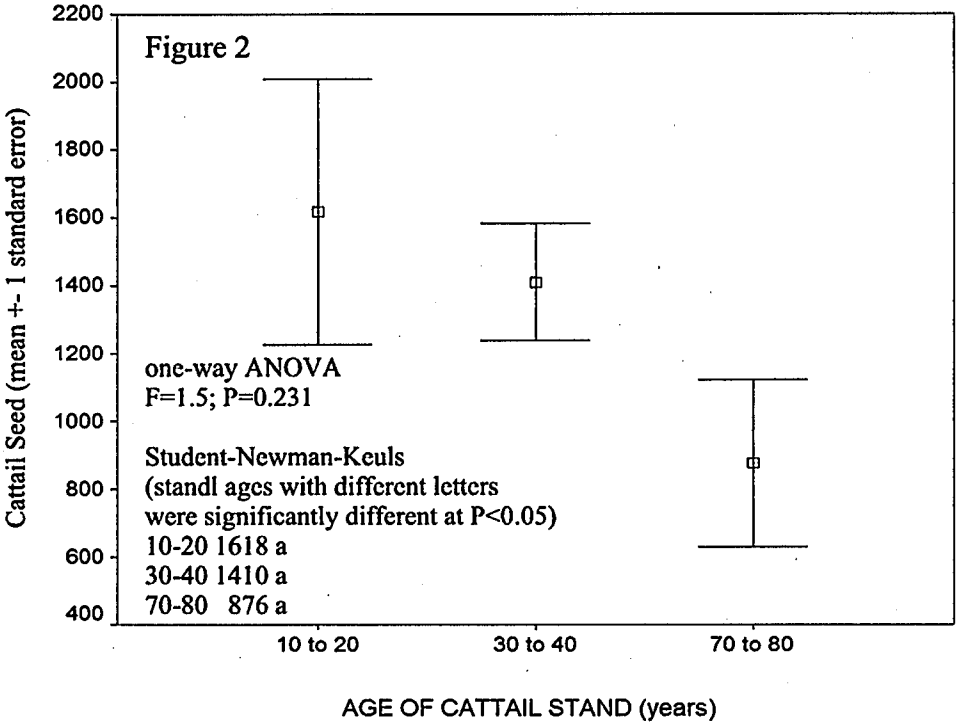
The greatest number of forb-sedge-grass seed was found at the lake shore sedge assemblage; 1778 seeds/m^2. A similar quantity of forb-sedge-grass seed was present at the remnant sedge meadow and forested swamp, 935 seeds/m^2 and 793 seeds/m^2. The least amount of forb-sedge-grass seed ranged from 428 seeds/m^2 at the hybrid cattail assemblage to 204 seeds/m^2 at the north graminoid fen.

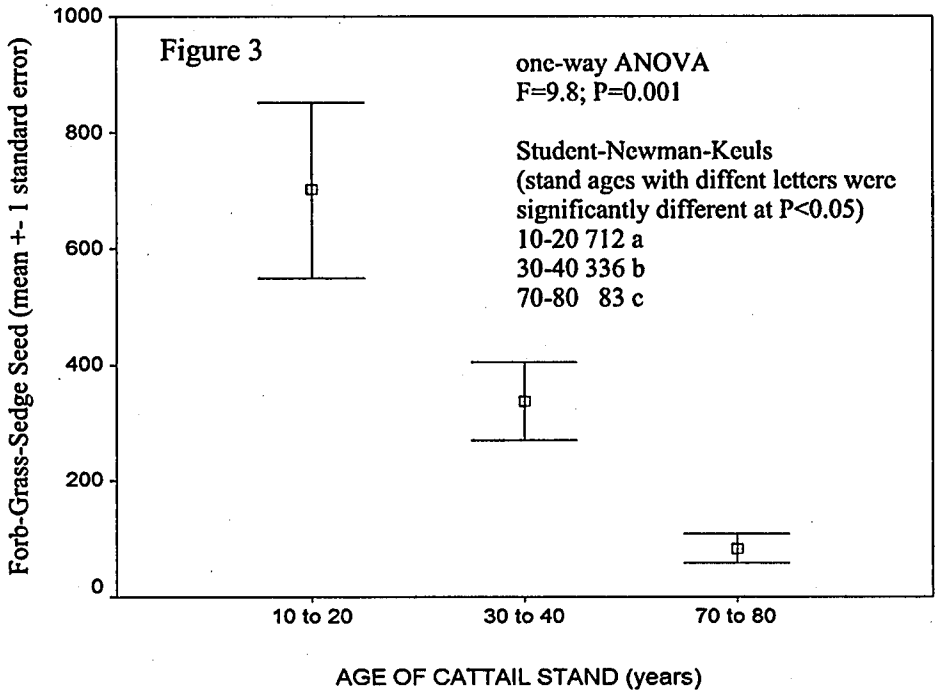
Cattail stands of differing ages exhibited declining trends in species diversity, total seed, cattail seed and forb-sedge-grass seed with increasing stand age (figures 1- 4). Species number at stand 10-20 and 30-40 were 45 species and 55 species, respectively (figure 1). Species number declined to 19 species at stand 70-80. Species diversity was similar at stand 10-20 and 30-40, 11.1 species/m^2 and 8.6 species/m^2, and significantly greater than species diversity at stand 70-80, 5.7 species/m^2.

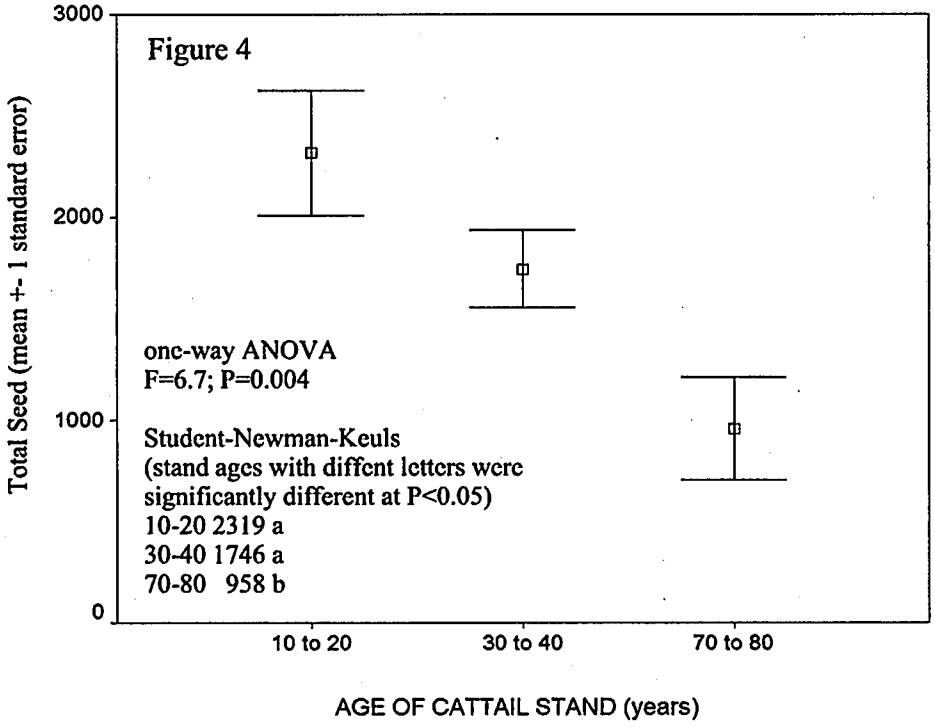
Cattail seed exhibited a trend of declining quantities with stand age, 1618 seeds/m^2, 1410 seeds/m^2, and 876 seeds/m^2, for stands 10-20, 30-40, and 70-80, respectively (figure 2). There was no significant difference among stand ages in cattail seed.

Each stand age exhibited a significant difference in seed quantity of forb-grass-sedge seed. Seed quantity at stand 10-20 was 712 seeds/m^2, declining by 52.8 percent, to 336 seed/m^2 at stand 30-40. Seed quantity at stand 70-80, 83 seeds/m^2, represented a decline of 75 percent from stand 30-40 and a decline of 88 percent from stand 10-20. Total seed was similar at stands 10-20 and 30-40; 2319 seeds/m^2 and 1746 seeds/m^2, respectively. Seed quantity at stand 70-80 was 958 seeds/m^2, which was significantly fewer seed than detected at stands 10-20 and 30-40.


Figure 1
Total Species Present in the Seedbank
10-20: 45
30-40: 55
70-80: 5
one-way ANOVA
F=4.6; P=0.017
Student-Newman-Keuls
(stand ages with different letters
were significantly different at P<0.05)
10-20 11.1 a
30-40 8.6 a
70-80 5.8 b
Species Diversity (mean +- 1 standard error)
14
12
10
8
6
4
10 TO 20
30 TO 40
70 TO 80
AGE OF CATTAIL STAND (years)


Figure 2
one-way ANOVA
F=1.5; P=0.231
Student-Newman-Keuls
(standl ages with different letters
were significantly different at P<0.05)
10-20 1618 a
30-40 1410 a
70-80 876 a
Cattail Seed (mean +- 1 standard error)
2200
2000
1800
1600
1400
1200
1000
800
600
400
10 to 20
30 to 40
70 to 80
AGE OF CATTAIL STAND (years)


Figure 3
one-way ANOVA
F=9.8; P=0.001
Student-Newman-Keuls
(stand ages with diffent letters were
significantly different at P<0.05)
10-20 712 a
30-40 336 b
70-80 83 c
Forb-Grass-Sedge Seed (mean +- 1 standard error)
1000
800
600
400
200
0
10 to 20
30 to 40
70 to 80
AGE OF CATTAIL STAND (years)


Figure 4
one-way ANOVA
F=6.7; P=0.004
Student-Newman-Keuls
(stand ages with diffent letters were
significantly different at P<0.05)
10-20 2319 a
30-40 1746 a
70-80 958 b
Total Seed (mean +- 1 standard error)
3000
2000
1000
0
10 to 20
30 to 40
70 to 80
AGE OF CATTAIL STAND (years)

SECTION II:D ABIOTIC PARAMETERS: HYDROLOGY; WATER CHEMISTRY; SOIL CHEMISTRY

INTRODUCTION

Wetland is comprised of a richness of unique landscape types that have in common the diagnostic features of hydrophytic vegetation, hydric soils and wetland hydrology. The chemistry of the soils and water and hydrological parameters such as fluctuation, source and depth along with biotic interactions determine the structure of vegetation and species present. The above mentioned abotic factors along with the vegetation allow for classification of various wetland types (Cowardin et al. 1979, Eggers and Reed 1987).

Cowles Bog Wetland Complex, historically, was a landscape of wetland splendor comprised of a variety of wetland types. Wetland types such as forested swamp, the white cedar population on the raised fen, and peripheral zones of sedge meadow continue to express vestigial pockets of vegetation that allow for visible distinction among these wetland types. However, today, most of CBWC is occupied by cattail and common reed, therefore, inventory of hydrology, soil chemistry, and water chemistry was necessary to identify potential wetland types and vegetation types that will define desired end points resulting from restoration actions.

METHODS

Hydrology: The hydrology of CBWC was monitored with a series of staff gauges and wells. Eleven staff gauges were placed throughout the wetland in March 2002. The staff gauges were made of porcelain enameled steel, mounted on 2 x 10 cm boards, and scaled in centimeters.

In late April 2002, 26 shallow groundwater wells were installed. The wells were constructed of 3.8 cm PVC and had two staggered paired columns of 0.3 cm holes, which were 2.5 cm apart. The wells were 1.5 m long, and were capped at the bottom. The holes covered the lower 84 cm of the wells, and were covered with a well filtering sock. Well installation was accomplished through use of a Dutch auger to make a small diameter hole in the wetland soil. This was followed by pushing the well into the muck soils approximately 1 m below the surface. The wells were covered with a PVC cap. Ground water levels were monitored weekly with an electronic water level probe from the first week in May to the end of December.

In early 2003, regression analyses were conducted in which water level association among wells was determined. In cases where the R value for two wells exceeded 0.9, a graph was generated to provide a visual presentation of the association of water levels between the subject well monitoring points. Based on wells that indicated parallel readings, eleven wells, were deleted from monitoring in 2003. The locations of the remaining wells were evaluated, and in early spring 2003, 18 additional wells were installed for a total of 33 groundwater wells. These 33 wells and staff gauges were monitored weekly from early May through early December of 2003. Exhibit B:3 provides locations of the monitoring wells and staff gauges.

In order to predict surface water levels for the area between wells and staff gauges, four comprehensive surface water depth readings were made in 2003. Surface water depth in centimeters was recorded at 1,100 locations on April 11, May 2, June 4, and July 11, 2003. These locations corresponded with vegetation monitoring plot locations. For each sample location, a predictive equation was generated through regression of surface water data with that of several nearby wells and/or staff gauges. Based on regression equations, expected surface water depths at each of the 1,200 sample points were generated for at least one event each month in which water level was monitored at the wells and staff gauges.

Surface water data were used to generate a series of maps showing the amount of standing water and groundwater levels throughout CBWC from April through December of 2003. These contour maps were generated with Surfer® 8, a contour and surface mapping computer program. Contours were generated with Surfer's default kriging algorithm. These default settings use point type kriging, and employ a linear variogram.

Water Chemistry: In 2002, on two occasions water was sampled from a subset of monitoring wells and chemical analyses conducted. Sampling and analyses were conducted for the purpose of training staff in water quality analyses and gaining awareness of effort required to collect and analyze water samples.

Based on information gained from the 2002 trial runs, in 2003, ground water samples were collected at 26 wells and surface water samples at 14 locations. All water samples were collected at three time points; spring (mid-April), summer (mid-July), and fall (mid-November).

Ground water samples were obtained with a small hand pump. The well was completely purged followed by sample collection after well regeneration. A 250 ml Whirlpack® plastic bag was filled with a water sample, labeled, and put in a cooler with ice packs. Surface water samples consisted of three subsamples which were collected at random points within a defined polygon. The three subsamples were obtained with a PVC dip cup, placed in 250 ml Whirlpack® plastic bags and then placed in a cooler with ice packs. The subsamples were homogenized at the laboratory.

All water samples from all time points were analyzed for total nitrogen and nitrate and the April samples for total phosphorous by Dr. William Crumpton at Iowa State University. For these analyses 125 ml of unfiltered water was placed in a labeled bottle and preserved with H_2SO_4 to a pH<2. Nitrate and total nitrogen concentrations were determined by persulfate digestion followed by spectophotometric analysis. Total phosphorus was determined by persulfate digestion followed by colorimetric analysis.

Other water analyses, pH, total hardness, alkalinity, conductivity and calcium hardness, were conducted at the water quality laboratory at Indiana Dunes National Lakeshore. Analyses for total hardness and calcium hardness were conducted using the EDTA titrimetric method (Standard Methods 1985). Total alkalinity was determined by titration with a standard sulfuric acid solution (1.6N) to an end point pH as evidenced by the color change of a methyl red/bromcresol green indicator solution. Conductivity and pH was determined with Fisher and Hach water probes, respectively.

Soil Chemistry: Soil samples for chemical analyses were taken at randomly selected points along the vegetation transect. To assure that sampling was representative of CBWC, CBWC was stratified using known and suspected wetland types.

Each sample consisted of three to five soil cores. Cores were obtained with a golf hole cutter and were 20 cm deep and 10 cm in diameter with a volume of 1,647 cm^3. The number of cores taken was determined by the soil being sampled; soils that were full of thick roots, rhizomes, or debris were sampled most heavily. Additional data taken at sample locations included depth of groundwater, depth of underlying sand layer, and location descriptions. Sample extraction occurred between October 10 and November 7, 2002.

For each sample point, rhizomes, sticks, and other debris were removed from all soil cores followed by homogenization in a 5-gallon bucket. Samples were spread out (~.2.0 cm thick) on a plastic drop cloth and allowed to air dry. When dry, samples were sifted through a #10 sieve. The resulting soil was separated into three labeled sample bags. Sample processing began shortly after extraction, and continued into December. Samples were shipped to Key Agricultural Labs in Macomb, Illinois, and Dr. Stephen Broome of the University of North Carolina for analysis.

RESULTS

Hydrology: Exhibits D:1-D:10 provide a spatial presentation of monthly surface water and groundwater levels throughout CBWC from April to December 2003. A summary of hydrology data is provided in Table 20.

The hydrological pattern of CBWC followed a typical pattern observed in mid-western wetlands. Wetland hydrology is fully expressed during spring, declines in the summer months, and then starting in early to late fall the wetland rehydrates. In 2003, this seasonal wetland hydrological cycle was documented. During the spring months, April through May, surface water was absent in only 7.0 to 8.5 ha of wetland. Groundwater levels ranged from -2 to -15 cm. Starting in mid June and through the summer months, June through September, the absence of surface water increased from 7.0 ha on May 27 to 69 ha on September 16. Maximum depth to groundwater at a given point was -42 cm on September 16. From September 16 through December 9, wetland without surface water declined from 69.0 to 23.0 ha. However, maximum depth to groundwater at a given point remained constant at -42 to -44 cm (these low levels reflect a well adjacent to a ditch).

During the spring months, maximum surface area of CBWC experience surface water. The surface water depths present on 61 to 62 ha of CBWC ranged from 1 to 10 cm. Pockets of deeper surface water ranging from 10 to 50 cm were present on 3 to 5 ha of wetland. Water depths in the documented range in conjunction with saturated soils in the absence of standing water are favorable for development and persistence of wetland dominated by graminoids and forbs.

Table 20: Wetland Surface Area (ha) Experiencing the Indicated Water levels During Ten Time Periods in 2003. The Range of Ground Water (GW) Levels (cm below the ground surface) in Wetland not Experiencing Surface Water is Provided.

Water level	Apr 11	May 2	May 27	Jun 16	Jul 11	Aug 12	Sep 16	Oct 15	Nov 10	Dec 9
0	8.5	7.0	7.0	13.0	16.0	63.0	69.0	48.0	43.0	23.0
1-5	45.0	41.0	40.0	41.0	46.0	10.0	4.0	20.0	25.0	43.0
5-10	17.0	20.0	21.0	15.0	11.0	1.0	1.0	5.0	5.0	7.0
10-20	3.0	5.0	5.0	4.0	1.0	0.0	0.0	1.0	1.0	1.0
20-50	0.5	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
GW	-2 ; -15	-2 ; -7	-1 ; -17	-1 ;-45	-1; -10	-1 ; -25	-3 ; -42	-2 ; -43	-2 ; -44	-2 ; -44

Water Chemistry: A summary of groundwater chemistry results is provided in Table 21. Given that groundwater chemistry values were within acceptable and anticipated ranges, at this time, more detailed analyses were not conducted.

Table 21: Groundwater Chemistry Characterizing the Indicated Vegetation Units. Fen is inclusive of all three fen units and Sedge Meadow represents the Southwestern portion of the East Shrub Unit. The Number Presented Represent Mean Values Derived from Wells Samples in the Units at the Three Sample Times (Ca= Calium mg/l; Alk= Alkalinity mg/l; TH = total hardness mg/l; C= conductivity ohms; NO3 =nitrate mg/l; Total N= total nitrogen mg/l; total P = total phosphorus ppb

Unit	pH	Ca	Alk	TH	C	NO3	Total N	Total P
Cattail	7.0	185.1	246.1	291.4	499.9	0.37	0.78	310
West shrub	6.7	158.5	193.0	321.0	449.9	0.40	0.57	267
Forested swamp	6.8	135.0	156.0	208.8	309.5	0.37	1.12	534
Fen	7.4	230.0	324.1	384.9	605.8	0.31	0.42	54
Sedge meadow	7.0	200.7	220.5	331.9	549.5	0.37	0.78	310

The highest values of pH, calcium, alkalinity total hardness and conductivity were present in the fen unit while the lowest chemical values were found in the forested swamp. Groundwater chemical concentrations for fen units and the forested swamp unit presented respectively were as follows: pH 7.4 and 6.8; calcium 230 mg/l and 135 mg/l; alkalinity 324 mg/l and 156 mg/l; total hardness 384.9 mg/l and 208.8 mg/l; conductivity 605.8 ohms and 309.5 ohms. Values for these

constituents at the cattail unit, west shrub unit and sedge meadow were midway between the high concentrations at the fen units and low concentrations at the forested swamp unit.

Nitrate concentrations ranging from 0.31 mg/l at the fen to 0.40 mg/l at the west shrub unit were similar among vegetation units. Total nitrogen and total phosphorus exhibited a similar trend to that expressed previously except that these nutrients had the highest values in the forested swamp, 1.12 mg/l and 534 ppb, respectively, and the lowest values in the fen units, 0.42 mg/l and 54 ppb, respective. Total nitrogen in other units ranged from 0.57 to 0.78 mg/l and total phosphorus ranged from 267 to 310 ppb.

Surface water chemistry reflected, in part, the spatial difference exhibited by ground water. Surface water pH values were all above 7.0 with a range from 7.0 to 7.8. Higher pH was present at surface water sample points associated with the fen units and lower values with surface water points associated with the forested swamp. Total hardness, calcium, alkalinity and conductivity reflected a similar pattern.

Soil Chemistry: Exhibits E:1-E:14 provide a spatial presentation of soil chemistry at CBWC. This spatial presentation demonstrates that soil chemistry at CBWC is not homogenous. Cation exchange capacity, total cations and calcium exhibit a similar pattern with concentrations highest in association with the fen units and mid-way on the western edge. High values for each at these two points of concentration range from 100 to 170 centimoles/Kg, 80 to 180 centimoles/Kg and 80 to 140 centimoles/Kg. For all of these constituents, the highest point of concentration was located at the interface between the raised fen and north graminoid fen. This is the area of the historic quaking bog.

Potassium, sodium and phosphorus exhibited an overlap in their spatial concentrations. All of these constituents displayed a plume from the southern dike which extended northeast with an eventual decline in concentration. Also, for each constituent there was an area of concentration adjacent to the northeast edge of the raised fen. These zones of high concentration ranged from 0.6 to 1.5 centimoles/Kg for potassium, 1.6 to 3.6 centimoles/Kg for sodium, and 20 to 54 ppb for phosphorus.

Nitrate and ammonium concentrations demonstrated a plume that moved northeast from the northwestern edge of the disturbed prairie to the culvert at Mineral Springs Road. These plumes were evident with all measurements of nitrate and ammonium but were best expressed by nitrate analyses of N/dm^3, and N/l and ammonium analyses of N/l. Concentrations of ammonium N/l and N/dm^3 and nitrate N/g exhibited similar patterns with sporadic nutrient concentration on the western and southern edges and a concentration to the south of the west edge of the raised fen. In this last case, this area of nutrient concentration was associated with an area of dead tamarack trees and may reflect the decomposition of them.

Percent hydrogen and pH showed a similar pattern of lower pH values and higher percent hydrogen along the peripheral zones of CBWC. Higher pH and low percent hydrogen concentrations were present midway on the edge of the southern dike extending to the fen units. Percent saturation of hydrogen ranged from 16 to 56 percent on the peripheral zones and 0 to 20 percent in the central zone. pH ranged from 4.4 to 6.4 on the peripheral zones and 6.4 to a high of 7.6 in the central zone. The highest pH was found on the eastern portion of the raised fen.

The pattern of soil density reflected, in part, depth to sand with soil density being only 0 to 0.4 g/cm^3 in the western portion of CBWC. A pocket of higher soil density was present on the eastern edge of the raised fen. Soil density increased as one transitions to the disturbed prairie from 0.4 g/cm^3 to 1.2 g/cm^3.

A detailed evaluation of differences in soil chemistry among vegetation units is provided in Table 22 for nitrate ug N/g, ammonium ug N/g, phosphorus ug P/g, percent carbon and density g/cm^3. Nitrate was highest in the cattail unit, 99.9 ug N/g, and lowest in the west shrub and forested swamp units, 21.1 and 16.7 ug N/g, respectively. In other units nitrate ranged from 39.6 ug N/g to 52.5 ug N/g. As indicated by the spatial analyses, nitrate levels differed within vegetation units. Nitrate levels were less in the western half of the cattail unit, 54.0 ug N/g than in the eastern half of the cattail unit, 170.7 ug N/g. Nitrate levels in the north and south graminoid fens were similar, 25.9 and 37.0 ug N/g, but much lower than that of the raised fen, 80.0 ug N/g.

The cattail unit had higher NH_4 , 144.8 ug N/g, than other units but not significantly so when compared to the west shrub unit and wetland east of Mineral Springs road. The least concentration of ammonium was present at the forested swamp, 54.2 ug N/g, east shrub unit, 63.7 ug N/g, and fen units, 77.0 ug N/g. The eastern half of the cattail unit had NH_4 levels of 197.1 ug N/g and the western half 109.0 ug N/g. However these levels were not significantly different. The ammonium levels on the fen units ranging from 66.4 ug N/g to 86.6 ug N/g were similar.

Table 22: Comparison of Soil Chemistry among Defined Vegetation Units (mean (standard deviation). Analyses of overall differences were conducted using Non-parametric Tests, Kruskal-Wallis and Mann-Whitney U, and a Parametric Test, One Way Anova. Post testing for differences among areas when Primary testing Indicated a Significant Difference at 0.05 was conducted using Games-Howell.

Vegetation Unit	N	NO3-ugN/g	NH4-ugN/g	P-ugP/g	C %	Densityg/cm^3
Cattail	60	99.9(14.4)a	144.8(13.7)a	15.6(13.6)a	38.1(0.5)a	0.36(0.01)ab
West Shrub	16	21.1(3.7)b	113.4(26.9)ac	5.2(4.8) b	38.8(0.2)a	0.34(0.01)a
Forested Swamp	14	16.7(4.4)b	54.2(7.4)bc	5.3(4.3)b	39.0(0.4)a	0.40(0.01)bc
Fen (all units)	35	52.5(8.7)cd	77.0(7.6)bc	13.6(1.4)a	34.9(0.5)b	0.47(0.02)c
East Shrub	14	39.6(12.3)bc	63.7(10.1)bc	5.0(0.5)b	23.0(2.8)c	0.75(0.02)d
East-Mineral Spring	11	48.2(9.8)bd	95.2(28.9)acd	6.4(0.7)b	19.7(2.0)c	0.85(0.04)de
Kruskal-Wallis test		0.000	0.000	0.000	0.000	0.000
Cattail Unit						
Cattail West	37	54.0(14.4)	109.0(13.9)	21.8(2.2)	39.5(0.59)	0.29(0.01)
Cattail East	24	170.7(22.0)	197.1(23.1)	5.8(0.7)	35.7(0.91)	0.49(0.01)
Mann-Whitney U		0.000	0.001	0.000	0.000	0.000
Fen Units						
Raised	16	80.0(12.8)a	86.6(9.5)a	10.4(1.1)a	33.7(0.6)a	0.57(0.02)a
North Graminoid	13	25.9(10.6)b	70.2(16.5)a	16.9(3.0)a	35.8(1.0)a	0.36(0.03)b
South Graminoid	6	37.0(19.6)b	66.4(10.1)a	14.5(3.2)a	36.2(1.3)a	0.41(0.05)b
One-way ANOVA		0.010	0.528	0.116	0.141	0.000

Total phosphorus was highest at the cattail unit, 15.6 ppb and the fen units 13.6 ppb than at other units which were similar, 5.2 to 6.4 ppb. As indicated by the northeast plume present in the western half of the cattail unit, total phosphorus was higher in the western portion of the cattail unit, 21.8 ppb than in the eastern portion of the cattail unit, 5.8 ppb. Total phosphorus was similar among the fen units.

Percent soil carbon in the western vegetation units of west shrub, cattail and forested swamp, ranged from 38.1 to 39.0 percent and were significantly higher than at other vegetation units.

Percent carbon at the fen units was 34.9 percent and significantly higher than percent carbon at the east shrub unit, 23.0 percent, and percent carbon of wetland soils east of Mineral Springs road, 19.7 percent. Percent carbon at the western portion of the cattail unit was significantly higher, 39.5 percent, than that found in the eastern portion of the cattail unit, 35.7 percent. Fen units with a range from 33.7 to 36.2 percent had similar values of percent carbon.

Soil density reflected values shown by the spatial analysis. Generally soil density was greater in the east shrub unit and wetland east of Mineral Springs road, 0.75 and 0.85 g/cm^3 than western vegetation units. Soil density was the least in the west shrub and cattail units, 0.34 and 0.36 g/cm^3. The eastern portion of the cattail unit had significantly greater soil density, 0.49 g/cm^3 than the western portion of the cattail unit, 0.29 g/cm^3. The north and south graminoid fen had similar soil density, 0.36 and 0.41 g/cm^3, but soil density at these units was significantly less than that of the raised fen, 0.57 g/cm^3.

Section II:E Management Experimentation

Introduction

Restoration of CBWC, among other tasks, will require the removal of cattail, neutralization of the seedbank which is dominated by cattail seed, and establishment of desired alternative vegetation.

Cattail eradication at CBWC, for reasons given in Section III:C, will require herbicide applications to cattail foliage. There is controversy in the Chicago area restoration community pertaining to the herbicide concentration necessary to kill cattail and the preferred cattail growth stage for treatment. Generally, herbicide concentrations used by the Chicago region restoration community range from 2 to 6 percent and the preferred growth stage to apply herbicide is at the time of flower. A literature search did not result in firm conclusions to these issues.

The seedbank of CBWC was dominated by cattail, wool grass and soft rush. Of these three species, cattail far exceeded the other two dominants in seed number and frequency. Cattail was present at all seedbank sample points suggesting that cattail seed has dispersed throughout CBWC, even in areas where its vegetative presence is absent. In the cattail unit, cattail presence in the seedbank was 1,435 seeds.

Endogenous sources of seed can be a significant positive contribution to vegetation establishment during a restoration process (van der Valk et al. 2009). However, if the endogenous seed is comprised of non-desirable species, then actions must be taken to prevent recruitment of seed from the endogenous source which in this case is the seedbank.

A series of investigations were implemented. These investigations were designed to answer the following questions:

1. What concentration of herbicide is required to achieve cattail mortality?
2. What impact does litter have on seedbank recruitment?
3. What is the time line for seedbank recruitment?
4. What impact does planting density have on seedbank recruitment?

Methods

Introduction: A randomized block design was applied to determine answers to the above questions. Ten blocks were established to explore management consequences on seedbank recruitment and three blocks were established to examine various herbicide issues. Exhibit F:1 provides an aerial overview of the experimental design.

Herbicide Concentration and Timing: Three randomized blocks with eight plots were established to investigation herbicide concentration and timing on cattail mortality. The plots, 1.5 x 3 m, were marked with PVC stakes. The plots were separated by a 3 m buffer zone and arranged in a south to north direction. The plots within each block were randomly selected to receive one of four herbicide concentrations (1%, 2%, 3%, 4%) applied either at the flowering stage or at the fruiting stage. The herbicide used in the experiment was aquamaster which is a glyphosate based herbicide approved for use in wetlands.

Herbicide was applied on June 21, 2002 (flowering treatment) and August 21 2002 (fruiting treatment). Each plot received one liter of herbicide, which was mixed to the proper concentration, and distributed evenly throughout the plot with a backpack sprayer. Solo® sprayers, which allow complete evacuation of the herbicide reservoir, were filled with one liter of chemical at a time. This ensured that each plot received the same amount of chemical.

Cattail was evaluated in September 2002 and then again in late spring of 2003. The number of green stems, yellow-green stems and completely dead stems were counted.

Impacts of Litter on Seedbank Recruitment: Five blocks, with 12 plots in each block were established to investigate the impacts of litter on seedbank recruitment. Plots were 3 x 3 m, with a 4 m buffer zone between each plot. The plots were arranged in south to north columns.

Herbicide was applied to plots on June 10 and 11 and re-spray on July 10 to ensure that kill-off was complete. Standing and matted cattail litter was removed from half of the plots. Litter was cut to a height of approximately six inches with a gasoline powered brush cutter. Fallen litter was then removed from the entire plot with a pitchfork.

The plots were randomly selected for two different types of monitoring. In one set, in order to determine seedbank recruitment timeline, cattail seedlings were counted and then removed. The number of cattail seedlings present in an m^2 plot in the center of the 3 x 3 m plot was determined by counting the seedlings that were present within four 15 x 15 cm quadrats which were arranged within the meter plot. These quadrats were positioned approximately 20 cm off of the corners of the meter plots.

In the second set, in order to evaluate recruitment of adult cattails from the seedbank, cattail stems in an m^2 plot were counted. In this case, there was no attempt to remove cattail seedlings. All plots were evaluated in fall 2002, spring 2003, fall 2003, fall 2004, and fall 2005.

Impacts of Planting Density on Seedbank Recruitment: Five blocks, with 18 plots in each block were established to investigate impacts of planting density on seedbank recruitment. Treatments were litter present versus litter absent, planting density (1plant, 6plants and 36 plants) and species installed (tussock sedge, blue joint grass (*Calamagrostis canadensis*), lake sedge (*Carex lacustris*)) Plot preparation was similar to that given above.

Plants were installed in a 1 x 1 m^2 plot nested in the middle of the 3 x 3 m^2 plot. Each block had one plot with each plant species at each plant density for both of the litter treatments. For tussock sedge and blue joint grass, one plug was considered one plant. For lake sedge stems were counted as plants. Plants were installed on July 31 and August 1 of 2002.

The plots were evaluated in late summer of 2002, 2003, 2004, 2005. The evaluation was comprised of the following data collection:

1) Water depth.
2) Presence of other species within the m^2 plot.
3) Stem counts of cattail
4) Cover of planted species.
5) Vertical growth of planted species; height measurements (in cm) of 5 of the tallest stems in the square meter plot.
6) Lateral spread of planted species.

Results

Herbicide Concentration and Timing: The results of herbicide treatment were interesting because all cattail stems in all treatment died. However, stem decline was more rapid in treatments which received greater concentrations of herbicide. It could not be determined until spring 2003 that all cattail stems in the 1 percent treatment had died.

Unfortunately, for the intended purpose, the experiment was flawed. The experiment was flawed because it is not possible to completely cover a cattail stem with herbicide, as done in this experiment, when treating cattail in dense monotypic stands. Only one side of the stem may receive herbicide when herbicide is being applied from a backpack sprayer in dense cattail. Therefore, only 20 to 40 percent of the total stem surface may be exposed to herbicide. A more applicable experiment would have been to apply herbicide of differing concentrations and on differing quantities of stem surface.

Impacts of Litter and Planting Density on Seedbank Recruitment: A select group of five figures (Figures 5 – 9) are provided that summarizes treatment results providing guidance for possible restoration actions. Cattail stems were present in plots without litter in 2002 and increased throughout the four year monitoring period. In 2005, there were approximately 30 stems/ m^2 present in plots without litter. In contrast cattail stems were not present in plots with litter until September 2004. Stem number increase from 2004 to 2005, but in 2005 plots with litter had approximately 5 fewer stems/ m^2 than plots without litter.

Figure 6 presents data from plots without litter but with differing densities of plant installation. In September 2002, 1 to 2 cattail stems were present at all plots. In September 2003, there were few stems present in the plots but plots with only one installed plant exhibited twice as many cattail stems as plots with 6 or 36 installed plants. From September 2004 through 2005, cattail stems increase in all treatments, however, significant differences in stem density were present among treatments. Plots with one installed plant exhibited the greatness number of cattail stems while those with 36 installed plants exhibited fewer cattail stems.

Figure 7 suggest that seedbank suppression may be species specific. Analyses conducted on plots without litter across all planting densities indicated that from September 2002 to 2003 the number of cattail stems in plots of the three species was similar. However, between 2004 and 2005, stem density increased more rapidly in blue joint grass plots than in either of the sedge plots. By September 2005, stem density in the blue joint grass plots was significantly greater than stem density in plots of the other species. All three species may be equivalent in their ability to suppress recruitment from the seedbank, but once adult plants are present, cattail may be able to spread more aggressively in blue joint grass than in either tussock sedge or lake sedge.

Figures 8 and 9 indicate that there is a three year time-line for recruitment of cattail seed from the seedbank with maximum recruitment occurring in year two. Figure 8 suggests that the cattail seedbank is suppressed by litter. It is interesting that plots with litter show a similar time-line of recruitment. One might anticipated a time separation between treatments where plots with litter would have exhibited continued recruitment from the seedbank as litter decomposed. One explanation for the data is that while litter did decompose and decline in presence there remained a thin layer of organic matter which may be inhibiting seedbank recruitment.

Figure 9 presents data from plots without litter but with differing densities of plant installation. Species of similar planting densities were combined for this analysis. As shown in Figure 8, maximum cattail recruitment occurred in the second year following cattail removal. There was a direct association between planting density and cattail seed recruitment. Plots with only one plant recruited 200 seedlings/ m^2 while plots with 36 plants recruited fewer than 20 seedlings/ m^2.

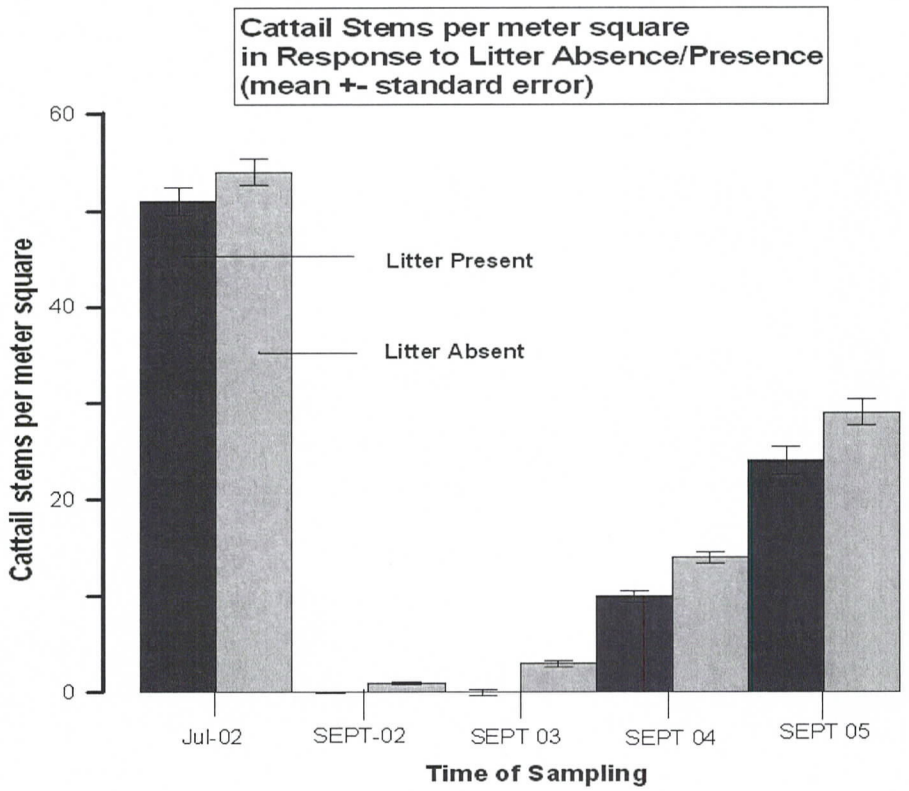
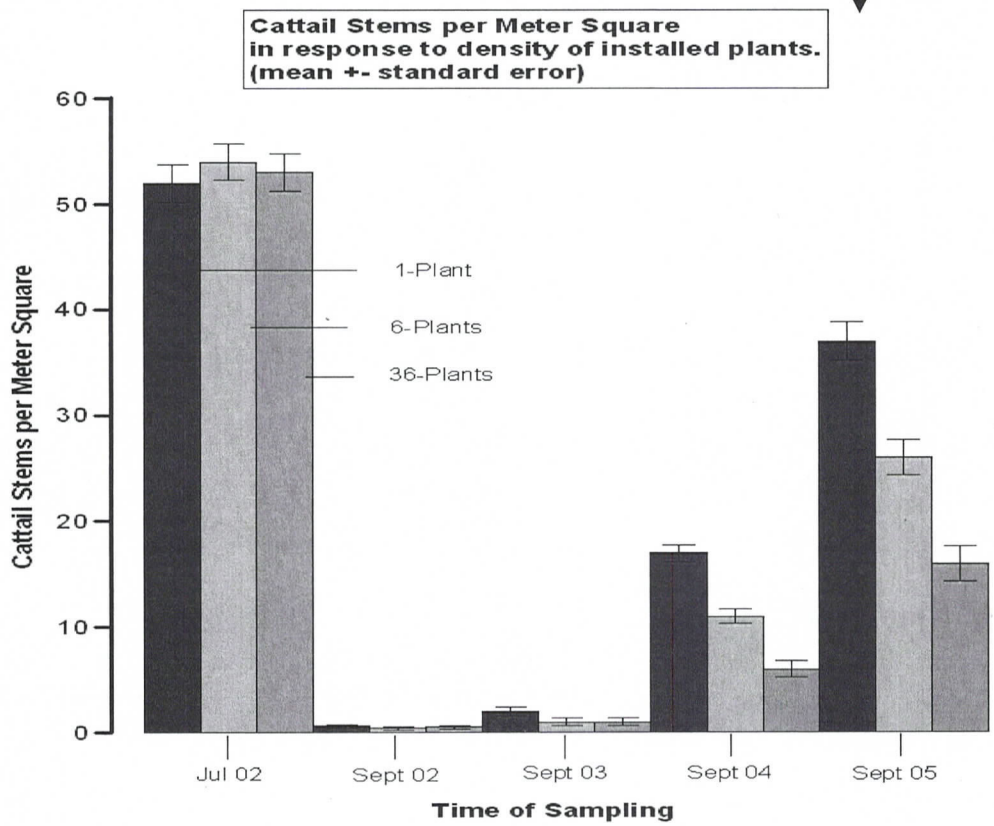


Figure 5

Figure 6



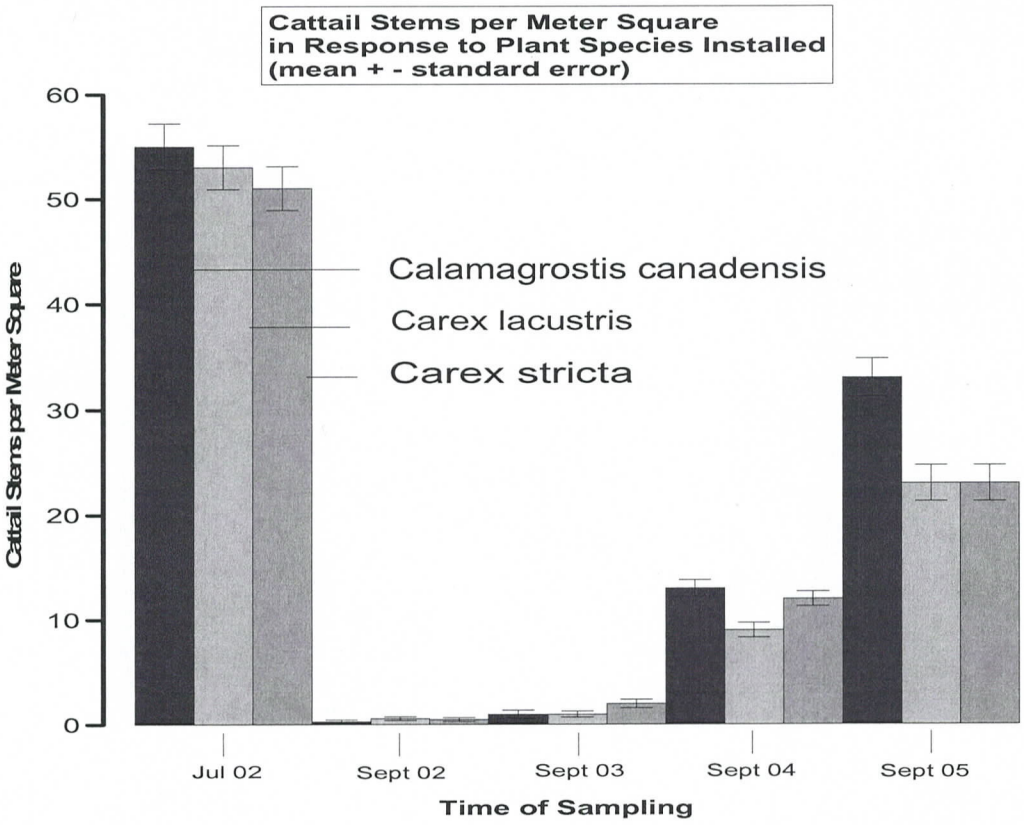


Figure 7

Figure 8

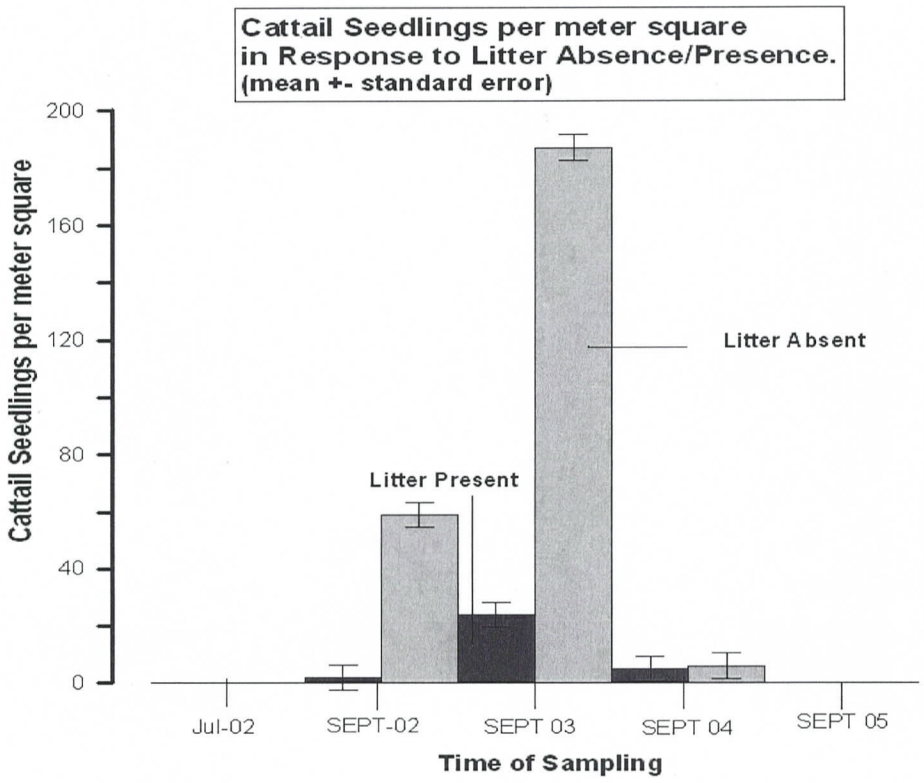
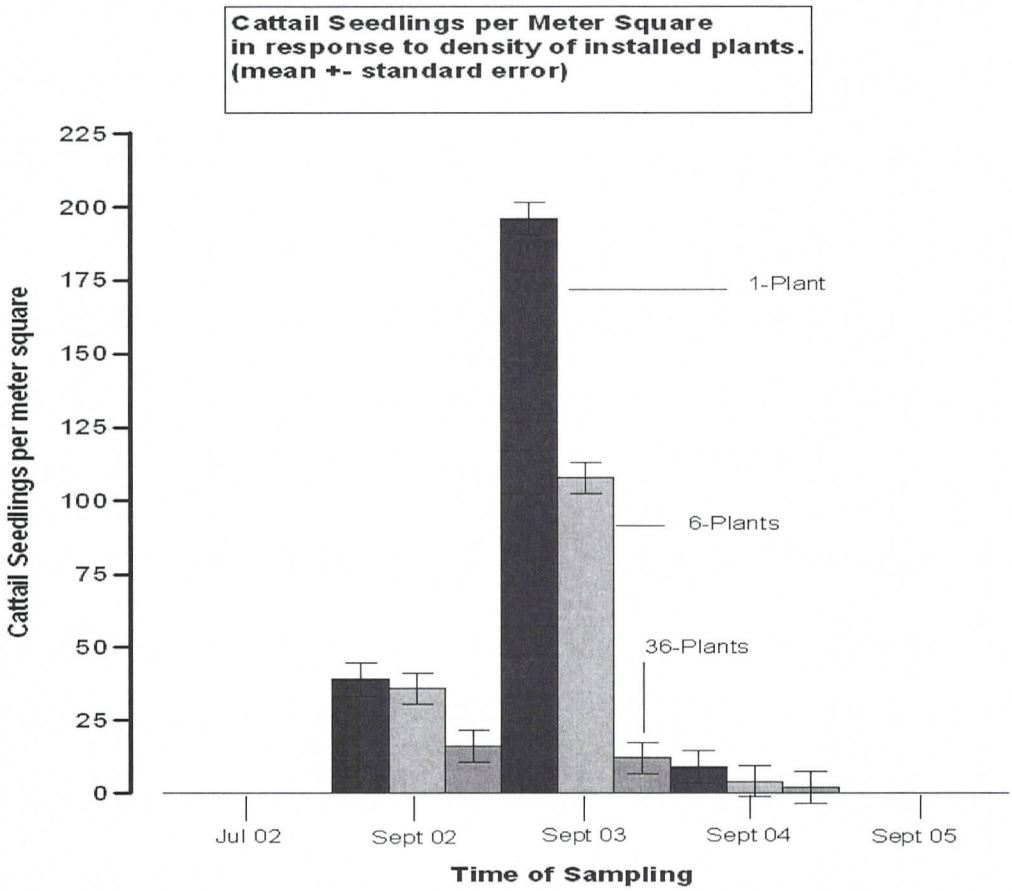


Figure 9


Cattail Seedlings per Meter Square
in response to density of installed plants.
(mean +- standard error)
Cattail Seedlings per meter square
225
200
175
150
125
100
75
50
25
0
1-Plant
6-Plants
36-Plants
Jul 02
Sept 02
Sept 03
Sept 04
Sept 05
Time of Sampling

SECTION III: RESTORATION

INTRODUCTION

Section I provided documentation confirming that CBWC was a unique natural resource; one of a kind in the vicinity of a large Midwestern metropolitan area. Its uniqueness was celebrated and understood by a small group of early 20th century humans.

Today, one only knows this early splendor of CBWC based on the limited writing and photographic documentation of early 20th century professionals. And, given the limited technology of the early 20th century, one can only mentally view and experience CBWC through murky cave light providing obscure, shadowy images. These images may include Cowles and students viewing the tamarack swamp from the Mineral Springs train station; a stimulating vista of lakeplain wet-mesic prairie, a diversity of graminoids/forbs of the great subdunal wetland and finally the conifers of the tamarack swamp and quaking bog, in which a most unique floristic family cooperatively coexisted. The uniqueness of this resource was why these citizens invested time and finances traveling to Northwest Indiana dune lands.

One must trust that these early honorees of CBWC left earth prior to late 20th century actions; actions that demonstrated a total disregard for earth's adroitness to generate distinctiveness. Therefore, there are two philosophical reasons for restoring CBWC: 1) to honor early 20th century explorers responsible for conveying the uniqueness of CBWC to early 21th century humans; and, 2) to provide, in perpetuity, a landscape of demonstration to humans yet to experience earth so that they will know what was here 100's years ago before aggressive landscape alteration by their ancestors.

The purpose of this section is to propose actions to facilitate restoration of CBWC's floristic resource and not to assign ownership to negative forcing functions. For example, high soil calcium at the interface between golf course ditch and CBWC and the phosphorous plume on the southwest portion of CBWC may be due to leakage from fly ash ponds. The plumes of ammonium and nitrate extending from the disturbed prairie unit to the mineral springs culvert are curiously associated with ditch systems that convey water from the open water body into CBWC.

It is not the intent to provide in this section detailed restoration statements suitable for contracting purposes. At this time there is no dedicated funding source and, even if there was a dedicated funding source, while initial restoration actions could be provided in contracting detail, secondary, tertiary and other additional restoration actions must be adaptive to system response to primary restoration actions.

Section III:A will provide an overview of desired vegetation/wetland types, Section III:B will provide restoration goals and objectives, and; Section III:C will present the pros and cons of restoration tactics.

Section III:A-Desired Wetland/Vegetation Types

Exhibit G:1 provides a presentation of desired vegetation units of CBWC. The identification of desired units is based on early and late 20th century documentation of CBWC and on the 2002-2004 inventories. Table 20 provides a summary of Exhibit G:1.

Table 20: Desired Wetland/Vegetation Types Following Restoration of Cowles Bog Wetland Complex.

Wetland/vegetation type	Area (ha)	Wetland/vegetation type	Area (ha)
Wet prairie/sedge meadow	9.6	Bog (poor fen)	3.0
Forested Swamp	7.3	North Graminoid Fen	1.4
Raised Fen	3.0	South Graminoid Fen	0.8
Deep Marsh	4.3	Shallow Marsh	4.2
Sedge Meadow	33.1	Remnant Sedge Meadow	6.5
Lake Plain Wet/Mesic Prairie	9.8		
Total	67.1		15.9

Eleven vegetation units representing eight wetland types are proposed. Fen wetland and sedge meadow wetland are comprised of three potentially different presentations of plant assemblages. Differences in soil chemistry among fen units suggest that fen plant assemblages on the raised fen, south fen and north fen will differ in structure and species composition. It is recognized that it is likely that the consequence of spatial differences in soil chemistry found in the sedge meadow unit will result in differing plant assemblages. Following is a discussion of desired vegetation types.

Deep marsh and Shallow marsh: Cowles bog deep and shallow marshes are areas of seasonal inundation. Normal water level adjacent and west of Mineral Springs Road is controlled by the position of the lower rim of the culvert beneath Mineral Springs road. The duration of water levels above the established normal water level is a product of culvert diameter. There is

evidence that in the 1920's there was a second culvert beneath Mineral Springs road south of the current culvert. One might suggest that a second culvert would be desired, however, the hydrological amplitude is minimal and of short duration.

Hydrological monitoring in 2003 (Exhibit series D) suggests that standing water was present in a portion of the indicated deep marsh throughout the growing season. An abandon muskrat lodge was observed approximately 100 m west of the culvert. This observation in conjunction with observations in years of higher than normal rainfall (2006–2009), a time period when standing water was observed throughout the summer, indicate that the zone can support shallow and deep marsh vegetation. The presence of deeper water in the location of Cowles Bog deep marsh and shallow marsh will contribute to a richness of wetland types and provide habitat for waterfowl.

Sedge Meadow: The sedge meadow vegetation type will be expressed in Cowles Bog wet prairie/sedge meadow, Cowles Bog sedge meadow and Cowles Bog remnant sedge meadow. In this last case, early 20th century sedge meadow continues to persist, but there is a substantial presence of cattail and cattail continues to encroach into the remnant sedge meadow through vegetative growth.

Cowles Bog wet prairie/sedge meadow unit differs from the sedge meadow unit in the following features: 1) a floating mat is present at the sedge meadow unit while a firm soil substrate is present at the wet prairie/sedge meadow unit, 2) the sedge meadow unit experiences surface water over in its entirety while the wet prairie/sedge meadow has pockets of higher elevations which are not inundated, and; 3) total phosphorus levels, a potential driver favoring certain species, is 0 to 12 ppb in the wet prairie/sedge meadow but 12 to 52 ppb in the western portion of the sedge unit. The above differences will result in plant assemblages in the wet prairie/sedge meadow unit that may be similar to some plant assemblages in the sedge meadow unit but overall will be sufficiently distinct to allow identification of it to be a different sedge meadow assemblage.

The sedge meadow unit is the largest proposed vegetation unit and occupies land that historically was defined as the great subdunal marsh. The western portion of this unit extending east to Cowles Bog shallow marsh is a floating mat. This floating mat likely formed in the 70's. The rehydration of muck soils and positive hydrostatic pressure following dike construction may

have caused dissociation of the muck into a top and bottom layer. Exploration of the soil profile revealed a top layer of 30 to 50 cm of fabric followed by a zone of unconsolidated peat of varying depth, and then on top of the sand layer a zone of consolidated peat of 30 to 40 cm.

The presence of this floating mat may impact the final plant assemblages characterizing the sedge meadow unit. Restoration work over the last several years suggest that following eradication of cattail their rhizomes decompose causing the floating mat to lose its stability resulting in an increase in mat elevation of 6 to 12 cm. Elevation increases appear to be largely a phenomena that occurs in the central portion of the floating mat. This increase in elevation results in wet prairie hydrology rather than sedge meadow hydrology. Decreasing hydrostatic pressure generated from the open water body south of the dike may diminish the increase in surface elevation of the floating mat following cattail eradication. A decline in hydrostatic pressure may be accomplished through restoration of the disturbed prairie unit.

The above scenario may instigate an adaptive response changing the sedge meadow unit to a wet prairie/sedge unit. However, at this time based on 2002-2004 inventories, current hydrology is supportive of plant assemblages dominated by sedge species. The hydrology of this unit is relatively uniform with maximum water depths in the spring of 1 to 10 cm followed by saturated soils throughout the summer months. Deeper and persistent pockets of water, associated with seepage from the open water body south of the dike are present on the southern edge of the sedge meadow unit.

Soil chemistry of vegetation units in which sedge meadow has been defined as a desired vegetation type is not homogenous. This heterogeneity of soil chemistry will facilitate development of a variety of coexisting sedge meadow plant assemblages with readily discernable dominants. A trail of slightly acidic to basic soils extended from the southwestern edge to two-thirds the distance to the eastern edge. Other soil constituents that will influence species composition of the western portion of sedge meadow included pockets of high phosphorus concentration, low nitrate levels, and high cation exchange capacity, total cations and calcium. In this later case, these three soil characteristics have levels that are equivalent to that found at the fen units.

The eastern portion of the sedge meadow unit displays plumes of high concentrations of nitrate and ammonium. Establishment of plant assemblages in the sedge meadow unit will be guided by soil chemistry. It is anticipated that differing sedge assemblages will develop in these areas of nutrient plumes.

Wet Prairie: Wet prairie vegetation has been identified in two vegetation units: Cowles Bog wet prairie/sedge meadow and Cowles Bog lakeplain wet-mesic prairie. The final wetland prairie plant assemblages in these two units will likely be distinct due to differences in soil types. Cowles Bog wet prairie/sedge meadow has muck soils and Cowles Bog lakeplain wet-mesic prairie has Maumee loamy sand soil. For this reason wet prairie associated with Cowles Bog wet prairie/sedge meadow unit will be discussed separately from Cowles Bog wet-mesic prairie.

As presented under the sedge meadow topic, wet prairie in Cowles Bog wet prairie/sedge meadow unit will be established on high elevations and sedge meadow on low elevations. Observations of seasonal hydrology of the wet prairie/sedge meadow unit suggest that more area has an absence of surface water than indicated in Exhibit Series D. Shrubs and trees will be removed to open the canopy (see Section III:B) and propagated plants installed and seed dispersed in accordance to desirable hydrology. The boundaries of this unit and the adjacent Cowles Bog bog unit will be adjusted based on field conditions, for example, based on pH and soil nitrogen levels one may want to slide the Cowles Bog bog unit west along Cowles Bog trail.

Bog: Cowles Bog bog is an interesting segment of CBWC. This vegetation unit exhibits pockets of sphagnum and includes a zone of approximately 30 dead tamarack trees. pH values as low as 5 would justify to some wetland professionals that the area should be referenced as a poor fen. Regardless of the assigned name, slightly higher elevations to the east, low nutrient levels, and the presence of sphagnum justifies providing uniqueness to this zone.

Additional investigation will be conducted in this unit prior to restoration actions. This Unit is one of the few zones that maintained standing water throughout 2003 (Exhibit D: September 16, 2003). The substrate of Cowles Bog bog is not solid and is largely comprised of shrubs with scattered forbs and graminoids growing on hummocks, on which, one often finds sphagnum. There are no documented accounts of this area being explored by early botanists and it was not visited by late 20th century investigators. One might speculate that 1970's water alterations

caused the decline of the tamarack stand and other associates of this community which may have included shrub species such as alder buckthorn (*Rhamnus alnifolia*), hoary willow (*Salix candida*), mountain holly (*Nemopanthus mucronata*), and leatherleaf (*Chamaedaphne calyculata*) and associated bog forbs and sedges such as two-seeded sedge (*Carex disperma*) and three-seeded bog sedge (*Carex trisperma*). All of these species have been reported present at CBWC and are species found in acidic wetlands.

At Cowles Bog bog an assemblage of calcifuge species, species that have been observed at CBWC will be established. Light intensity will be increased by removal of the shrub layer, the dead tamarack stand will be brought back to a living tamarack stand, other conifers will be established, and the presence of sphagnum will be increased.

Forested Swamp: In the mid-1900, Cowles Bog forested swamp was flung into a negative trajectory. The coniferous presence declined followed by an increased presence of red maple. A greater presence of red maple increase canopy cover reducing light intensity reaching the herbaceous understory. Decreasing light intensities resulted in declines and extirpation of state status species such as pink moccasin flower (*Cypripedium acaule*) and bunchberry (*Cornus canadensis*). The dominance of red maple reflects its tendency in the dunes area to be a species of opportunity colonizing disturbed areas.

Given that the forested swamp represents the only remaining dune wetland that historically was dominated by conifers, the forested swamp will be restored to reflect the yellow birch-conifer-red maple association present in the early 20th century. Restoring the canopy community will provide favorable habitat for reintroduction and augmentation of state status herbaceous species.

Fen: Based on soil chemistry data, the fen units have unique features suggesting that restoration efforts should be designed to allow their plant assemblages to express these differences.

The white cedar population on the raised fen and the tamarack grouping on the southwest edge of the raised fen will be augmented. The grouping of four white pines will be increased. Plant species reported by early botanist in the north graminoid fen (quaking bog) will be reintroduced, or if still present, their population augmented. On all fen units, plant assemblages dominated by high ion tolerant plants, Calciphiles, will be established.

Lake Plain Wet-Mesic Prairie: Prior to landscape alterations in the early 1900's, the disturbed prairie unit was vegetated with lakeplain wet-mesic prairie. Southern Lake Michigan's entire lakeplain wet-mesic prairie has been extirpated except for a narrow strip maintained by the Northern Indiana Power Service Company. Today, lakeplain wet-mesic prairie is globally imperiled.

Restoring the disturbed prairie unit to lakeplain wet-mesic prairie will require landscape modifications and plant installation. The present day assemblage of red maple-black locust-black cherry will be removed. A clay based substance will be placed at several strategic locations in the three major functioning ditches followed by placement of overcast into them. Overcast of other ditches will be return to its original locations. The land will be contoured as necessary to prevent erosive action due to the convergence of surface water.

Along the southern perimeter a pool and riffle conveyance channel will be constructed. A system of culverts will be installed beneath the south to north dike and surface water from the adjacent open water body directed into the conveyance channel. Water that currently is conveyed northwest from the south east corner of the disturbed prairie will be directed into the conveyance channel. The above actions will restore near surface groundwater levels, prevent direct flow of water from the open water body into Cowles Bog remnant sedge meadow, and potentially reduce hydrostatic pressure acting on Cowles Bog sedge meadow.

where will this water be directed to?

Following all landscape modifications the appropriate lakeplain wet-mesic prairie plant assemblage will be established. An excellent propagule source is available from the lakeplain wet-mesic prairie present at the adjacent utility-right-of-way.

Section III:B – Restoration Goals and Objectives

Cowles Bog Wet Prairie/Sedge Meadow
Goal: Restore wet prairie and sedge meadow plant assemblages.

Objectives:

- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce shrub species by 90 percent except for winterberry, speckled alder, chokeberry, pussy willow, dwarf birch, and poison sumac which will be reduced by 70 percent.
- Tamarack trees will be retained

- Yellow birch and paper birch over 12 cm diameter at breast height will be retained but smaller individuals removed.
- Tree species such as slippery elm, trembling aspen, and red maple will be reduced by 90 percent. Individuals of the above species that are situated along the western and northern border of Cowles Bog Trail will be favored to remain.
- Appropriate wet prairie and sedge meadow species will be established through seeding and plant propagation followed by plant installation.

Cowles Bog Bog
Goal- Restore a herbaceous and shrub plant assemblage comprised of acidophilic plant species and a tree community dominated by coniferous species.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce shrub species retaining only scattered clumps of speckled alder, chokeberry, dwarf birch, and poison sumac.
- Yellow birch over 12 cm diameter at breast height will be retained but smaller individuals removed.
- Tree species such as slippery elm, trembling aspen, and red maple will be removed.
- Twenty individuals of tamarack will be installed at the location of the dead tamarack stand and an additional 20 to 30 individuals scattered throughout.
- Shrub species such as alder buckthorn, Leatherleaf, and mountain holly will be established.
- A herbaceous plant assemblage dominated by calcifuges such as sphagnum, two seeded sedge, three seeded sedge, Venus fly trap, pitcher plant, and pink moccasin flower will be established.

Cowles Bog Forested Swamp
Goal- Restore a forested swamp that is dominated by a coniferous-yellow birch-black ash plant assemblage and with a herbaceous layer reflective of that described by early 20th century botanists and ecologists.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce native shrub species by 70 percent
- Reduce tree species such as slippery elm and trembling aspen by 80 perecent
- Reduce red maple trees by 70 percent
- Shrub species such as alder buckthorn, leatherleaf, and mountain holly will be established.
- Tree species such as white cedar, white pine and tamarack will be planted on hummocks currently occupied by red maple.

- The herbaceous plant assemblage will be augmented with reintroduced extirpated species and increased numbers of conservative forested swamp species. Species targeted include pink moccasin flower, twinflower (*Linnaea borealis*), bishop's cap (*Mitella diphylla*), purple fringed orchid (*Platanthera psycodes*), bog rosemary (*Andromeda glaucophylla*), and goldthread (*Coptis trifolia*).

Cowles Bog Raised Fen:
Goal: Augment the coniferous tree component and establish a herbaceous assemblage dominated by calciphiles.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce shrub species by 95 percent except for the spice bush population on the western half of the mounded fen.
- Supplement the white cedar stand on the western half by 30 individuals and establish an additional 30 trees of white cedar in scattered locations on the west and east portions.
- Supplement the tamarack stand on the southwestern edge by 10 individuals.
- Establish 10 white pine trees in appropriate locations.
- Establish a herbaceous plant assemblage of forbs grasses and sedges.
- Reintroduce extirpated species such as white lady's slipper, golden saxifrage (*Chrysosplenium americanum*), showy lady's slipper (*Cypripedium reginae*), fringed gentian (*Gentianopsis crinita*), small fringed gentian (*Gentianopsis procera*), Ohio goldenrod (*Oligeneuron ohiensis*) and riddell's goldenrod (*Oligeneuron riddellii*).

Cowles Bog North Graminoid Fen
Goal: Reestablish a plant assemblage that is reflective of the plant assemblage described by early 20th century botanist and ecologist exploring the quaking bog.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Establish a herbaceous plant assemblage of forbs grasses and sedges.
- Reintroduce extirpated species such as fringed gentian, small fringed gentian, Ohio goldenrod, riddell's goldenrod, short headed rush (Juncus brachycephalus), orange fringed orchid (Platanthera ciliaris), white beak rush (Rhynchospora alba) and pitcher plant (*Sarracenia purpurea*)

Cowles Bog South Graminoid Fen
Goal: Establish a plant assemblage that is dominated by calciphile species.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees

- Reduce native shrub and tree presence by 90 percent
- Establish a herbaceous plant assemblage of forbs grasses and sedges.
- Reintroduce extirpated species such as fringed gentian, small fringed gentian, white lady's slipper, Ohio goldenrod, riddell's goldenrod.

Cowles Bog Deep Marsh
Goal: Establish a plant assemblage that provides 50 percent cover of emergent wetland species.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce native shrub and tree presence by 90 percent
- Establish a herbaceous plant assemblage dominated by emergent wetland species.

Cowles Bog Shallow Marsh
Goal: Establish a plant assemblage that provides 80 percent cover of native emergent wetland species.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce native shrub and tree presence by 90 percent
- Establish a herbaceous plant assemblage dominated by emergent wetland specie.

Cowles Bog Sedge Meadow
Goal: Establish a plant assemblage that is comprised of a variety of sedge dominated plant assemblages.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce native shrub and tree presence by 90 percent
- Establish a herbaceous plant assemblage of forbs grasses and sedges. This assemblage will be dominated by sedge species

Cowles Bog Remnant Sedge Meadow
Goal: Remove all invasive species from a sedge dominated plant assemblage.

Objectives:
- Eradicate all cattail plants
- Eradicate all common reed plants
- Eradicate all non-native shrubs and trees
- Reduce native shrub and tree presence by 90 percent

Cowles Bog Lakeplain Wet-Mesic Prairie
Goal: Establish a plant assemblage of forbs-grasses-sedge that is comprised of species found in a lakeplain wet-mesic prairie.

Objectives:

- Remove the red maple-black locust-black cherry plant assemblage.
- Reshape the landscape such that water is not conveyed through the ditch system and minimal water is conveyed on the ground surface.
- Construct a pool and riffle conveyance system that will convey water west to east from the open water body and east to west from the current east west ditch. The pool and riffle conveyance system will be constructed to provide a source of groundwater that will move south to north through the subsurface of Cowles Bog lakeplain wet-mesic prairie.
- Establish a herbaceous plant assemblage of forbs grasses and sedges. This assemblage will be dominated by lakeplain wet-mesic prairie species.

Section III:C Restoration Tactics

Cost Considerations: Restoration of CBWC will require 10 to 15 years of restoration actions and cost 1.4 to 1.6 million dollars. This estimate assumes that in any given year at least $80,000 to $100,000 will be available to execute restoration actions. In addition, it may not be possible to reestablish all extirpated species within the 10 to 15 year time frame. Reestablishing a species may require one to two years of investigation into methods for species reintroduction followed by several years of action. For example, six years were required to reestablish six pink moccasin plants in the forested swamp. This effort included hand pollination, two years of flask propagation, and three years in the forested swamp until the plants flowered; a signature of success. In this example, only six plants survived out of 150 installed plantlets. Given knowledge gained from this attempt of reintroduction, it is certain that a second effort would realize a greater degree of success.

A significantly larger dedicated funding stream allows for product production in a shorter time frame, but the cost of follow-up maintenance may be greater. Given that one must conduct secondary, tertiary and so forth restoration actions adaptively to ecosystem response, it is estimated, regardless of the amount of funding available, that a minimum of eight years would be require to establish a semi-stable state at CBWC. And, as indicated above, this would not include completion of efforts to establish extirpated species.

The above cost estimates assume that 70 to 80 percent of the restoration will be conducted by GS5 – GS6 government employees. Given the 2009 pay schedule, the cost for in-the-field labor

is approximately $20/hour. Contracts awarded for wetland restoration work at Indiana Dunes National Lakeshore conduct by Chicago area firms have ranged from $55 to $75/hour for labor with additional costs for supplies and equipment. In short, a total contracted restoration would cost 3 to 4 times, the estimate provided above.

An interrupted funding stream will amplify the cost and length of time to accomplish restoration of CBWC. A restoration action with no follow-up actions for several years may necessitate a go-back-to-the-beginning response.

Cattail Eradication: A large cost to restoring CBWC is associated with eradicating cattail and common reed. As provided in Section I, Wilcox et al. (1984) presented reasons why cutting and flooding of cattail would not be a workable solution. The evaluation by Wilcox et al. remains relevant; cutting and flooding is not an option for cattail eradication at CBWC.

The use of track vehicles to access the cattail unit has been investigated. Coast Machinery LLC was contacted to inquire concerning the feasibility of using tracked vehicles such as the Marsh Master to access the cattail unit for herbicide treatment. It was communicated that the Marsh Master is not capable of transitioning through floating mat vegetation. The Marsh Master will drop through the floating mat follow by an inability for mobility. Smaller tracked vehicles such as a light weight ATV may be an option. However, in the situation in which the ATV drops through the floating mat one must be prepared to accept the new role of the ATV as a perpetual monument in celebration of the restoration effort.

The last consideration was aerial application. Aerial application of herbicide to the cattail unit would be a labor efficient method. However, aerial application to the 33.1 ha cattail unit would only be practical if funding was available for aggressive follow-up treatment and plant installation. For aerial applications to be practical, at a minimum, a dedicated funding stream of at least 100,000 for six years must be available.

Scientific literature was reviewed, communications were conducted with the restoration community and other conversations with those who simply do things were conducted. Given all information collected and the absence of dedicated funding, it was decided that the only approach to cattail eradication is a labor intensive approach; preferably conducted by dedicated nature loving folks.

In the cattail unit, paths through the cattail will be formed. Initially path formation was conducted using a bush cutter. However, returning seasonal staff claimed that pushing the cattail to the substrate using a 1.3 m piece of wood or even pushing a small lawn roller through the cattail is more efficient than brush cutting a path. Regardless, once the path is completed, a two person team with a 2.5 m ladder applies herbicide using a back pack sprayer. One team member holds the ladder while the other climbs the ladder and applies herbicide. The herbicide used will be a glyphosate based herbicide approved for use in wetlands, for example aquaneet, aquamaster, rodeo. Herbicide concentration will be 4percent. Applications will be initiated in late May and continue until senescence. Cattail present in areas in which collateral damage is not acceptable will be hand wicked or cut and herbicide dripped onto the cut portion of the cattail.

Plant Establishment: Seedbank inventory and the absence of nearby seed sources which may disperse into CBWC suggest that one cannot rely on an endogenous seed source to establish the desired vegetation types. Therefore, establishment of species representing desired vegetation types will be achieved through anthropogenic seed dispersal and plant propagation follow by plant installation. Native species with a current presence or historic presence will be targeted for reintroduction. Other species present or documented in other areas of the Great Marsh will be considered.

Only a small strip of Lakeplain wet-mesic prairie remains and much of this vegetation type was destroyed prior to exploration by early 20th century botanists. Species selected for vegetating the restored lakeplain wet-mesic prairie will comprise of species that have a current presence and other species based on literature documentation.

Summary: Given the historic and current knowledge of CBWC, understanding of the restoration process and assuming that an experienced skilled staff will be conducting the restoration, the determining resource driving restoration direction will be funding. A restoration plan with no funding commitment can only be comprised of the broad goals and objectives provided in Section III:B. However, given dedicated funding, a directed route of actions could be developed.

Two funding sources, dedicated and non-dedicated, were considered. If a dedicated funding source of $80,000 to 100,000 per year was available for 10 to 15 years one would initiate

restoration in the cattail unit and then work out to peripheral zones in which one finds pockets of native species. In consideration of the seedbank, the approach would be seedbank depletion.

In the case of a non-committed funding source; a two to three year funding stream of an unknown amount, then restoration actions should focus on the peripheral zones. Buffer zones would be developed to protect remnant populations of native plants. As additional funding was located, restoration actions would proceed into the cattail unit working from the edge toward the center. In consideration of the seedbank, the approach would be seedbank suppression.

The reasoning for the two different approaches is largely due to seedbank response. Experimental work on seedbank recruitment indicated that cattail seed is recruited from the seedbank over a three year time period. Therefore, given a three year funding stream, it would not be possible to deplete the seedbank, the preferred approach, and provide follow-up plant installation. Attempts at seedbank depletion would fail and the treated zone would rapidly colonize with cattail.

Experimental work indicated that litter and plant density can reduce recruitment of cattail from the seedbank. Therefore, given a two to three year funding stream, the preferred approach would be to treat the adult cattail the first year followed by aggressive plant installation in years 2 and 3. Cattail litter would suppress cattail recruitment initially followed by suppression of cattail recruitment by installed plants in following years. Suppression would not be 100 percent; however, cattail recruitment would be at a level that would allow treatment of it given the next influx of funding.

Seedbank depletion is the preferred approach, but a minimum of three years to deplete a seedbank is required. Seedbank depletion is preferred because it is less likely to result in cattail recruitment following future soil disturbances which may result from deer activity or uprooting of trees by wind.

LITERATURE CITED

Apfelbaum, S.I., K.A. Heiman, and Prokes John A. 1984. Ecological condition and management opportunity for the Great Marsh system, Indiana Dunes National Lakeshore, Porter, Indiana. Route 1, Box 130, Juda, WI, Applied Ecological Services.

Apfelbaum, S.L., K.A. Heiman, J. Prokes, D. Tiller, and J.P. Ludwig. 1983. Ecological condition and management opportunity for the Cowles Bog and western Great Marsh, Indiana Dunes National Lakeshore, Porter, Indiana. Iron River, Michigan 49935, Ecological Research Services, Inc.

Baker, H.G. 1989. The Natural History of Seed Banks. Pages 9-21.; In. Ecology of Soil Seed banks. Ed. By M.A. Leck, V. T. Parker; and R.L. Simpson. Academic Press, INC. San Diego, Calf.

Bartlein, P.J. and T. Webb. 1982. "Holocene climatic changes estimated form pollen data from the northern midwest." Quaternary history of the driftless area. Wisconsin Geological and natural history field trip. 67-82.Blukley, S.B. 1974. Study of the post-pleistocene ostracod distribution in the soft sediments of souther Lake Michigan. Urbana, Illinois, University of Illinois.

Brown, S. C. 1998. Remnant seed banks and vegetation as predictors of restored marsh vegetation. Canadian Journal of Botany 76:620-629.

Boelter, D.H. 1978. An appraisal of the organic deposits in the interdunal wetlands of the Indiana Dunes National Lakeshore. Washington D.C., United States Department of Agriculture, Forest Service.

Bowels, M.L. 1988. A report on special floristic elements at the Indiana Dunes National Lakeshore: new species monitoring and update of selected existing populations. Unpublished report by the Morton Arboretum, Lisle, Illinois.

Bowels, M.L. 1991. Report on the status of endangered and threatened plants at the Indiana Dunes National Lakeshore: monitoring of species new to the Lakeshore and re-monitoring of selected species. Unpublished report by the Morton Arboretum, Lisle, Illinois.

Braun-Blanquet, J. 1965. Plant sociology: The Study of Plant Communities. (translated revised and edited by C.D. Fuller and H.S. Conard) Hafner, London 439 pp.

Brennan, George A. 1923. The Wonders of the Dunes. The Bobbs-Merill Company, Indianapolis, Indiana

Buhl, C.A. 1934. Supplement to an Annotated Flora of the Chicago Area by H.S. Pepoon. Bulletin Chicago Academy of Sciences 5 (2): 5-12

Buhl, C.A. 1935. "Notes on the flora of the Indiana Dunes." American Midland Naturalist. 16:248-253.

Carter, V. and R. Stottlemyer. 1978. Ecology of cowles bog wetland complex indiana dunes national lakeshore special study. National Center Geological Survey Reston, Virginia, U.S. Geological Survey.

Chrzastowski, Michael J., and Todd A. Thompson. 1994. Late Wisconsinan and Holcene Geologic History of the Illinois-Indiana Coast of Lake Michigan. Journal of Great Lakes Research, Vol 20 no I.

Cole, K.L., Engstrom, D.R, Futyma, R.P., Stottlemyer S.R. 1990. Past Atmospheric Deposition of Metals in Northern Indiana Measured in a Peat Core for Cowles Bog. Environmental Science and Technology. 24:543-549.

Cohen, D.A. and R.J. Shedlock. 1986. Shallow ground-water, water levels,and quality of water, 1980-84, Cowles Unit, Indiana Dunes National Lakeshore. Indianapolis, Indiana, U.S. Geological Survey.

Cook, S.G. 1999. Henry Chandler Cowles and Cowles Bog, Indiana. Field Museum. Chicago, IL.

Cook, S.G. and R.S. Jackson. 1978. The Bailly area of Porter County, IN: The final report of a geo-historical study undertaken on behalf of the Indiana Dunes National Lakeshore. Robert Jackson & Associates, Evanston, IL.

Cowardin, Lewis, Virginia Carter, Francis Golet, and Edward LaRoe. 1979. Classification of Wetlands and Deepwater Habitats for the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington D.C. 103 pp.

Cressey, G.C. 1928. The Indiana Sand Dunes and Shore Lines of the Lake Michigan Basin. University of Chicago Press, Chicago, IL.
Daubenmire, R.F. 1959. Canopy coverage method of vegetation analysis. Northwest Science 33:43-64

Eggers, Steve and Domald M. Reed. 1987. Wetland Plants and Plant Communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers, St. Paul District, 201 pp.

Ewing, J.M. and M.J. Vepraskas. 2006. Estimating primary and secondary subsidence in an organic soil 15, 20, 30 years after drainage. Wetlands 26:119-130.

Faber-Langendoen, D. editor. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.)

Fuller, G.D. 1913. The Intenational Phytogeographic Excursion (I.P.E.) in America 1913. The Vegetation of the Chicago Region. Chicago, IL.

Fuller, G.D. 1925. The vegetation of the Chicago region. The University of Chicago Press, Chicago IL.

Futyma, R.P. 1988. "Fossil pollen and charcoal analysis in wetland development studies at Indiana Dunes National Lakeshore." Michigan State university Press. East Lansing, Michigan. 11-23.

Galatowitsch, S.M., N.O. Anderson, and D. Asher. 1999. Invasiveness in wetldn plants in temperate North America. Wetlands 19:753-755.

Gillies, D.C. and W.W. Lapham. 1980. Reassessment of the effects of construction dewatering on ground-water levels in the cowles unit, Indiana Dunes National Lakeshore, Indiana. Supplement to geological survey water-resources investigations 78-138. U.S. Geological Survey.

Hansel, A.K., A.F. Mickelson, A.F. Schneider, and C.E. Larson. 1985. "Late Wisconsinana and Holocene history of the Lake Michigan basin." In P.F. Karrow and Calkin P.E., editors, Quaternary evolution of the Great Lakes. Geological Association of Canada. 39-53.

Hardy, M.A. 1981. Effects of coal fly-ash disposal on water quality in and around the Indiana Dunes National Lakeshore, Indiana. Indianapolis, Indiana 46202, U.S. Geological Survey.

Hendrickson, W.H. and D.A. Wilcox. 1979. Relationship Between some Physical Properties and the Vegetation Found in Cowles Bog National Natural Landmark, Indiana. Paper presented at the Second Conference on Scientific Research in the National Parks November 26-30, San Francisco, California.

Klick, Kenneth F. 1988. Proposal for a Research Burn at Cowles Bog. Submitted to Indiana Dunes National Lakeshore pp. 26.

Kurz, H. 1923. "Hydrogen ion concentration in relation to ecological factors." The Botanical Gazette. 76:1-29.

Kurz, H. 1928. "Influence of Sphagnum and other Mosses on Bog Reactions." Ecology. 9:56-69.

Lyon, M.W. 1927. List of flowering plants and ferns in the Dunes State Park and Vicinity, Porter, County, Indiana. American Midland Naturalist. 10:245-295

Lyon, M.W. 1930. List of flowering plants and fern in the Dunes State Park and vicinity, Porter County, Indiana: supplement. The American Midland Naturalist. 12:33-43.

Marciniak, M.D. 1978. A historical study of the Indiana Dunes National Lake Shore. Indiana Dunes National Lakeshore.

Marie, J.R.. 1976. Model analysis of effects on water levels at Indiana Dunes National Lakeshore caused by construction dewatering: U.S. Geological Survey Water-Resources Investigations. 76-82, 32 p.

Meyer, W. and P. Tucci. 1979. Effects of seepage from fly-ash settling ponds and construction dewatering on ground-water levels in the cowles unit, Indiana Dunes National Lakeshore, Indiana. Indianapolis, Indiana, U.S. Geological Survey.

Middleton, B. 1999. Wetland Restoration, Flood Pulsing and Disturbance Dynamics. John Wiley and Sons, New York, NY, USA

Miller, B.B. and T.A. Thompson. 1990. "Molluscan faunal changes in the Cowles Bog area, Indiana Dunes National Lakeshore, following the low-water Lake Chippewa phase." Geological Society of America. Special Paper 251:21-27.

Mueller-Dombois , D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

National Engineering Handbook-Section 16: Drainage of Agricultural Land.

Newman, J. and M. Doyle. 1995. Occasional paper #6. Dune Acres Historical Commission.

Pepoon, H.S. 1927. An Annotated Flora of the Chicago Area. Chicago Academy of Sciences, Chicago, IL. 554 pp.

Peattie, D.C. 1930. Flora of the Indiana Dunes. Field Museum of Natural History, Chicago, Illinois

Resetar, A. 1985. The Status of State-Listed Herptofauna within the Indiana Dunes National Lakeshore.

Resetar, A. 1994. The Amphibians and Reptiles of the Indiana Dunes National Lakeshore.

Roberts, E.H. 1972. Dormancy: A factor affecting seed survival in the soil. In E.H. Roberts (editor), Viability of Seeds, p. 321-359. Syracuse University press, Syracuse, New York.

Rosenshein, J.S., and Hunn, J.D. 1968. Geohydrology and ground water potential of Porter and LaPorte Counties, Indiana: U.S. Geological Survey Open-file Report 75-312, 87 p.

Schafer, D.E., and D.O. Chilcote 1970. Factors influencing persistence and depletion in buried seed populations, II. The effect of soil temperatue and moisture. Crop Science 10:342-345.

Simpson, R.L., Leck, M.A., and Parker, V.T. 1989. Seed Banks: General Concepts and Methodological Issues. Pages 3-7; In. Ecology of Soil Seed Banks. Ed. By M.A. Leck, V.T. Parker; and R.L. Simpson. Academic Press, Inc. San Diego, CA

Sullivan, M. A. 1964. A report on Cowles Bog, Indiana. National Landmark Program, National Park Service, Department of the Interior.

Tansley, A.G. 1917. "International Phytogeographic Excursion (I.P.E.) in America, 1913." The New Phytologist, 12, Nos. 9, 10 (Nov., Dec. 1913), 322-36.

Texas Instruments Ecological Services, Inc.. 1974-81. Annual Reports, Bailly Nuclear-1 Site, Northern Indiana Public Service Company. Texas Instruments, Dallas

Thompson, T.A. 1990. "Post Lake Chippewa transgression deposits in Indiana Dunes National Lakeshore." In A.K. Hansel and W.H. Johnson, editors, Field Guidebook for the Ninth Biennial Meeting of the American Quaternary Association. 39-44.

Thompson, T.A. 1988. "Sedimentology and stratigraphy as tools in interpreting the evolution of wetland ares in the Indiana Dunes National Lakeshore." Michigan State University Press. East Lansing, Michigan. 25-36.

Thompson, T.A. 1990. "Dune and beach complex and back-barrier sediments along the southeastern shore of Lake Michigan; Cowles Bog area of the Indiana Dunes National Lakeshore." In A.F. Schneider and G.S. Fraser, editors, Late Quaternary history of the Lake Michigan basin: Geological Society of America Special Paper 251. Geological Society of America. Boulder, Colorado . 9-19.

Thompson, T.A. and S.J. Baedke. 1997. "Strand-plain evidence for late holocene lake-level variations in Lake Michigan." Geological Society of America Bulletin. 109:666-682.

Thompson, K. and Grime, J.P. 1979. Seasonal variation in the seed banks of herbaceous species in ten contrasting habitats. Journal of Ecology 67, 893-921.

Travis, S.E., J.E. Marburger, S. Windels, and B. Kubátová. 2009 (in press). Clonal diversity and hybridization dynamics of invasive cattail (Typhaceae) stands in the Great Lakes Region of North America. Journal of Ecology.

van der Valk, A.G. 1981. Succession in wetlands: A Gleasonian approach. Ecology 62, 688-698.

van der Valk, A.G. and Davis, C.B. 1978. The role of seed banks in the vegetation dynamics of prairie glacial marshes. Ecology 59, 322-335.

van der Valk, A.G., L. A. Toth, E. B. Gibney, D.H. Mason, and P.R. Wetzel. 2009. Potential propagule sources for reestablishing vegetation of the floodplain of the Kissimmee River, Florida, USA. Wetlands 29(3), 976-987.

Watts, M.T. 1975. "History book with flexible cover or the records in a quaking bog." In M.T. Watts, editor, Reading the landscape of america. Nature Study Guild Publishers. Rochester, New York. 74-94.

Wienhold, C. E, and A.G. van der Valk. 1989. The impact of duration of drainage on the seed banks of northern prairie wetlands. Canadian Journal of Botany 67:1878-84.

Wilcox, D.A., S.I. Apfelbaum, and R.D. Hiebert. 1984. "Cattail invasion of sedge meadows following hydrologic disturbance in the Cowles Bog Wetland Complex, Indiana Dunes National Lakeshore." Wetlands. 4:115-128.

Wilcox, D.A., R.J. Shedlock, and W.H. Hendrickson. 1986. "Hydrology, Water Chemistry and Ecological Relations in the Raised Mound of Cowles Bog." Ecology. 74:1103-1117.

Wilhelm, G.S. 1980. Report on the special vegetation of the Indiana Dunes National Lakeshore. INDU Research Program Report 80-01. pp 262.

Wilhelm, G.S. 1990. Special Vegetation of the Indiana Dunes National Lakeshore. The Morton Arboretum, Lisle, Illinois.

Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology and Evolution 15:402-407.

EXHIBITS A:SERIES

Exhibit A:1 An overview of the entire Great Marsh.

Exhibit A:2 Aerial photograph of Cowles Bog Wetland Complex in 2004.

Exhibit A:3 Aerial photograph of Great Marsh in 1938.

Exhibit A:4 Aerial photograph of Great Marsh in 1954.

Exhibit A:5 Aerial photograph of Great Marsh in 2004.

Exhibit A:6 Vegetation types in Cowles Bog Wetland Complex in 1938.

Exhibit A:7 Vegetation types in Cowles Bog Wetland Complex in 1970.

Exhibit A:8 Vegetation types in Cowles Bog Wetland Complex in 1973.

Exhibit A:9 Vegetation types in Cowles Bog Wetland Complex in 1977.

Exhibit A:10 Vegetation types in Cowles Bog Wetland Complex in 1982.

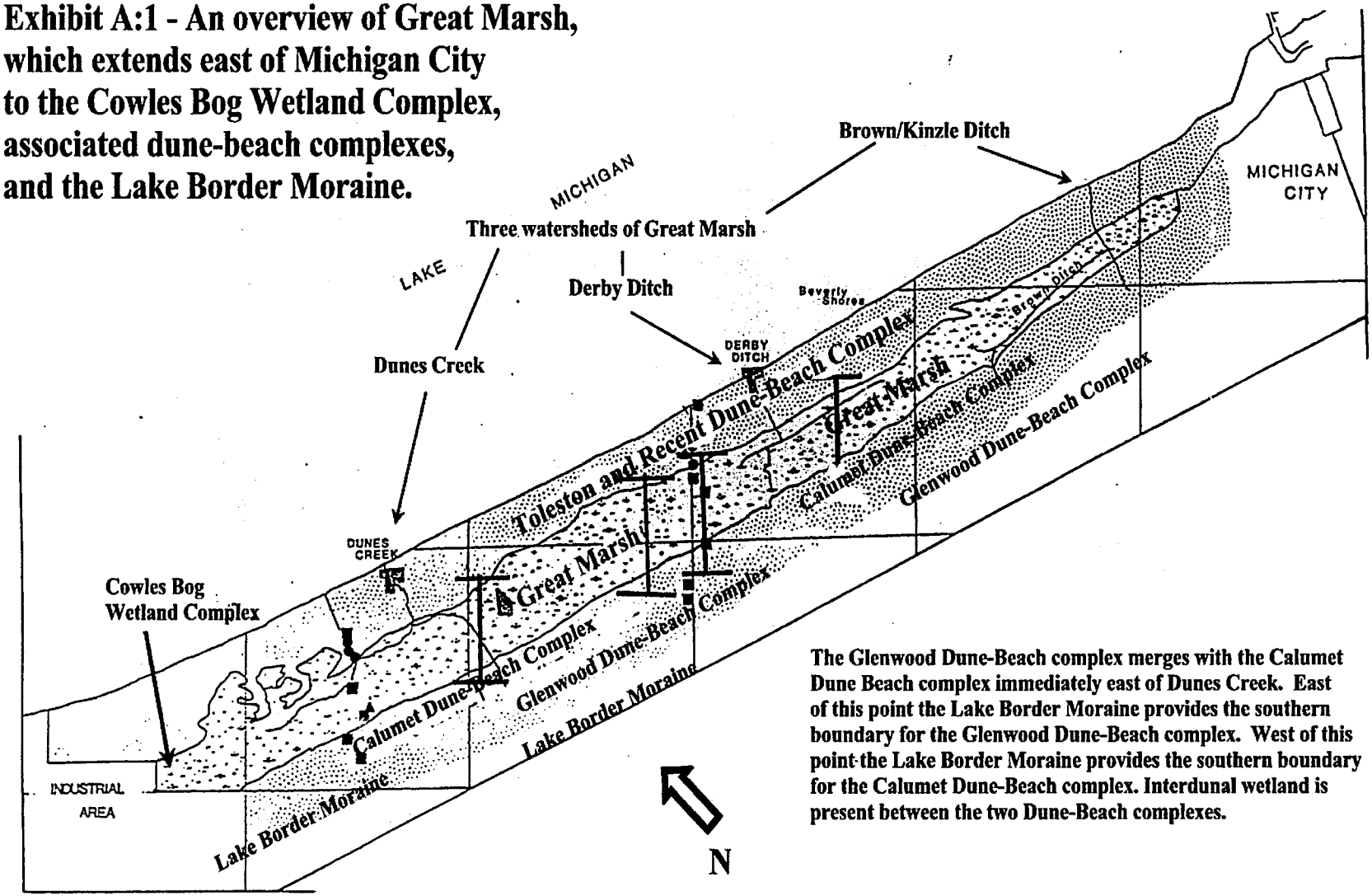
Exhibit A:11 An overview of Cowles Bog Wetland Complex.

Exhibit A:12 Soil types in Cowles Bog Wetland Complex in 1944.

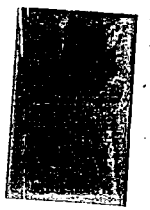
Exhibit A:13 Soil types at soil sample locations in Cowles Bog Wetland Complex.

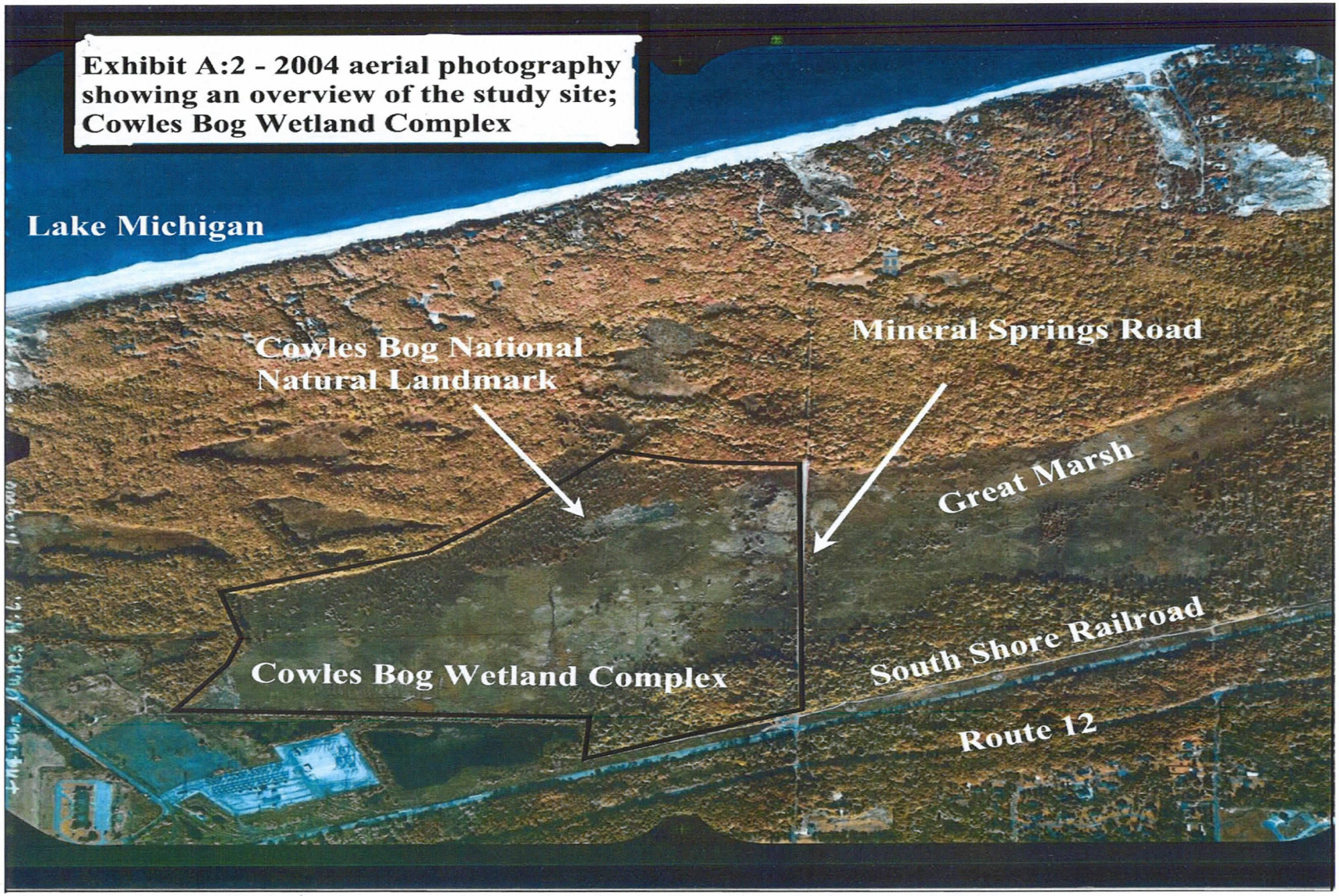
Exhibit A:14 Depth to Lake Chicago sand surface in Cowles Bog Wetland Complex.

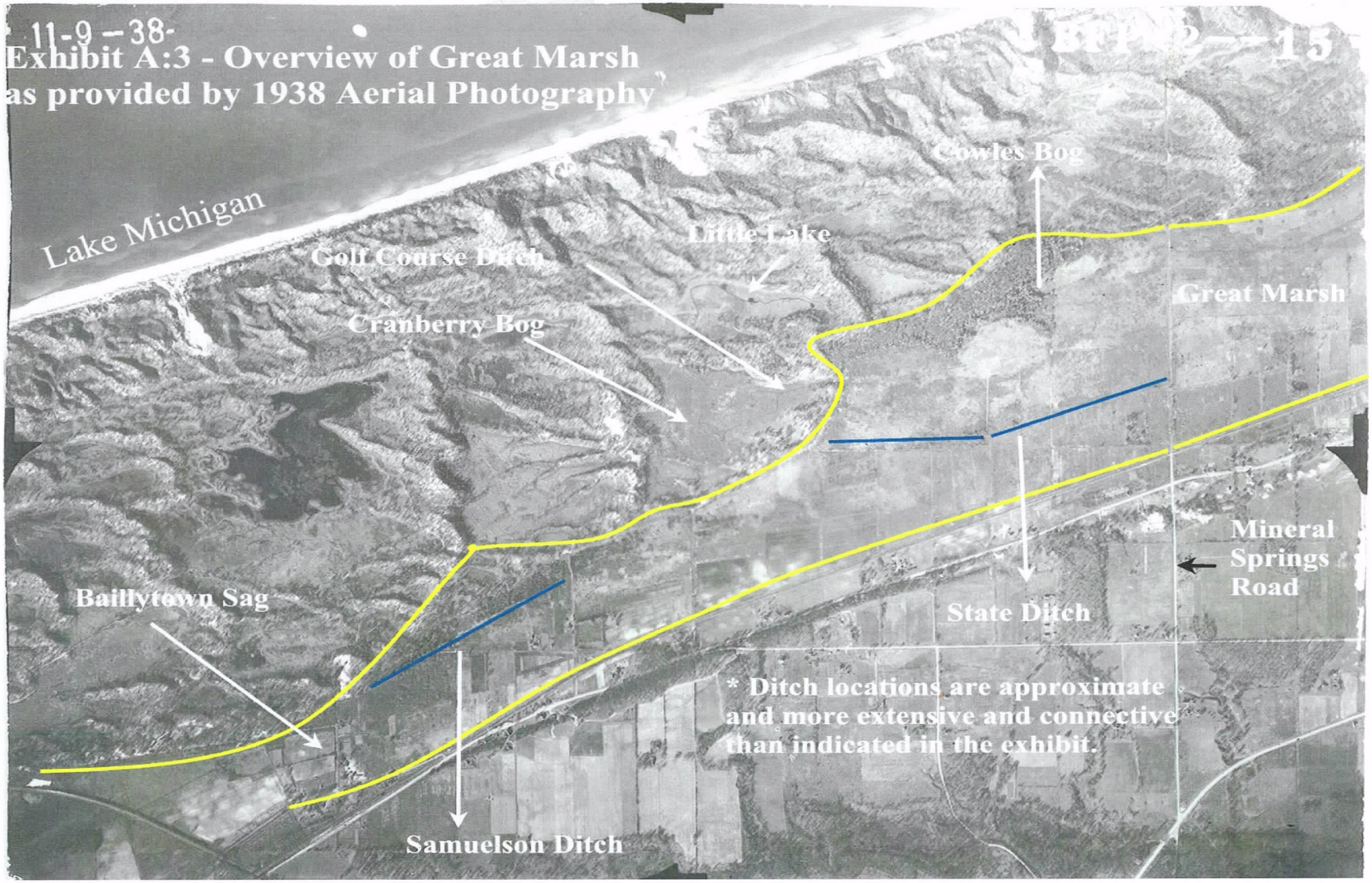
Exhibit A:1 - An overview of Great Marsh, which extends east of Michigan City to the Cowles Bog Wetland Complex, associated dune-beach complexes, and the Lake Border Moraine.



The Glenwood Dune-Beach complex merges with the Calumet Dune Beach complex immediately east of Dunes Creek. East of this point the Lake Border Moraine provides the southern boundary for the Glenwood Dune-Beach complex. West of this point the Lake Border Moraine provides the southern boundary for the Calumet Dune-Beach complex. Interdunal wetland is present between the two Dune-Beach complexes.




Exhibit A:2 - 2004 aerial photography showing an overview of the study site; Cowles Bog Wetland Complex
Lake Michigan
Cowles Bog National Natural Landmark
Mineral Springs Road
Great Marsh
Cowles Bog Wetland Complex
South Shore Railroad
Route 12


11-9-38-
Exhibit A:3 - Overview of Great Marsh
as provided by 1938 Aerial Photography
Lake Michigan
Golf Course Ditch
Cranberry Bog
Little Lake
Cowles Bog
Great Marsh
Mineral
Springs
Road
State Ditch
Baillytown Sag
Samuelson Ditch
* Ditch locations are approximate
and more extensive and connective
than indicated in the exhibit.


7-8-54
Exhibit A:4 - Overview of Great Marsh
as provided by 1954 Aerial Photography
Lake Michigan
Little Lake
Cowles Bog
Great Marsh
Cranberry Bog
Mineral
Springs
Road
Route 12
South Shore
Railroad
Baillytown Sag

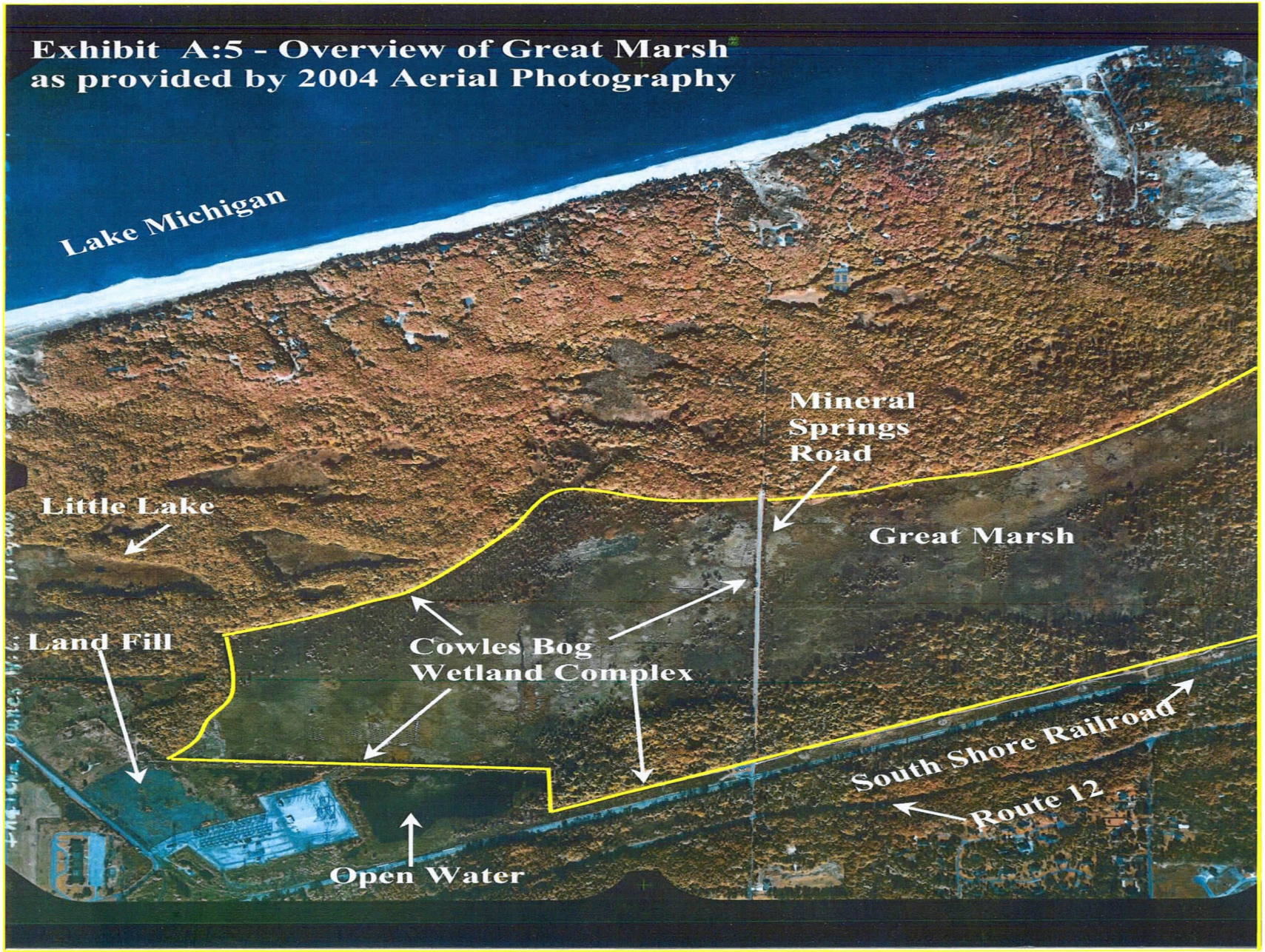

Exhibit A:5 - Overview of Great Marsh
as provided by 2004 Aerial Photography
Lake Michigan
Mineral
Springs
Road
Little Lake
Great Marsh
Land Fill
Cowles Bog
Wetland Complex
South Shore Railroad
Route 12
Open Water

EXHIBIT A:6 – Vegetation Types Present in Cowles Bog Wetland Complex in 1938 Based on Interpretation of Aerial Photography. Present were 56.4 ha of Sedge-grass, 2.0 ha of Cattail, 6.0 ha of Shrub and 16.3 ha of Forested Vegetation (Apfelbaum et al. 1983, Wilcox et al. 1984).

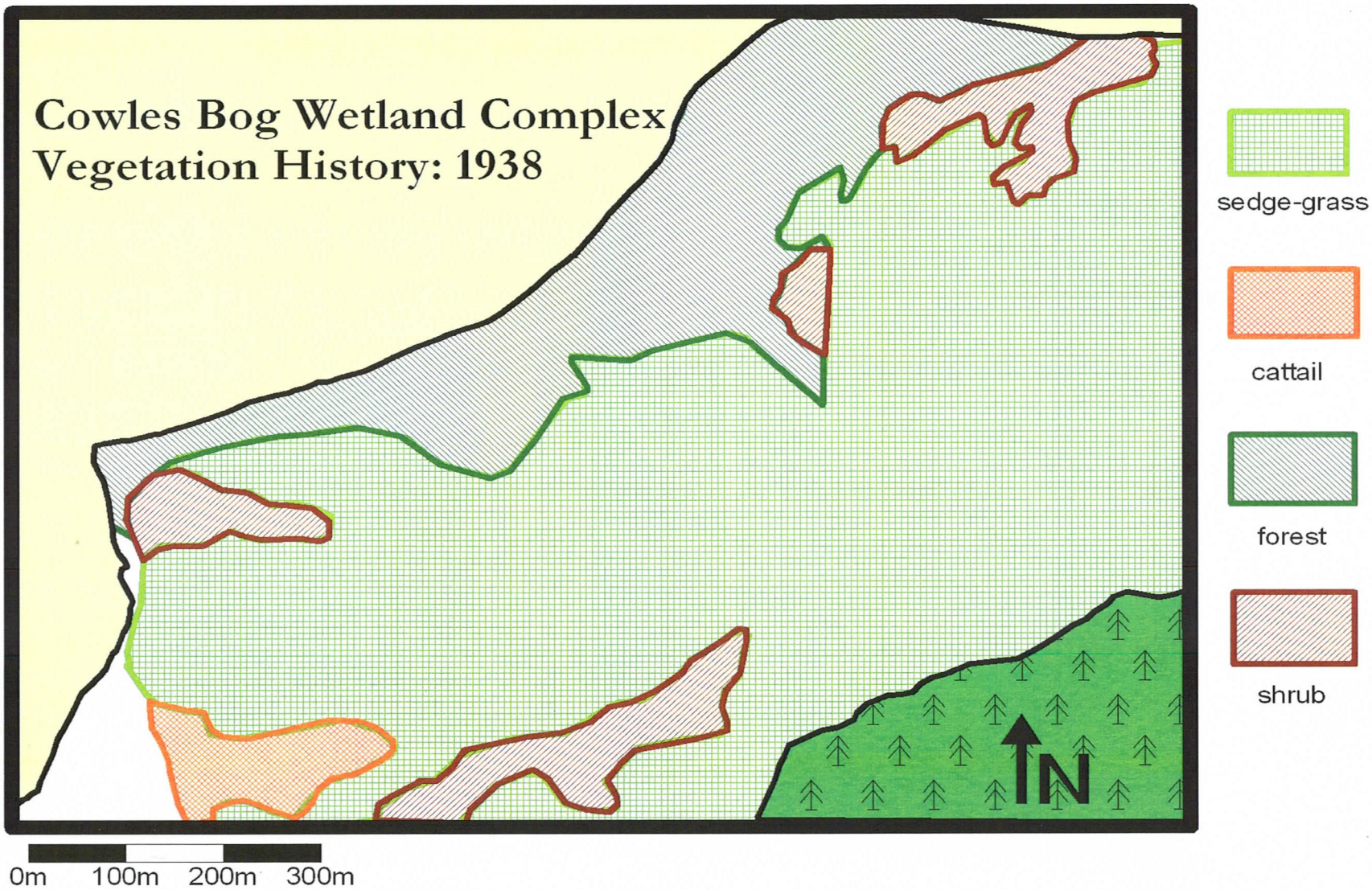


EXHIBIT A:7 – Vegetation Types Present in Cowles Bog Wetland Complex in 1970 Based on Interpretation of Aerial Photography. Present were 43.0 ha of Sedge-grass, 9.7 ha of Cattail, 14.8 ha of Shrub and 13.2 ha of Forested Vegetation (Apfelbaum et al. 1983, Wilcox et al. 1984).

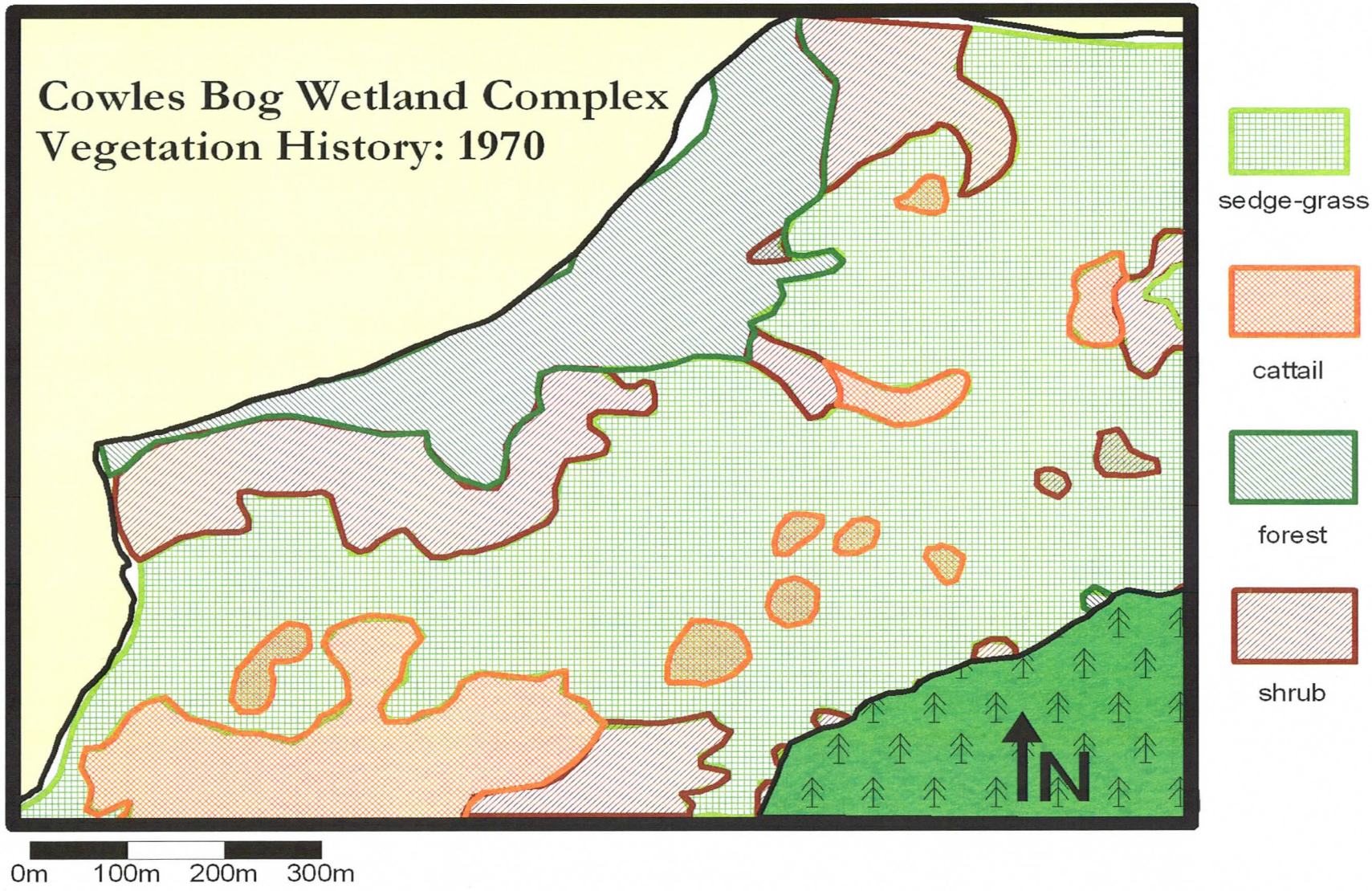


EXHIBIT A:8 – Vegetation Types Present in Cowles Bog Wetland Complex in 1973 Based on Interpretation of Aerial Photography. Present were 24.8 ha of Sedge-grass, 21.4 ha of Cattail, 16.5 ha of Shrub and 18.0 ha of Forested Vegetation (Apfelbaum et al. 1983, Wilcox et al. 1984).

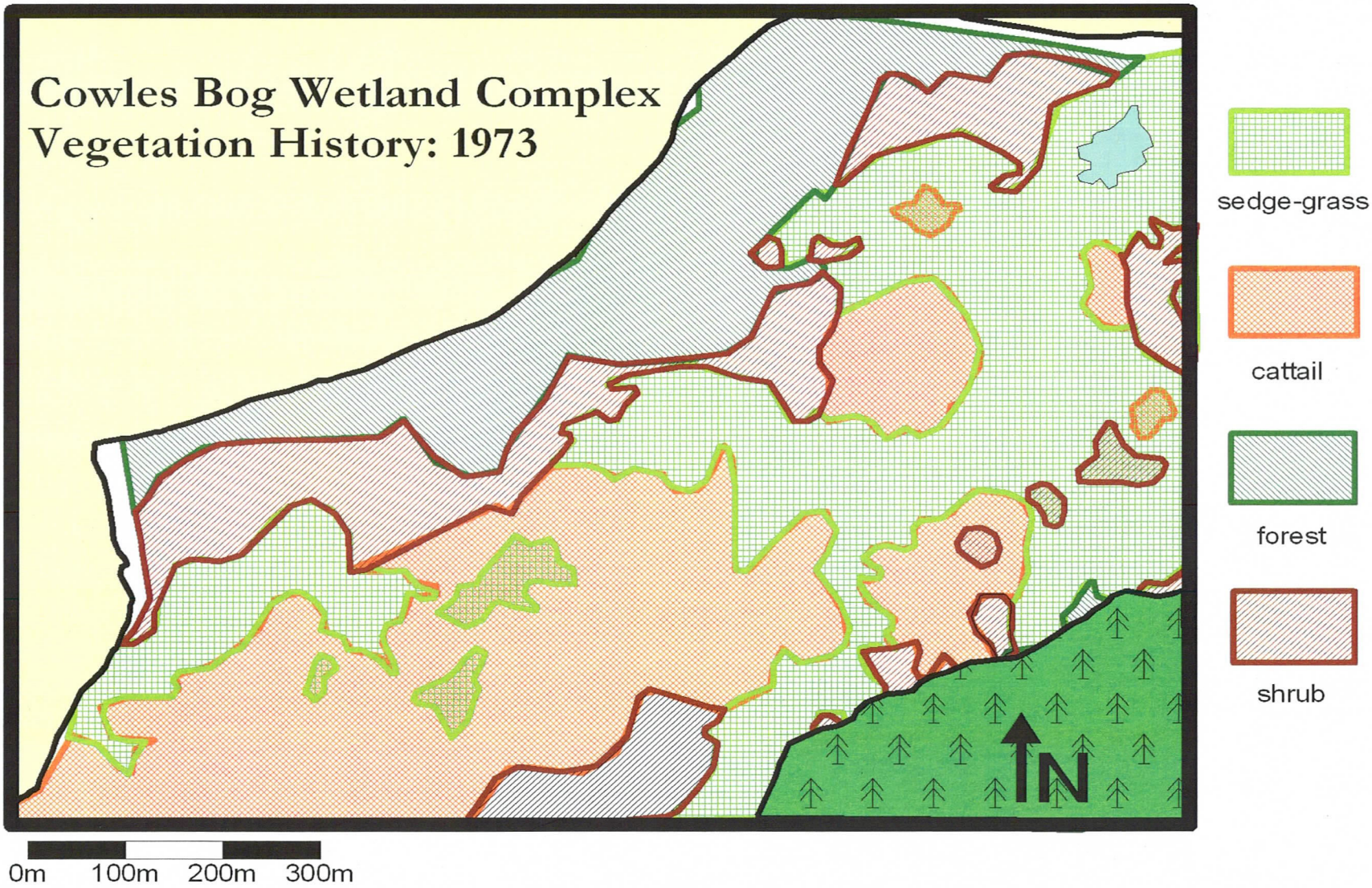


EXHIBIT A:9 – Vegetation Types Present in Cowles Bog Wetland Complex in 1977 Based on Interpretation of Aerial Photography. Present were 11.4 ha of Sedge-grass, 37.3 ha of Cattail, 15.1 ha of Shrub and 16.8 ha of Forested Vegetation (Apfelbaum et al. 1983, Wilcox et al. 1984).

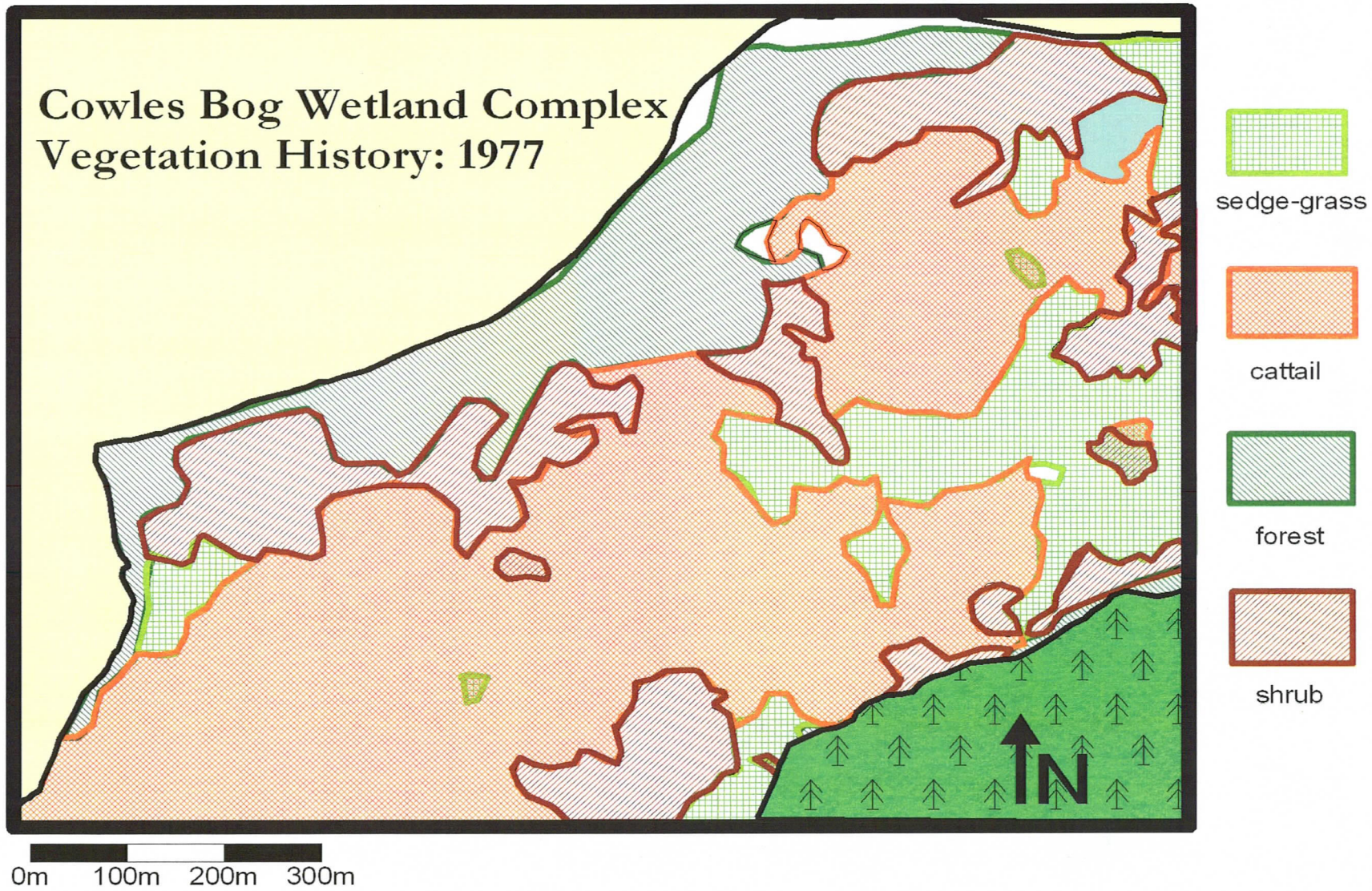


EXHIBIT A:10 – Vegetation Types Present in Cowles Bog Wetland Complex in 1982 Based on Interpretation of Aerial Photography. Present were 5.7 ha of Sedge-grass, 37.5 ha of Cattail, 18.3 ha of Shrub and 19.2 ha of Forested Vegetation (Apfelbaum et al. 1983, Wilcox et al. 1984).

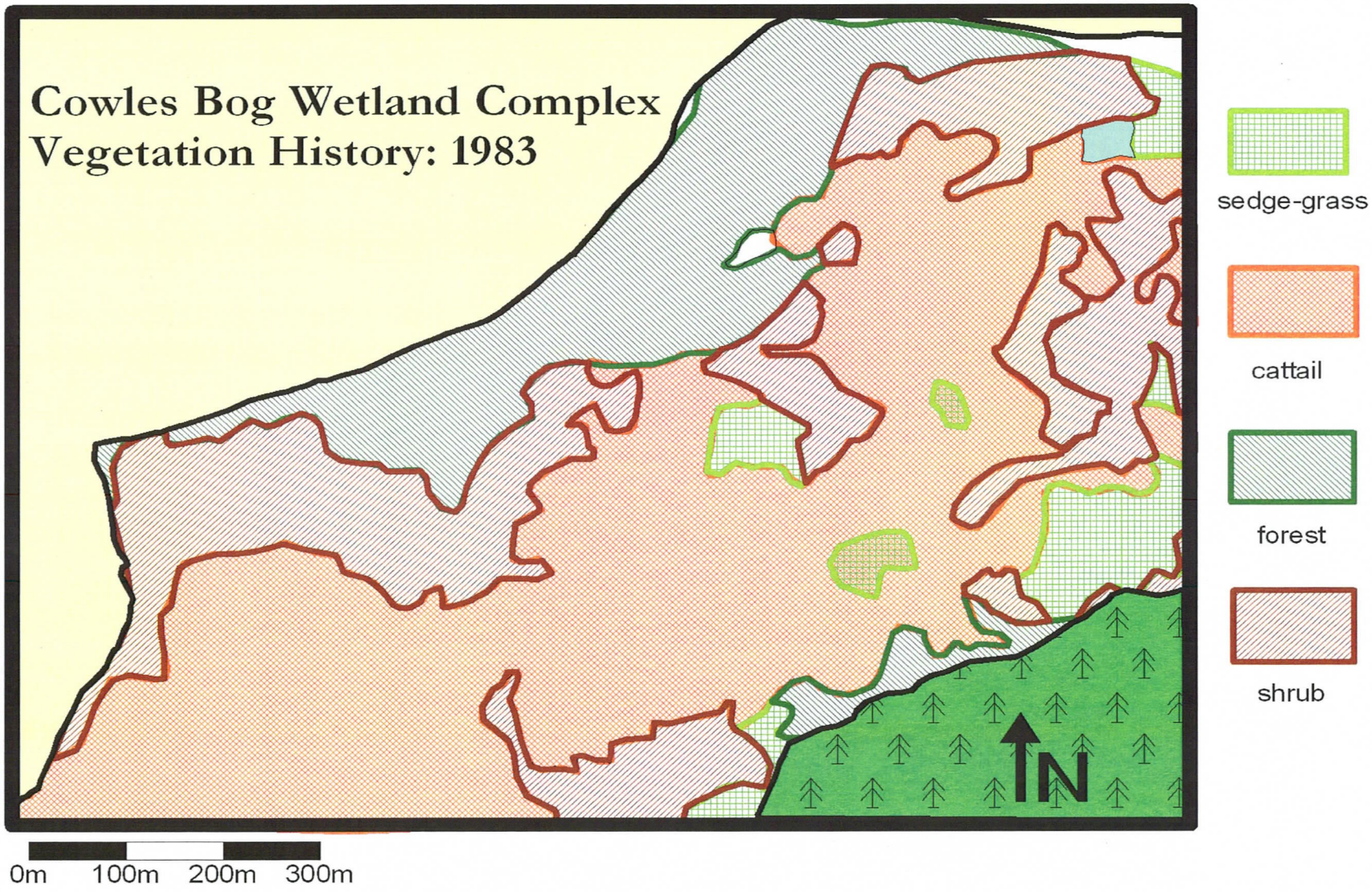


Exhibit A:11- Overview of Cowles Bog Wetland Complex showing Intra-dunal Wetlands, Contiguous Wetland, and Surface Water Flow Patterns.

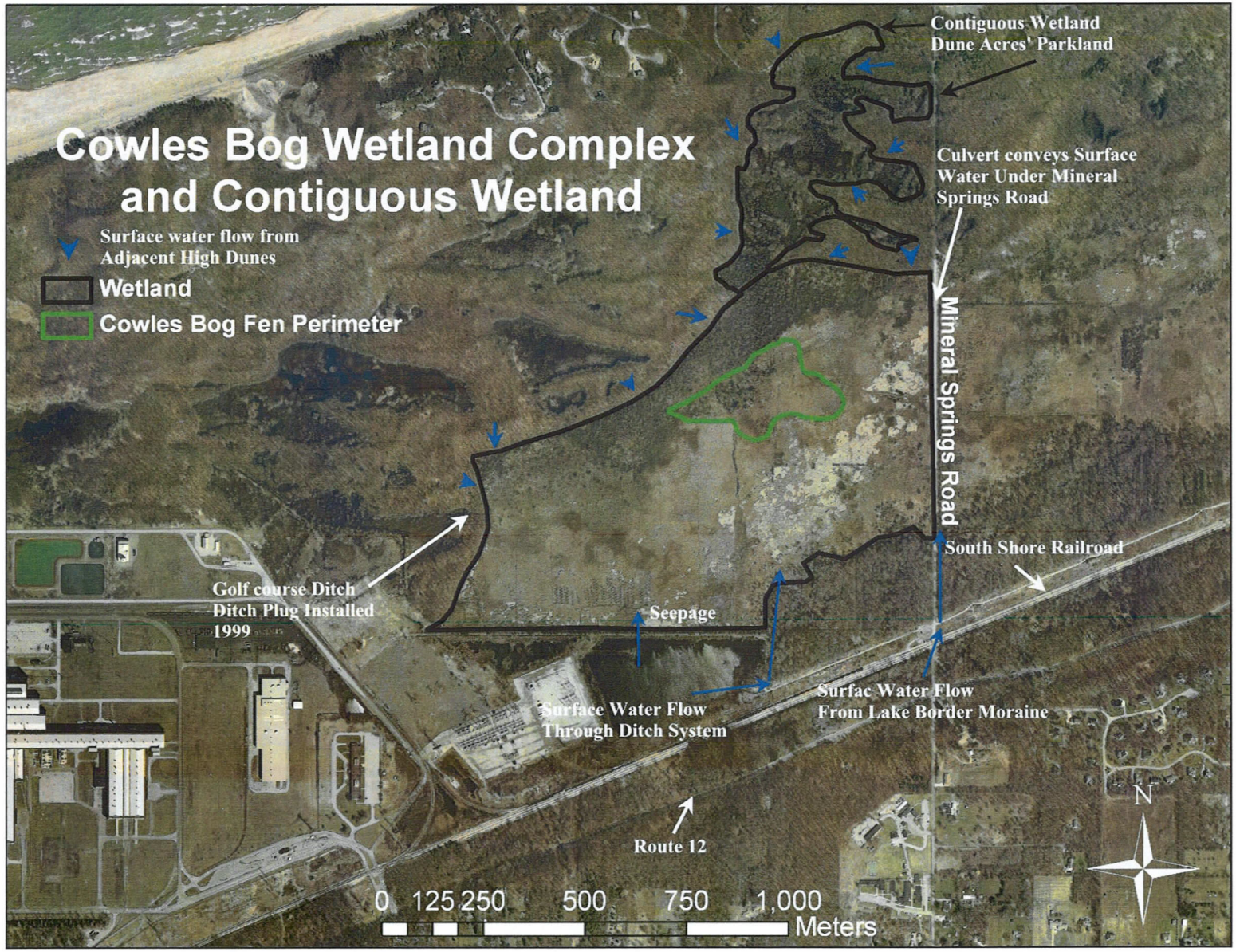


Fig #11

Exhibit A:12 – Soil Types as Mapped by the National Resources Conservation Service in 1944. The Soil Types are present on 2004 Aerial Photography.

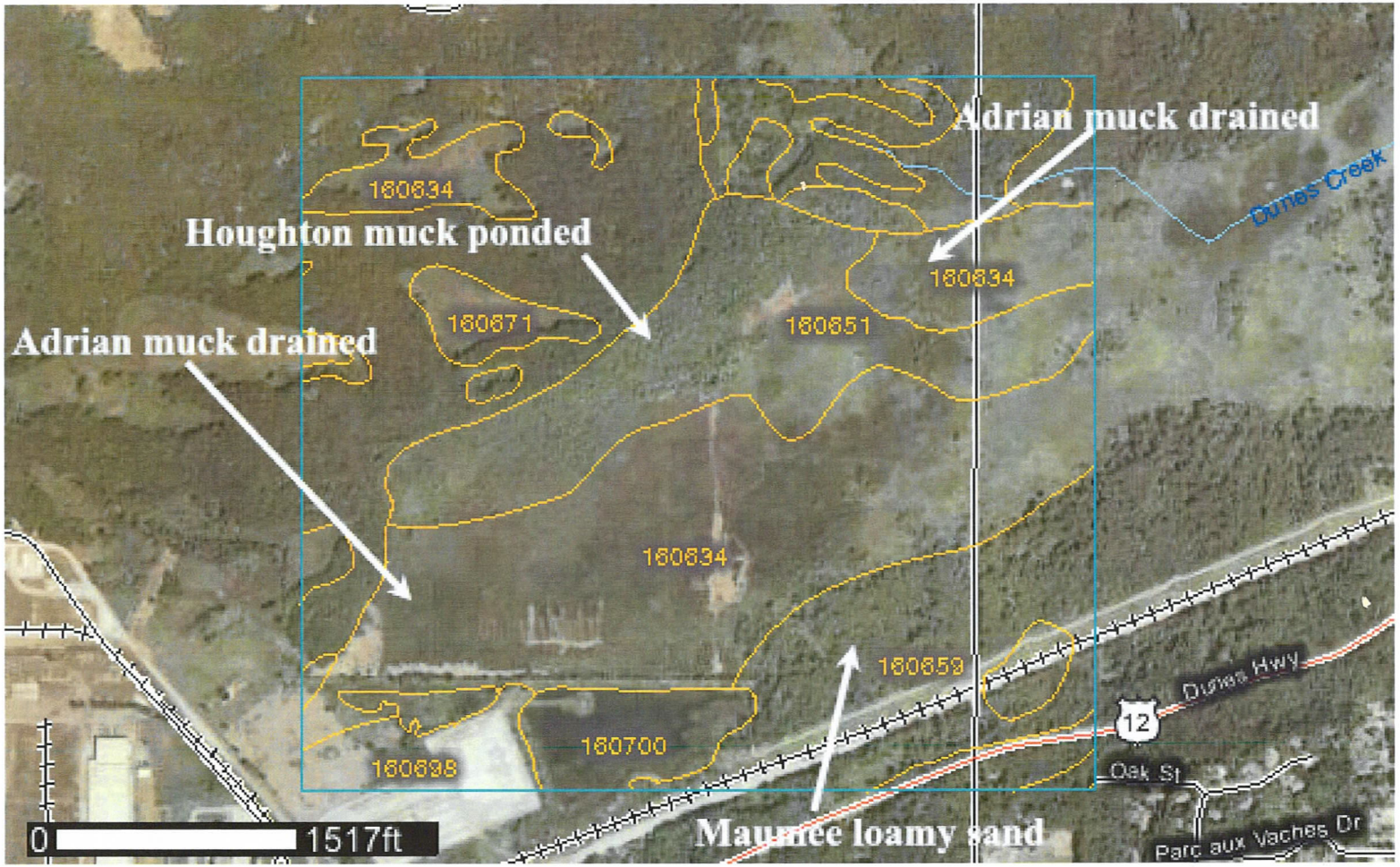


Exhibit A:13 – Soil Types Present at the Indicated Sample Locations.



Exhibit A:14 – Depth (cm) to the Historic Lake Chicago Sand Surface.

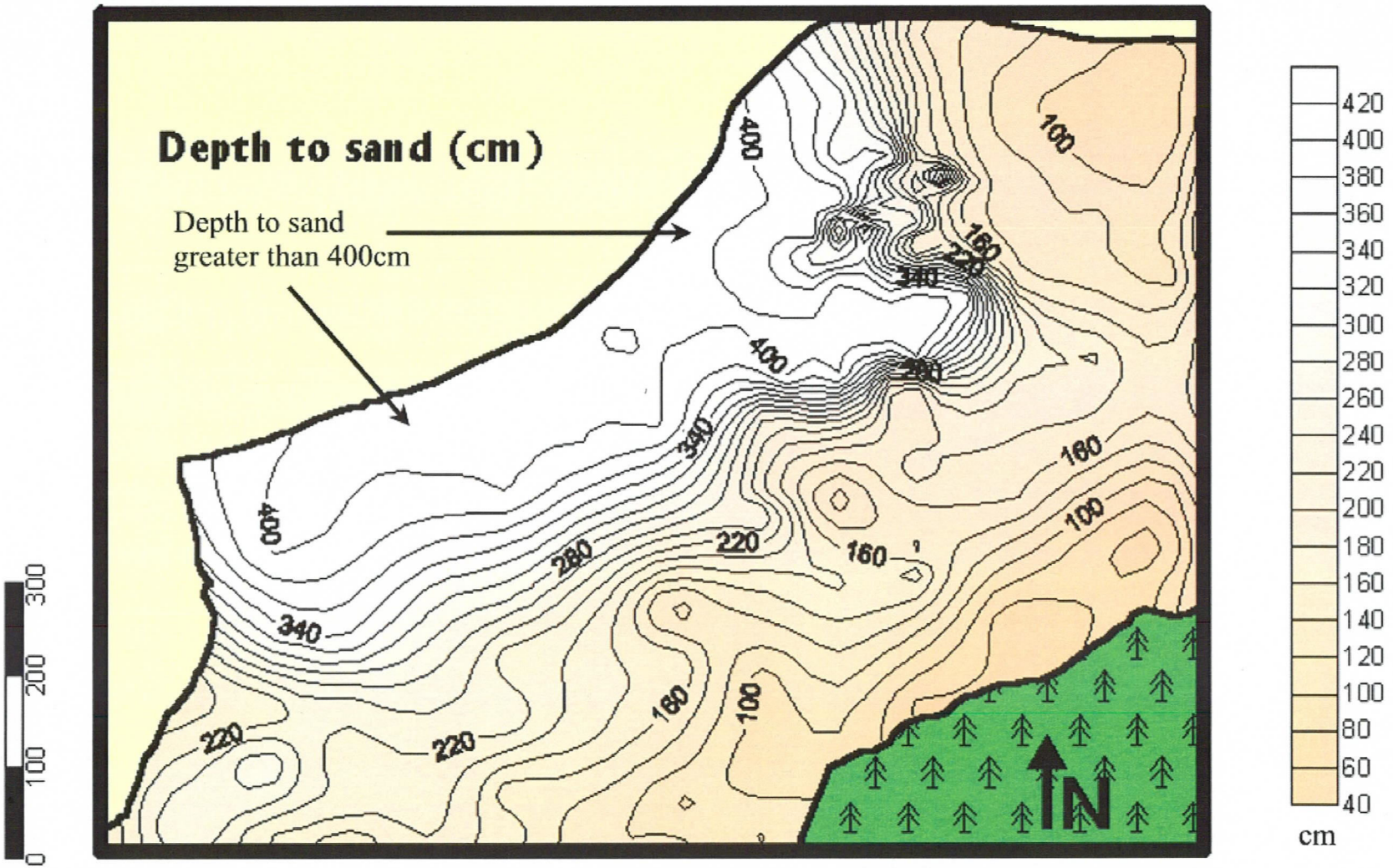


Fig A14 peat depth

EXHIBITS B:SERIES

Exhibit B:1 Vegetation sample locations in Cowles Bog Wetland Complex.

Exhibit B:2 Seedbank sample locations in Cowles Bog Wetland Complex.

Exhibit B:3 Well and staff gauge locations in Cowles Bog Wetland Complex.

Exhibit B:4 Well locations in Cowles Bog Wetland Complex that were sampled for water chemistry.

Exhibit B:5 Surface water locations in Cowles Bog Wetland Complex that were sampled for water chemistry.

Exhibit B:6 Soil sample locations in Cowles Bog Wetland Complex.

Exhibit B:1 – Vegetation Sample Locations in Cowles Bog Wetland Complex. Herbaceous Vegetation was Sampled at 10 m Intervals Along all Transects Except Fen Transect Which were Sampled at 5 m Intervals.

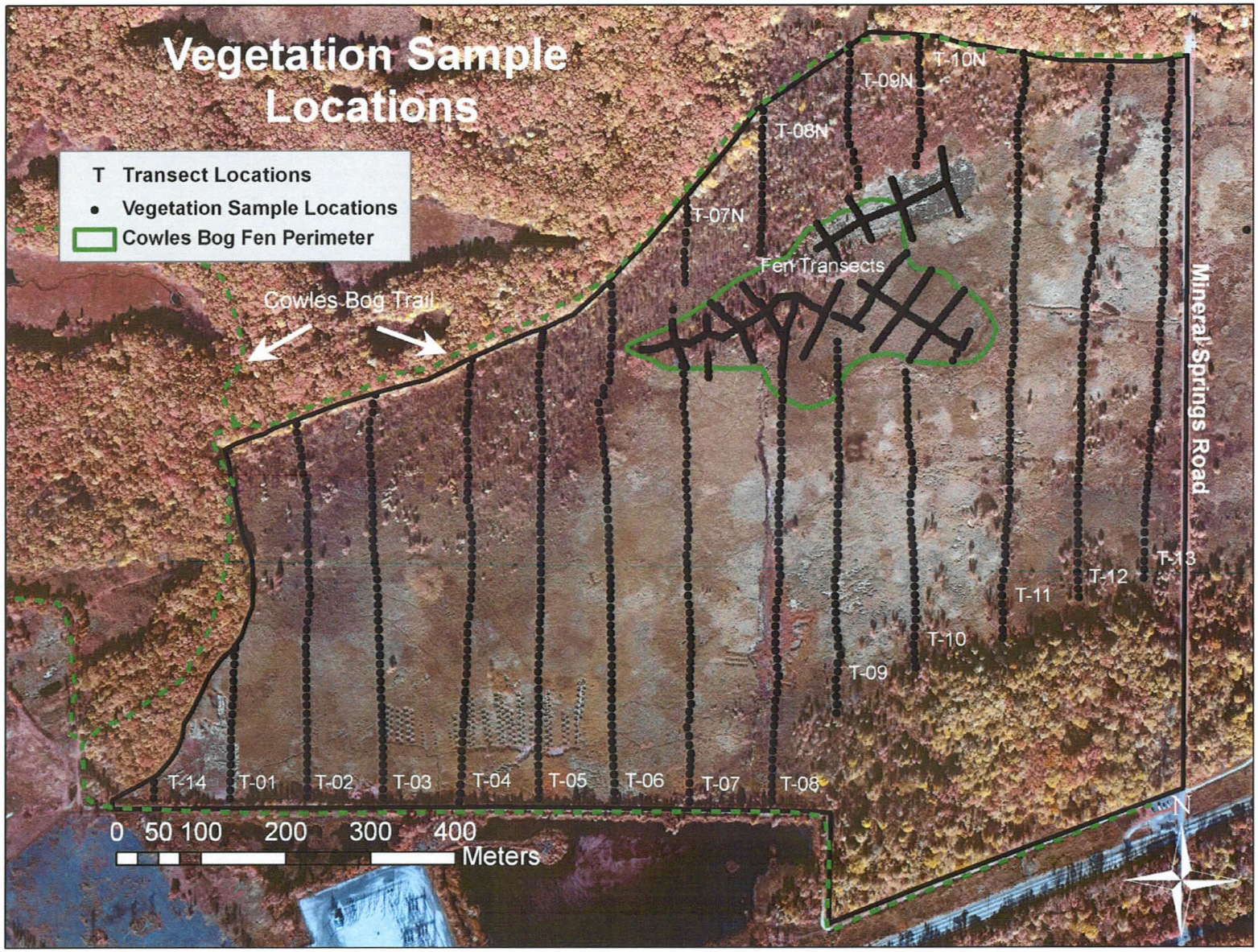


Exhibit B:2 – Seedbank Sample Locations in Cowles Bog Wetland Complex and Wetland East of Mineral Springs Road. The Vegetation Type Present at Each Sample location is Provided Through Color Coding.

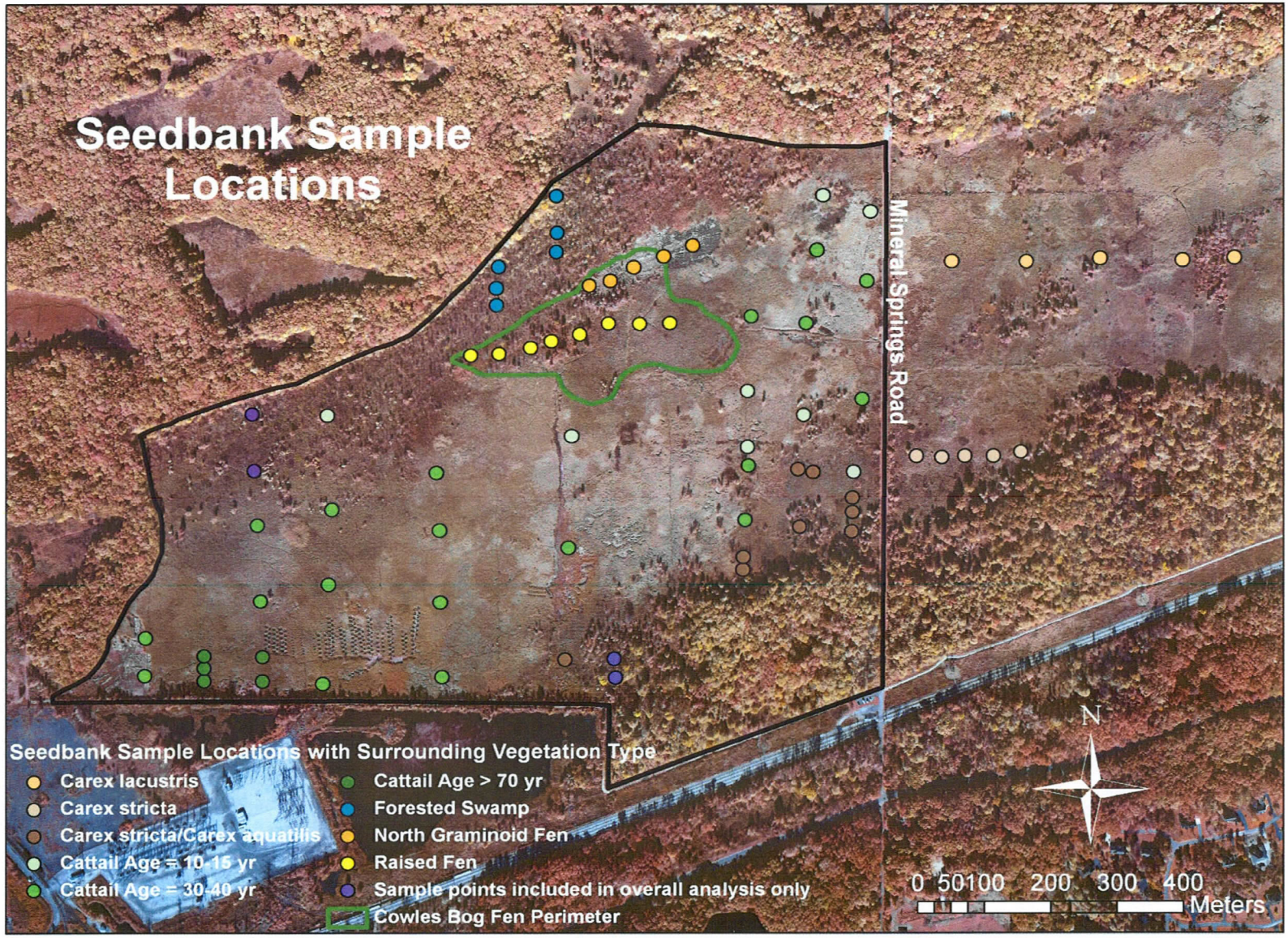


Exhibit B:3 – Groundwater Wells and Staff Gauge Locations used for Monitoring Groundwater and Surface Water Levels.

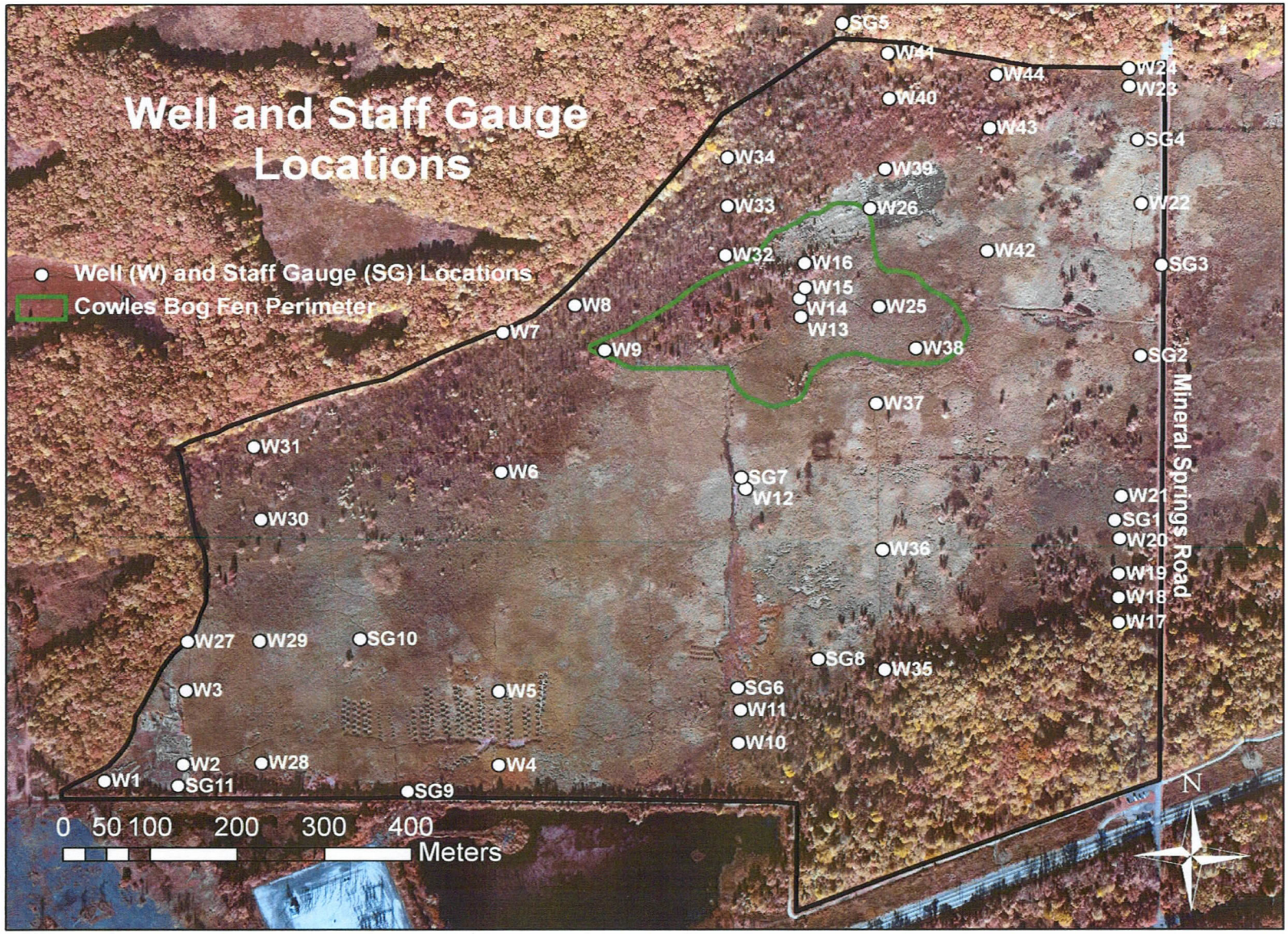


Exhibit B:4 – Well Locations Sampled for the Purpose of Ground Water Chemistry Analyses.

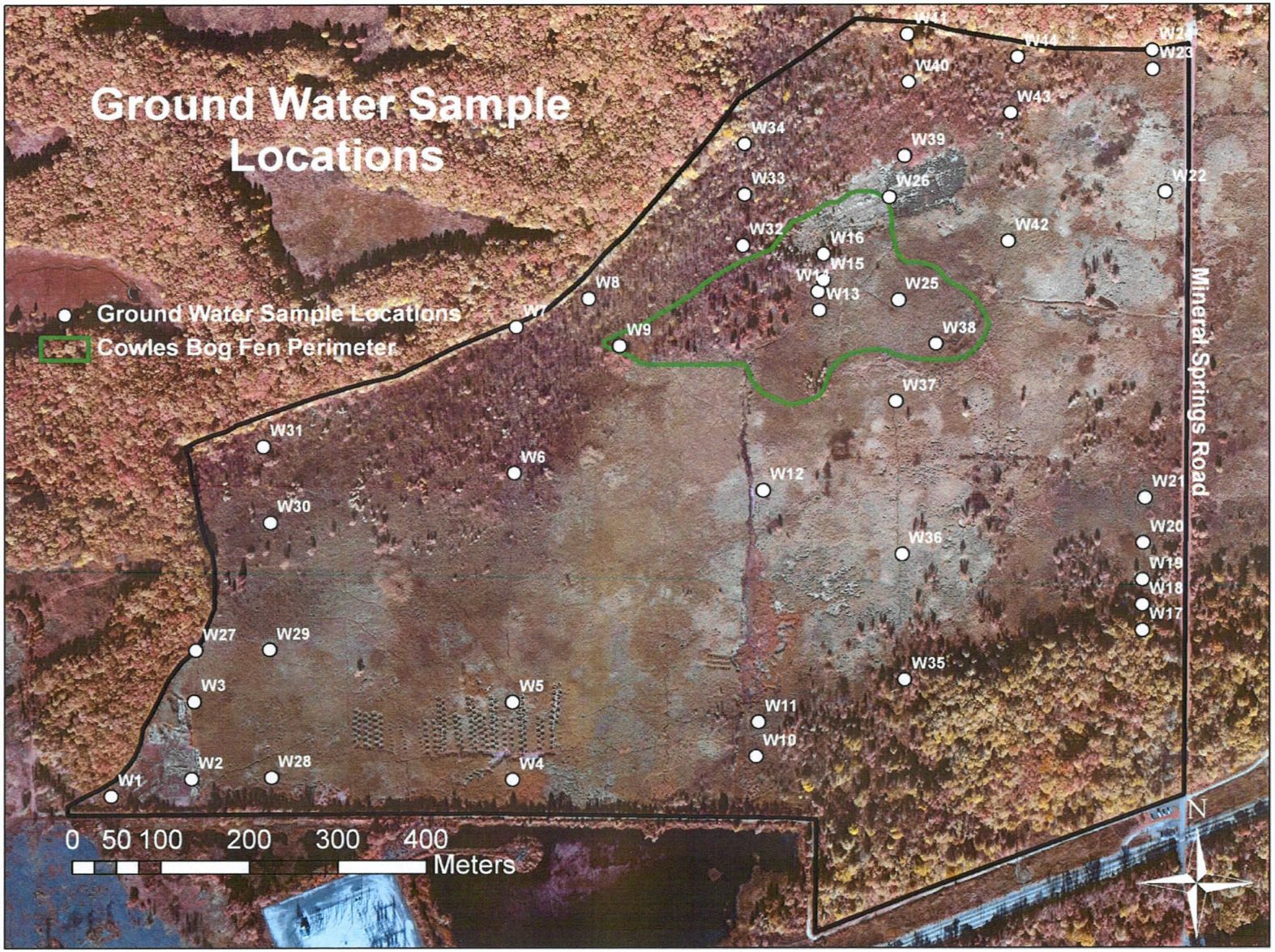


Exhibit B:5 – Surface Water Locations Sampled for the Purpose of Surface Water Chemistry Analyses.

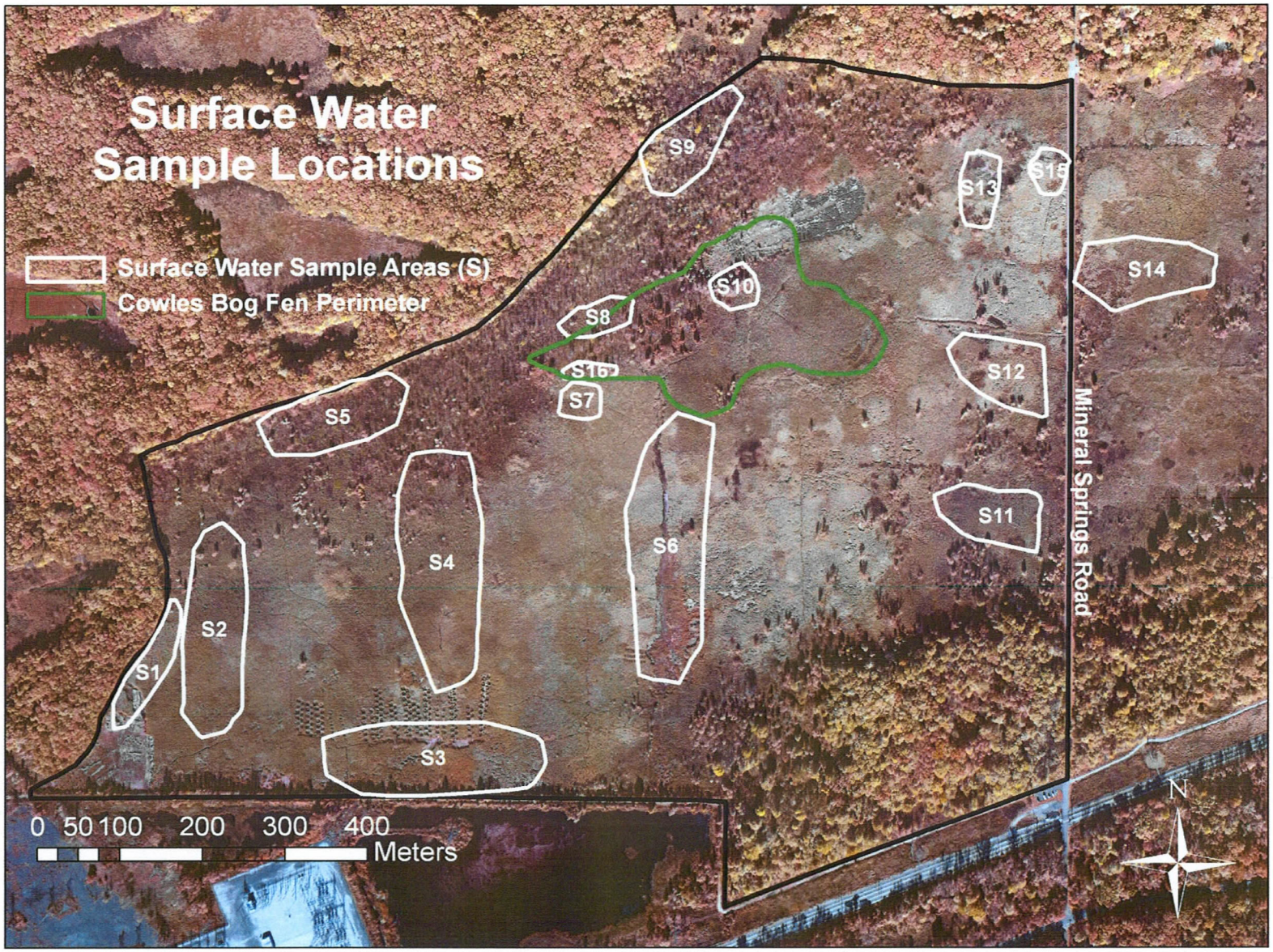
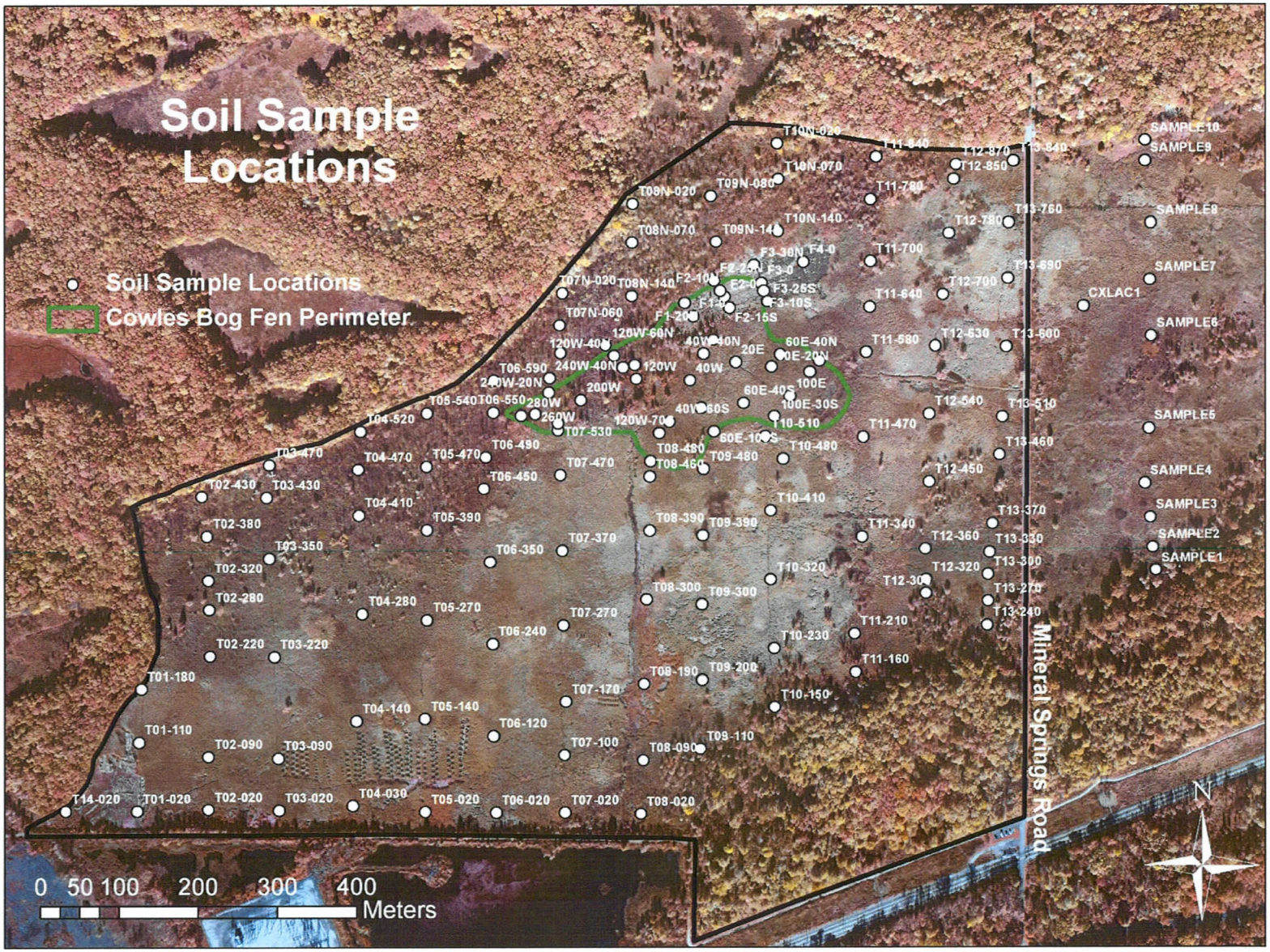


Exhibit B:6 – Sample Locations in Cowles Bog Wetland Complex and Mineral Springs Road East in Which Soil Samples for Soil Chemistry Analyses were Taken.



EXHIBITS C:SERIES

Exhibit C:1 Legend for vegetation exhibits in Cowles Bog Wetland Complex.

Exhibit C:2 Vegetation units in Cowles Bog Wetland Complex.

Exhibit C:3 West shrub unit in Cowles Bog Wetland Complex.

Exhibit C:4 Forested swamp unit in Cowles Bog Wetland Complex.

Exhibit C:5 Fen units in Cowles Bog Wetland Complex.

Exhibit C:6 East shrub unit in Cowles Bog Wetland Complex.

Exhibit C:7 Cattail stem density in Cowles Bog Wetland Complex.

Exhibit C:8 Cattail unit in Cowles Bog Wetland Complex.

Exhibit C:9 Disturbed prairie unit in Cowles Bog Wetland Complex.

Exhibit C:1 – Legend for Vegetation Exhibits to be Applied to all C-Series Exhibits.

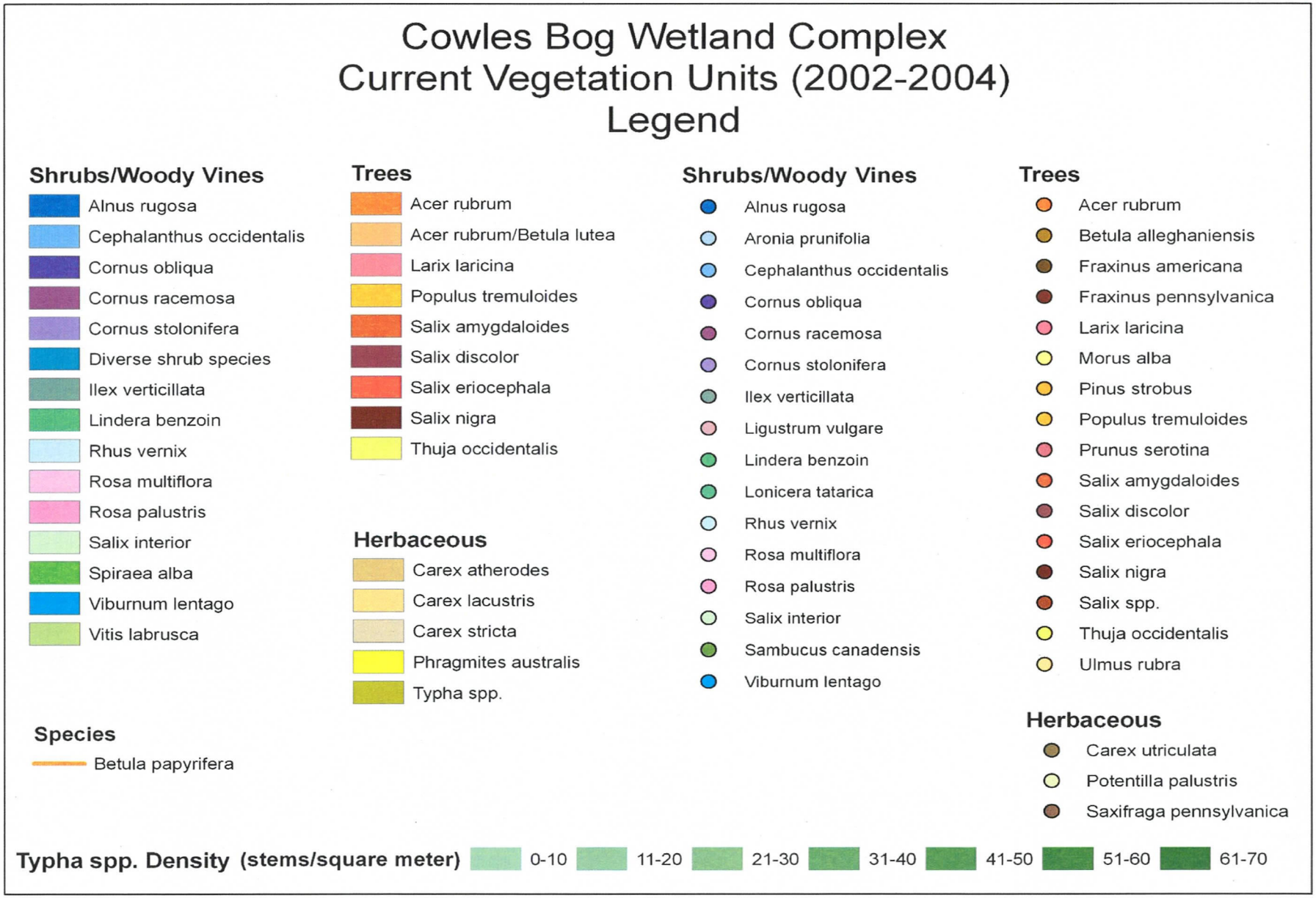


Exhibit C:2 – An Overall Presentation of Vegetation Units Present in Cowles Bog Wetland Complex in 2002-2004.

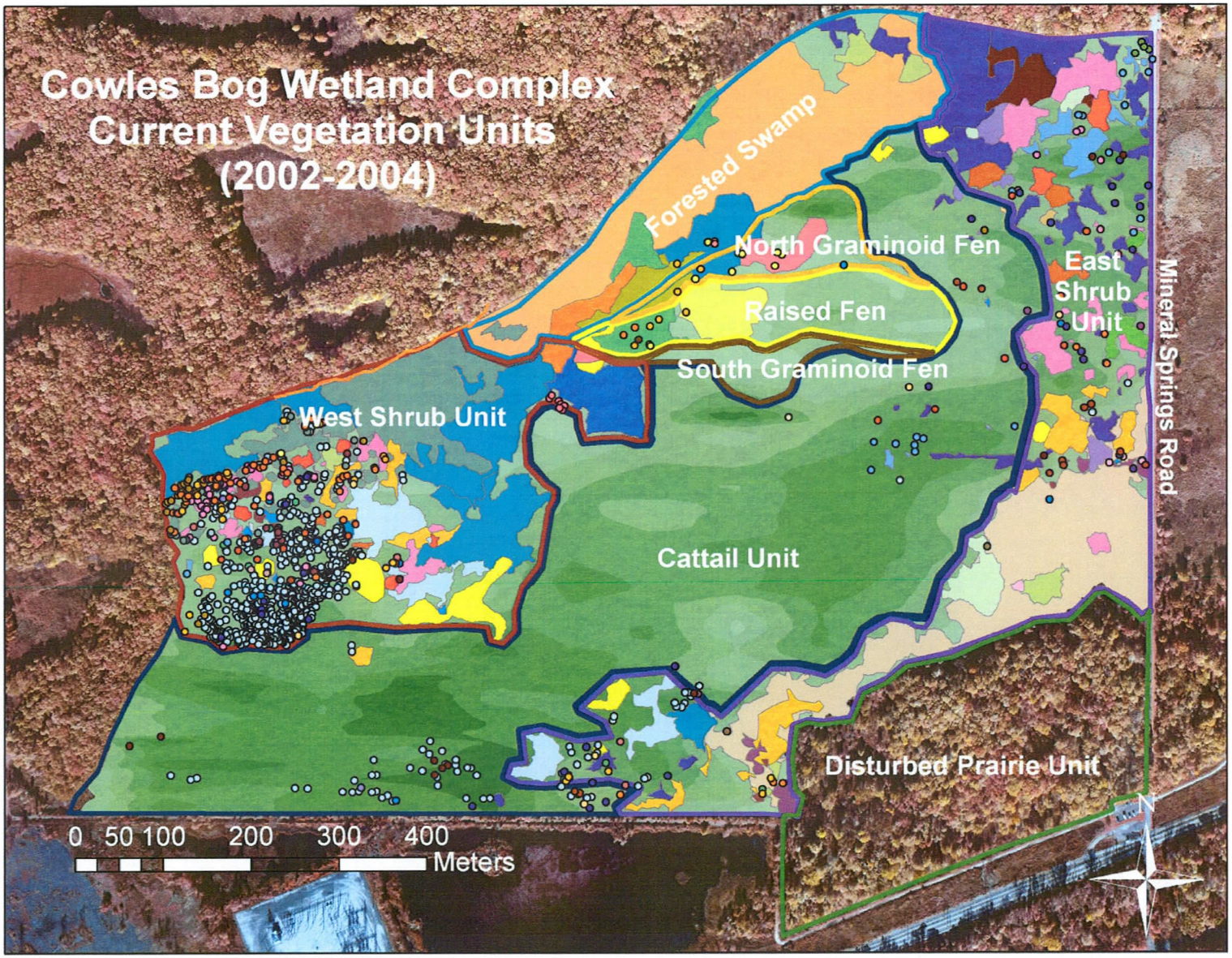


Exhibit C:3 - The West Shrub Unit is Defined With a Red Polygon. Shrub, Tree, and Herbaceous Assemblages and individual Shrubs and Trees are Defined.

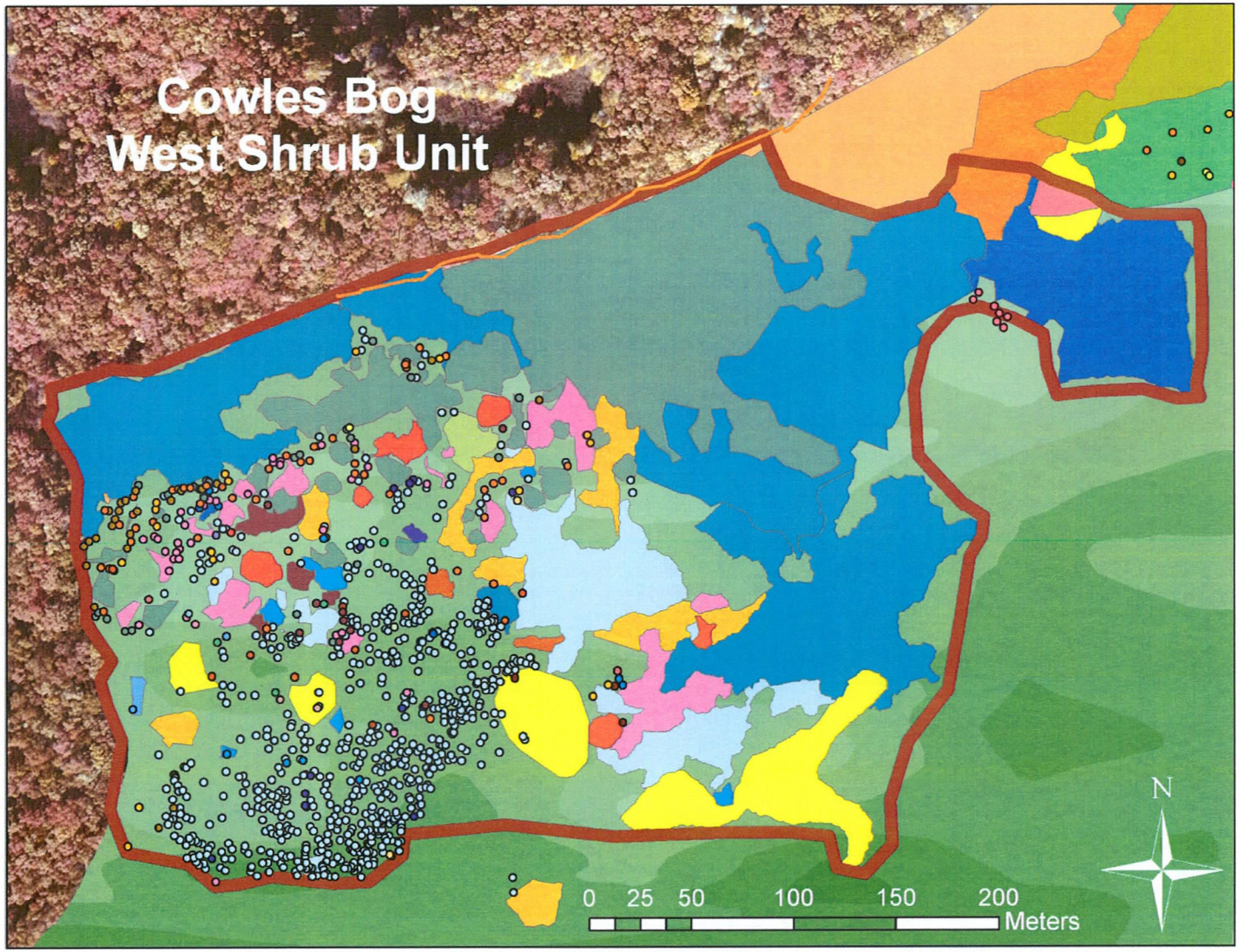


Exhibit C:4 - The Forested Swamp Unit is Defined With a Blue Polygon. Shrub, Tree, and Herbaceous Assemblages and individual Shrubs and Trees are Defined.

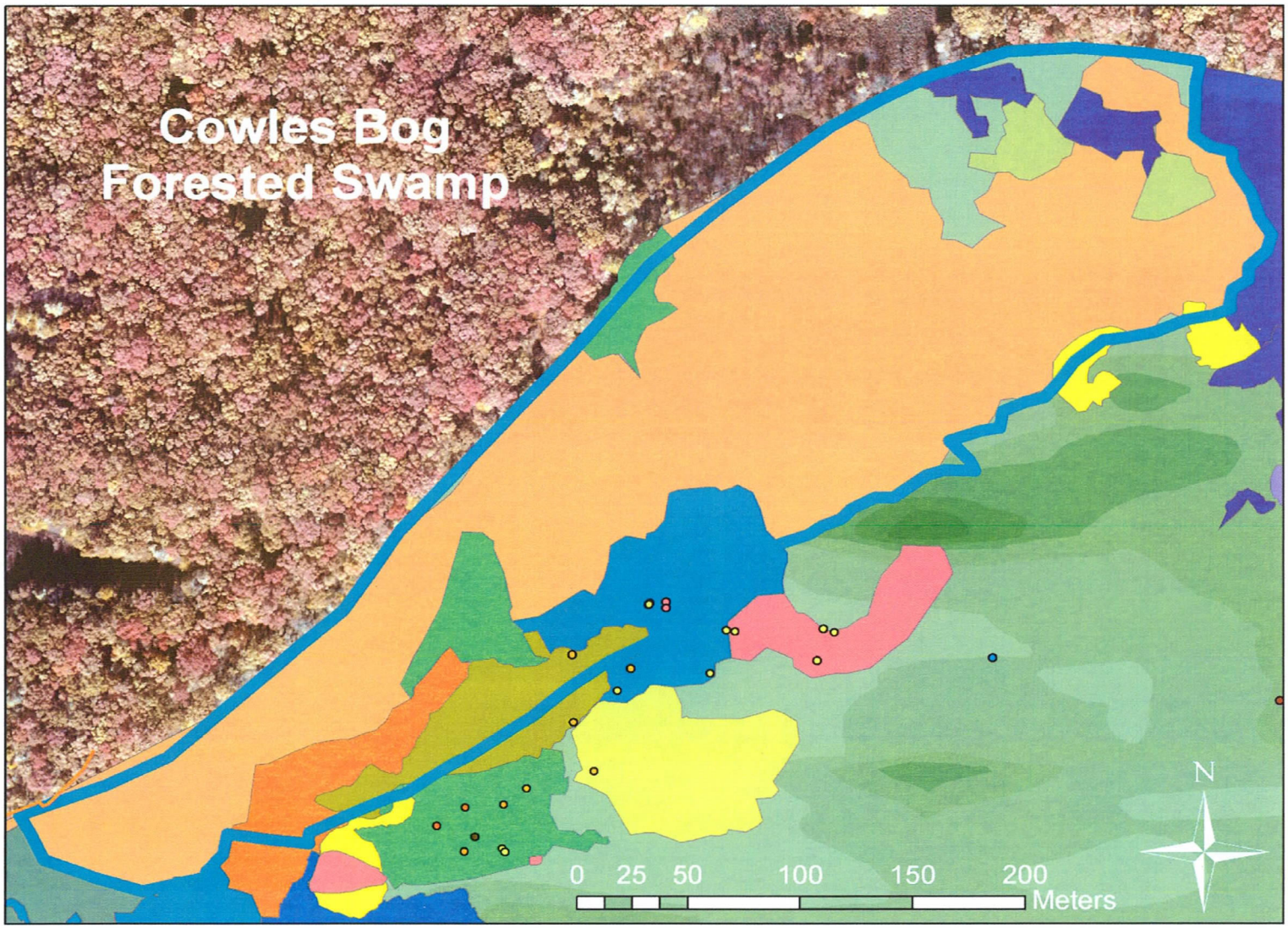


Exhibit C:5 - The Three Fen Units are Defined With Orange, Yellow and Brown Polygons. Shrub, Tree, and Herbaceous Assemblages and individual Shrubs and Trees are Defined.

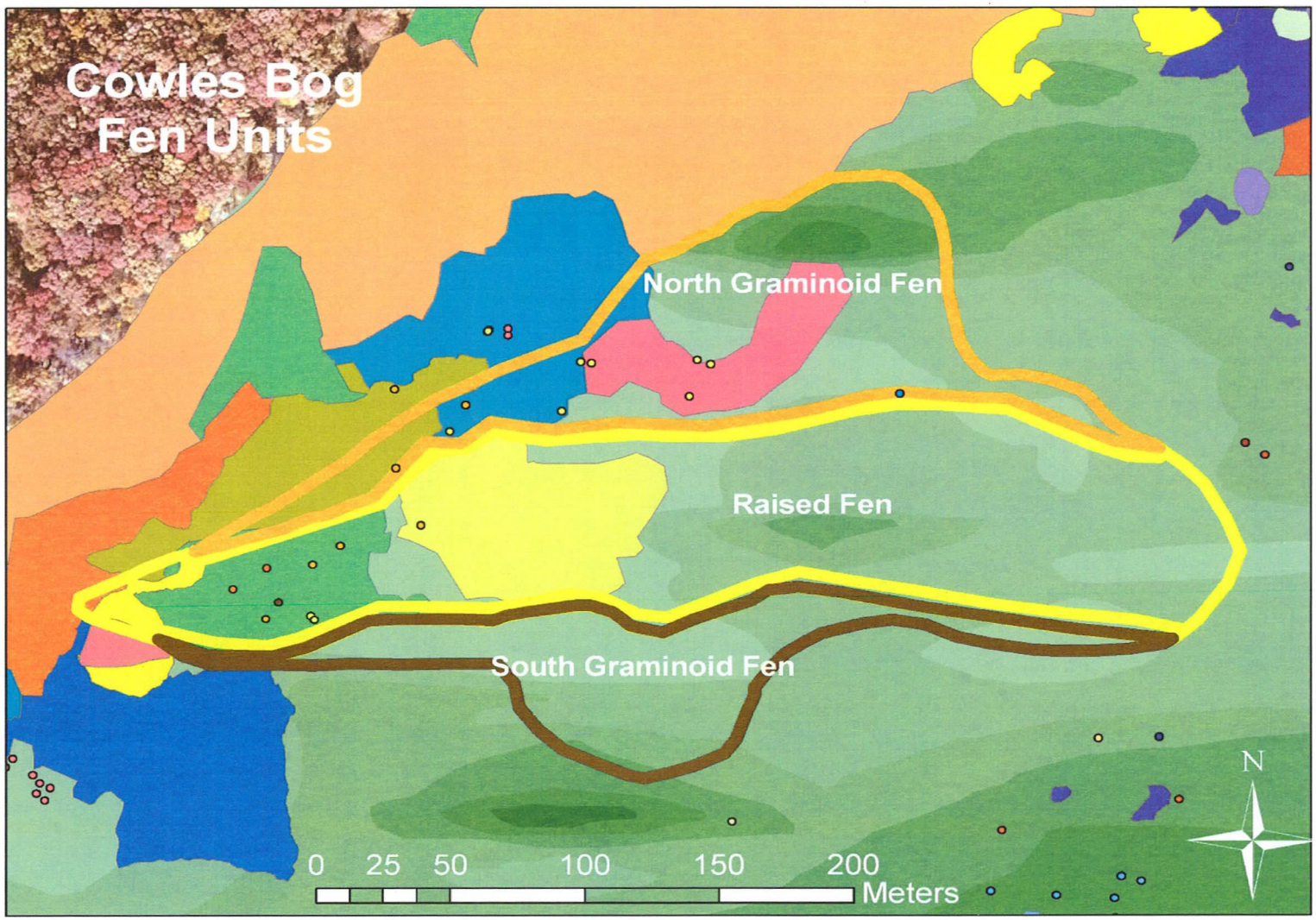


Exhibit C:6 – The East Shrub Unit is Defined With a Purple Polygon. Shrub, Tree, Herbaceous Assemblages and individual Shrubs, Trees are Defined.

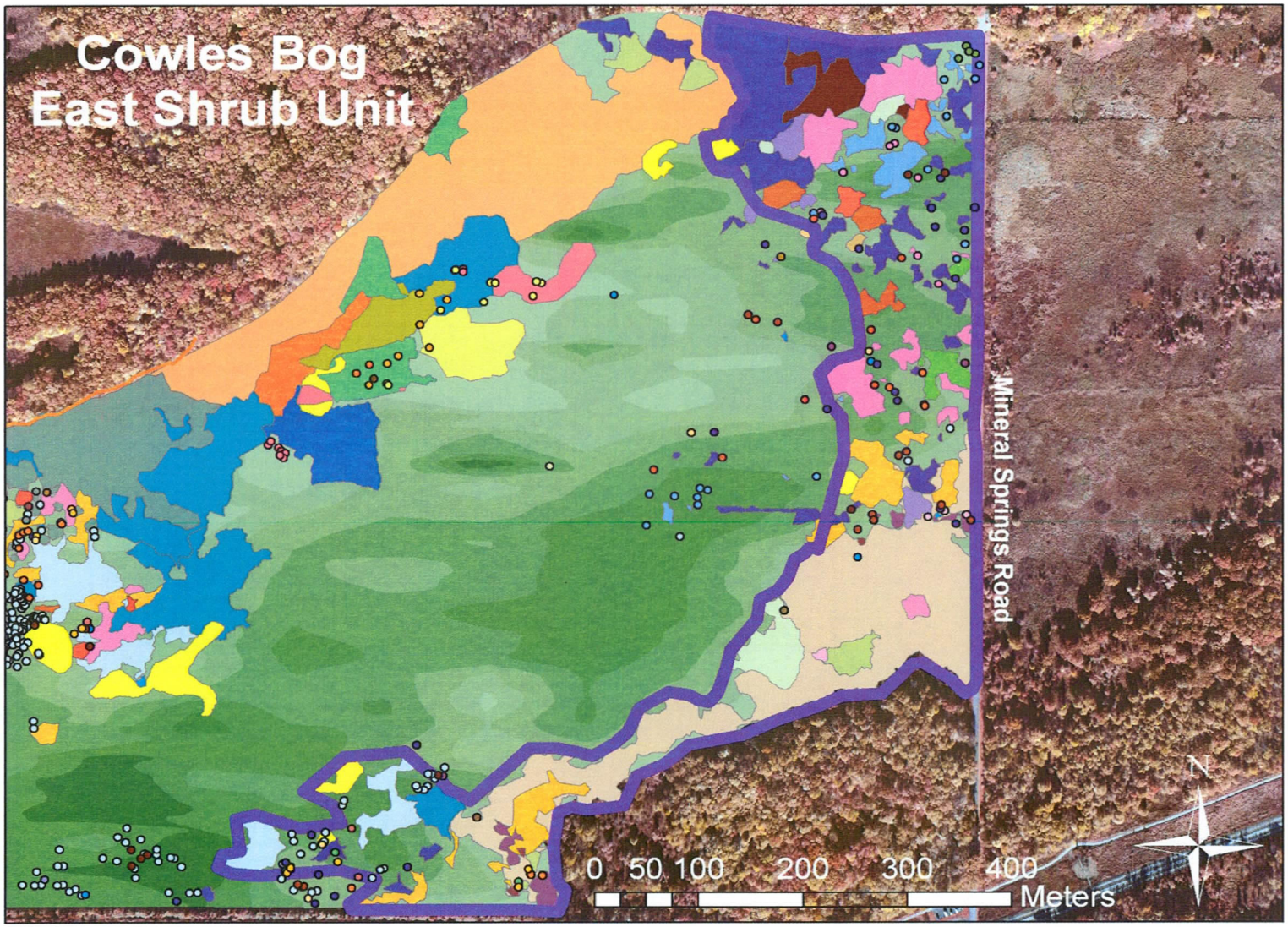


Exhibit C:7 – Stem Density of Cattail Presented Throughout the Entire Cowles Bog Wetland Complex.



Exhibit C:8 – The Cattail Unit is Defined With a Blue Polygon. Locations of Scattered Shrubs and Trees are Indicated.

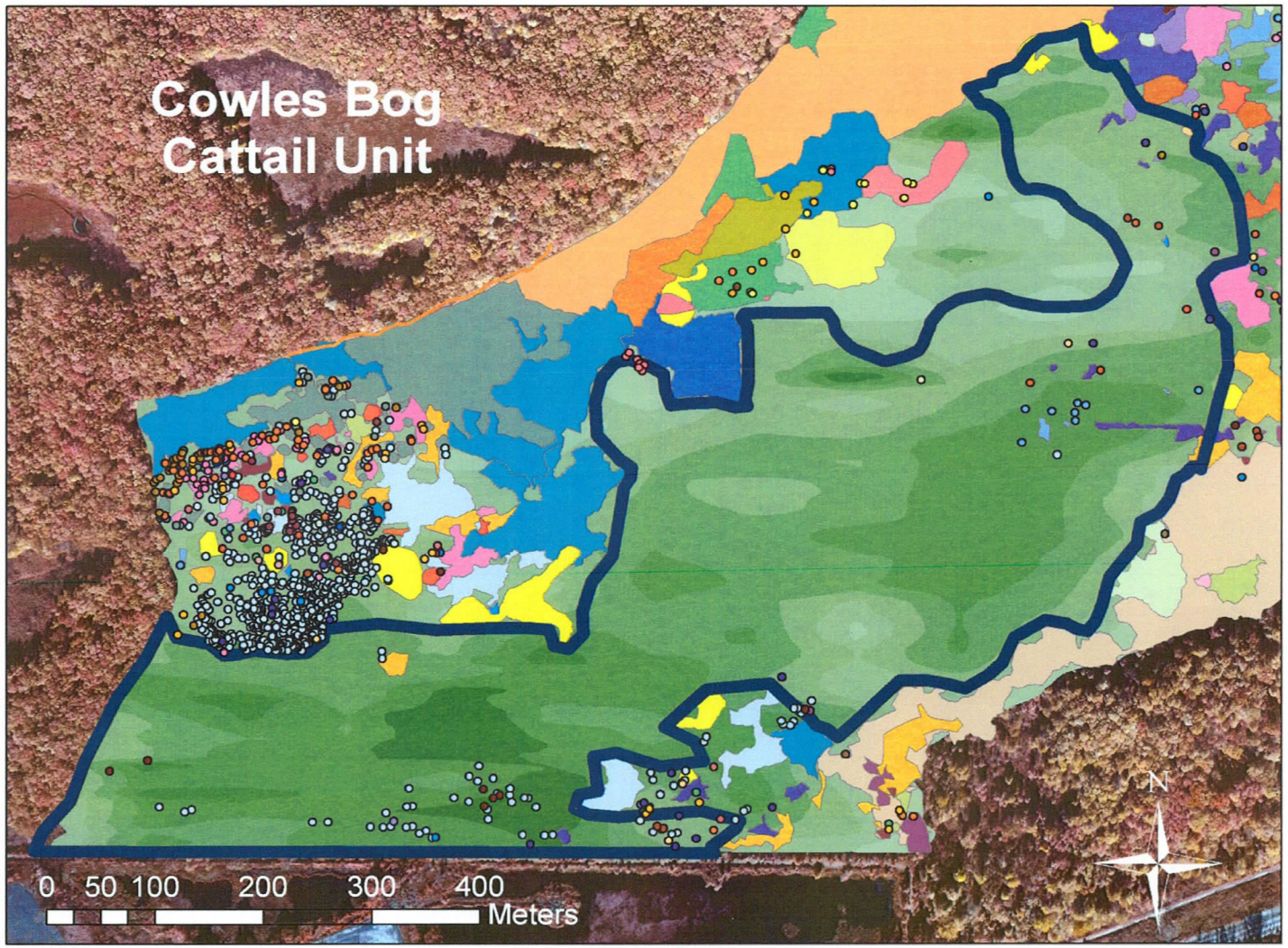


Exhibit C:9 – The Disturbed Prairie Unit is Defined With a Green Polygon. Locations of an Abandoned Home Site and Ditch System are Indicated. The Northern Ditch System Exhibits Limited Water Conveyance. The Southern Ditch System is Fully Functional.



EXHIBITS D:SERIES

Exhibit D:1 Surface and ground water depths recorded at Cowles Bog Wetland Complex April 11, 2003.

Exhibit D:2 Surface and ground water depths recorded at Cowles Bog Wetland Complex May 2, 2003.

Exhibit D:3 Surface and ground water depths recorded at Cowles Bog Wetland Complex May 27, 2003.

Exhibit D:4 Surface and ground water depths recorded at Cowles Bog Wetland Complex June 16, 2003.

Exhibit D:5 Surface and ground water depths recorded at Cowles Bog Wetland Complex July 11, 2003.

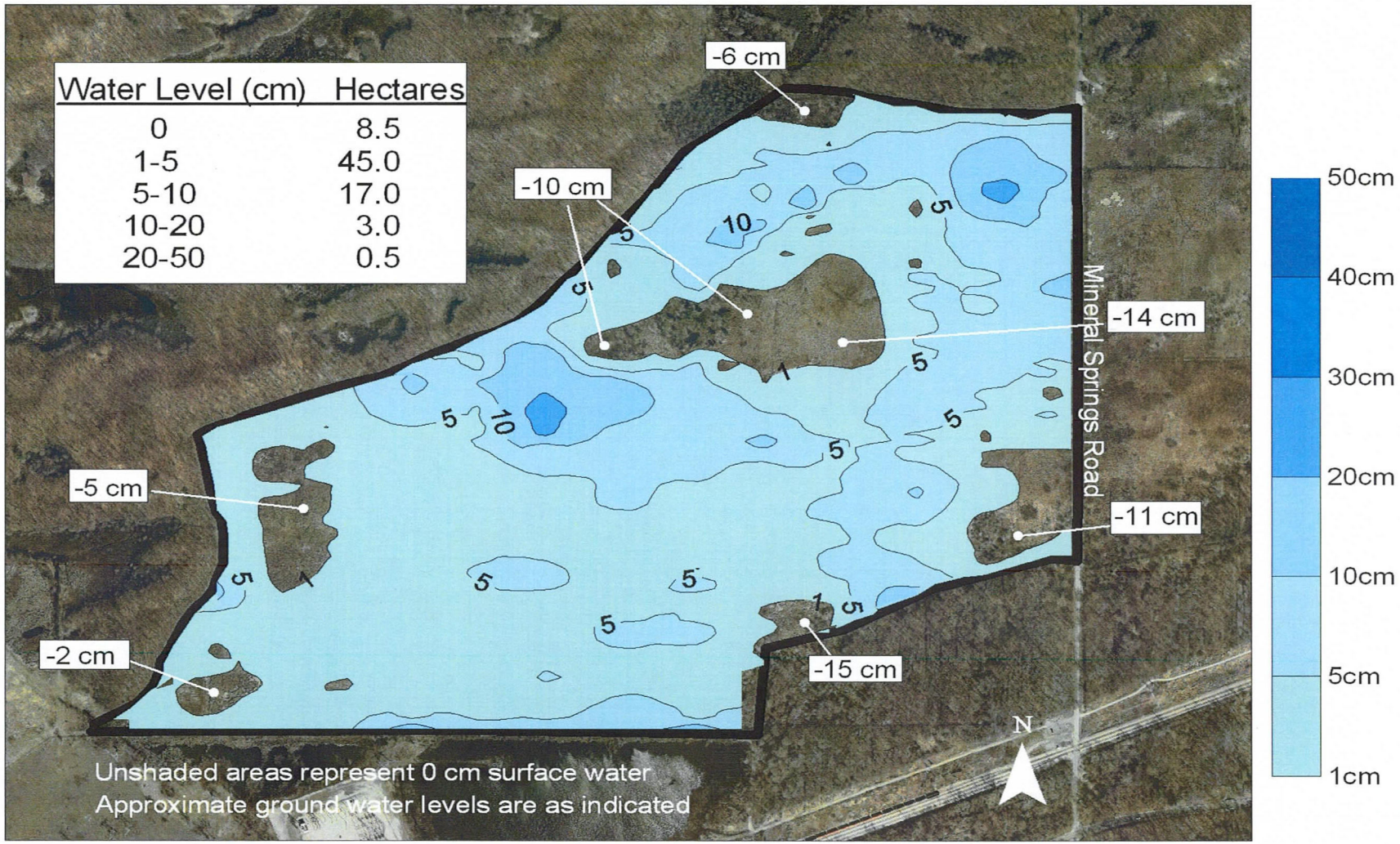
Exhibit D:6 Surface and ground water depths recorded at Cowles Bog Wetland Complex August 12, 2003.

Exhibit D:7 Surface and ground water depths recorded at Cowles Bog Wetland Complex September 16, 2003.

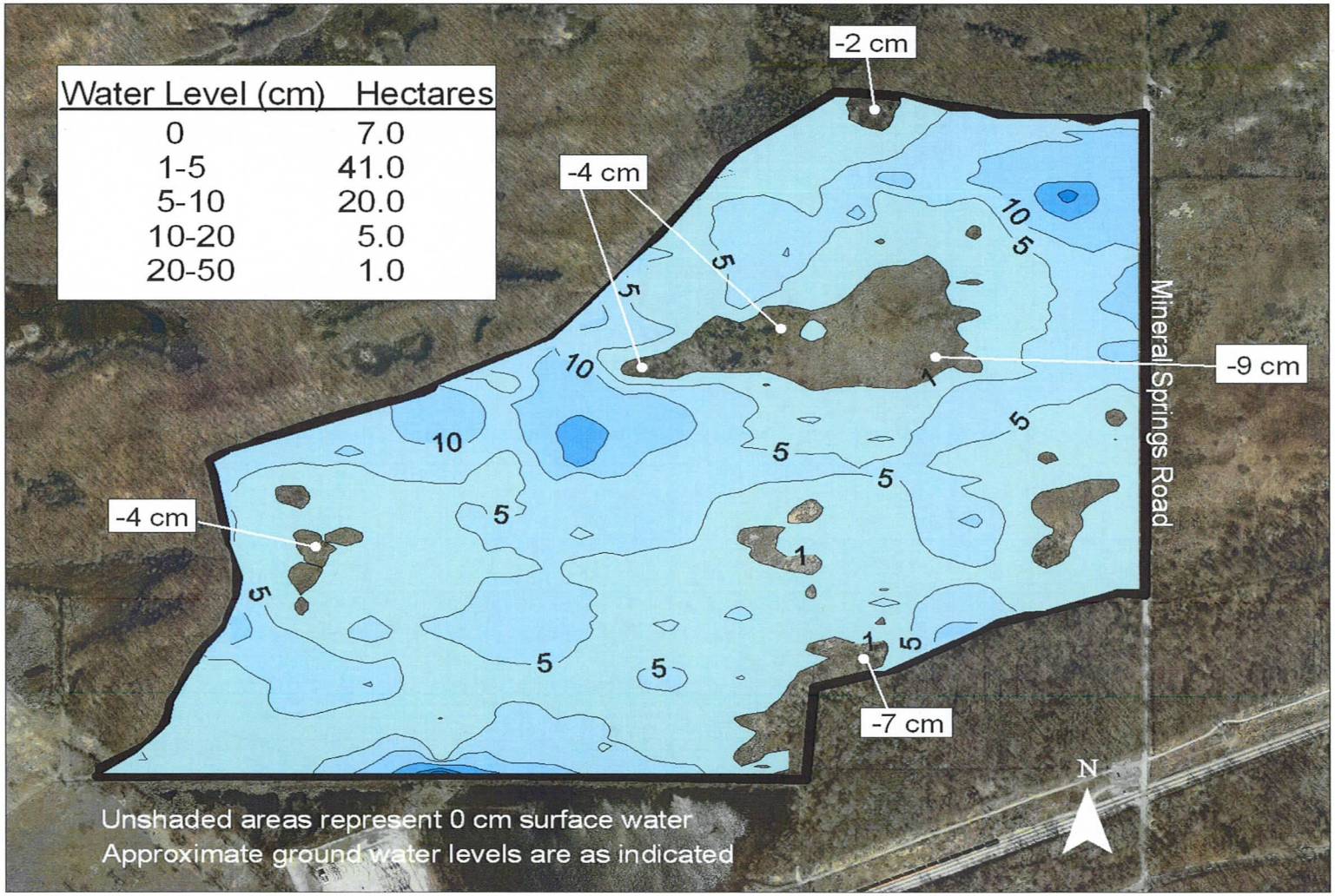
Exhibit D:8 Surface and ground water depths recorded at Cowles Bog Wetland Complex October 15, 2003.

Exhibit D:9 Surface and ground water depths recorded at Cowles Bog Wetland Complex November 10, 2003.

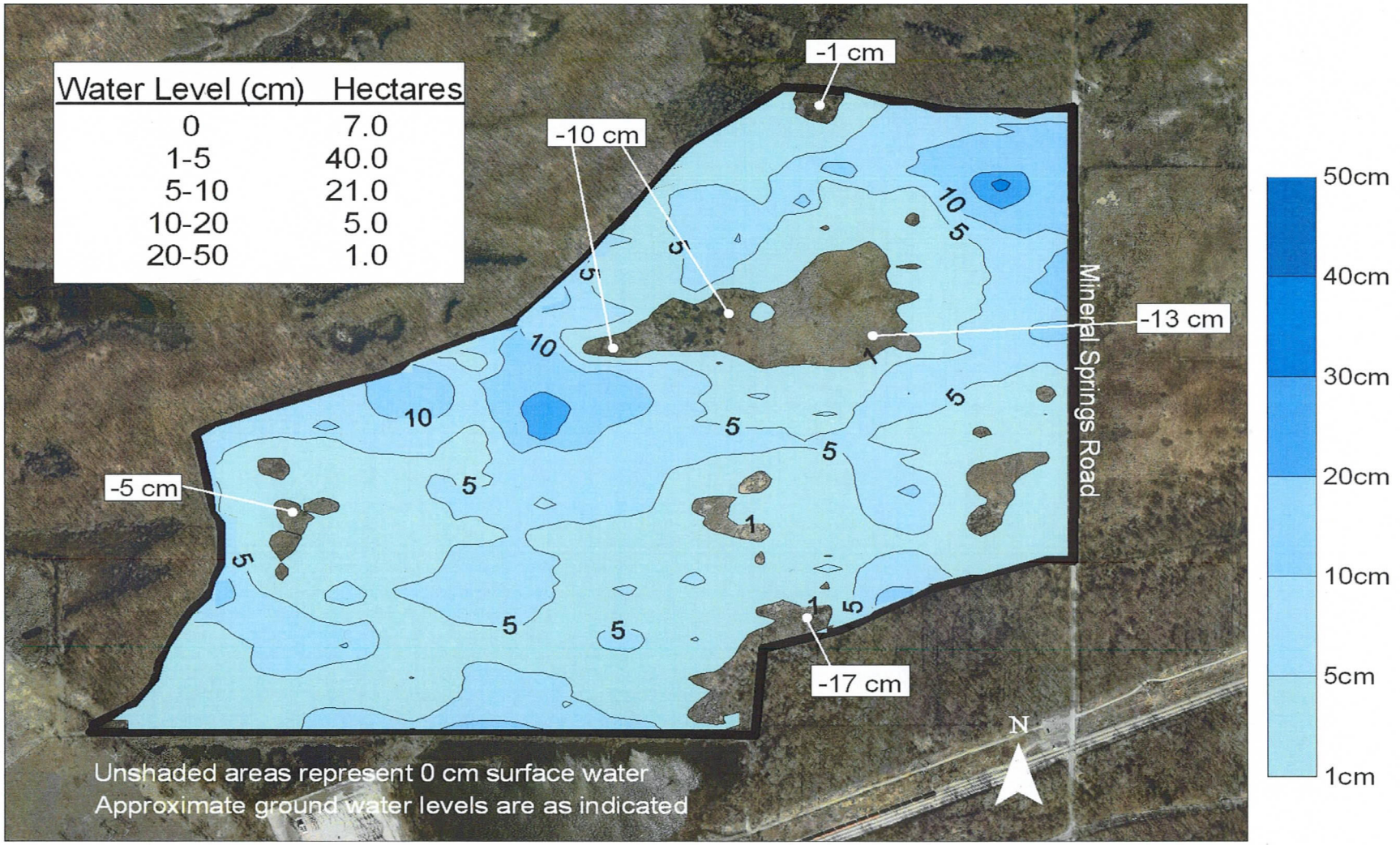
Exhibit D:10 Surface and ground water depths recorded at Cowles Bog Wetland Complex December 9, 2003.



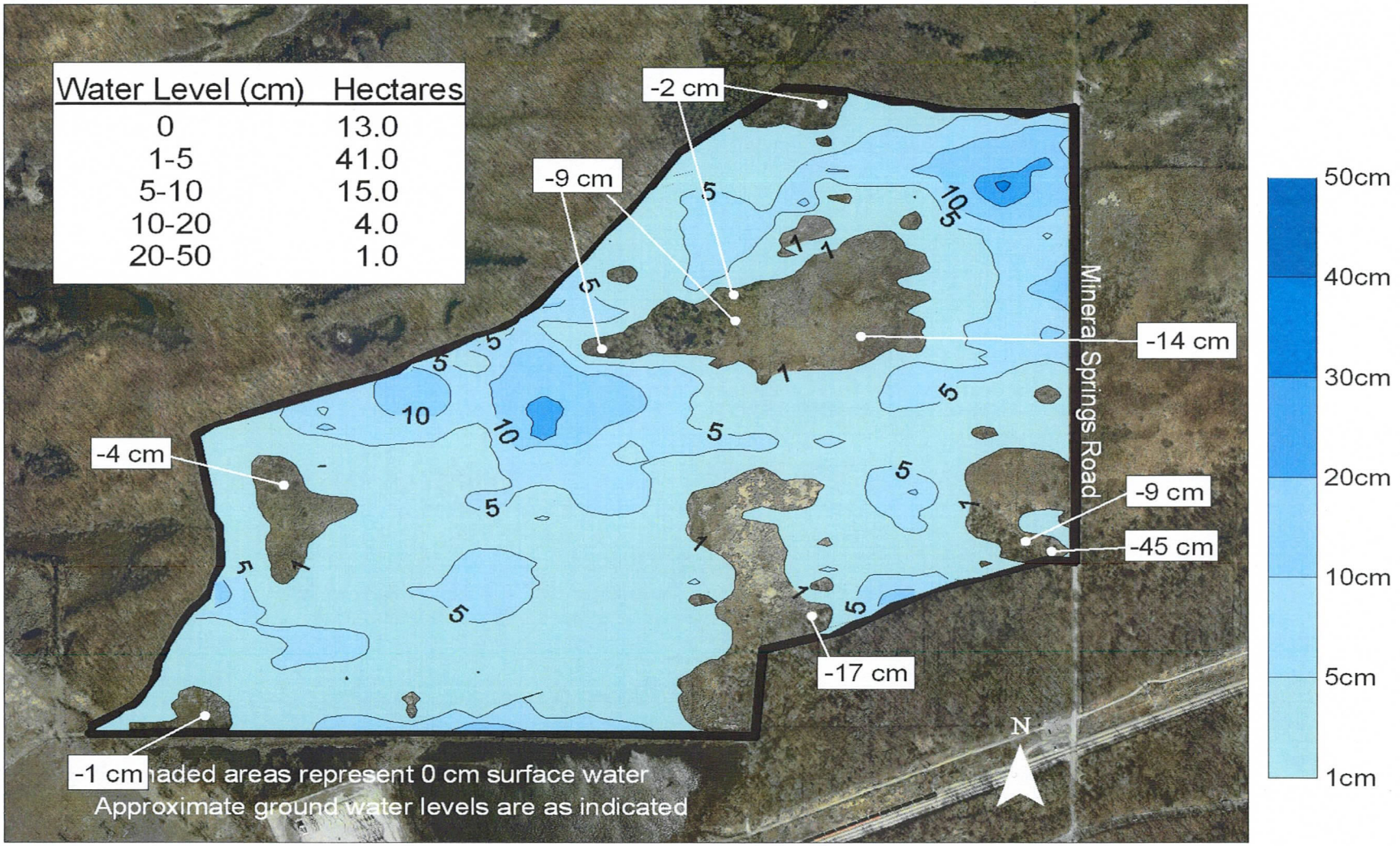
Surface Water Depths (cm)
11 April 2003



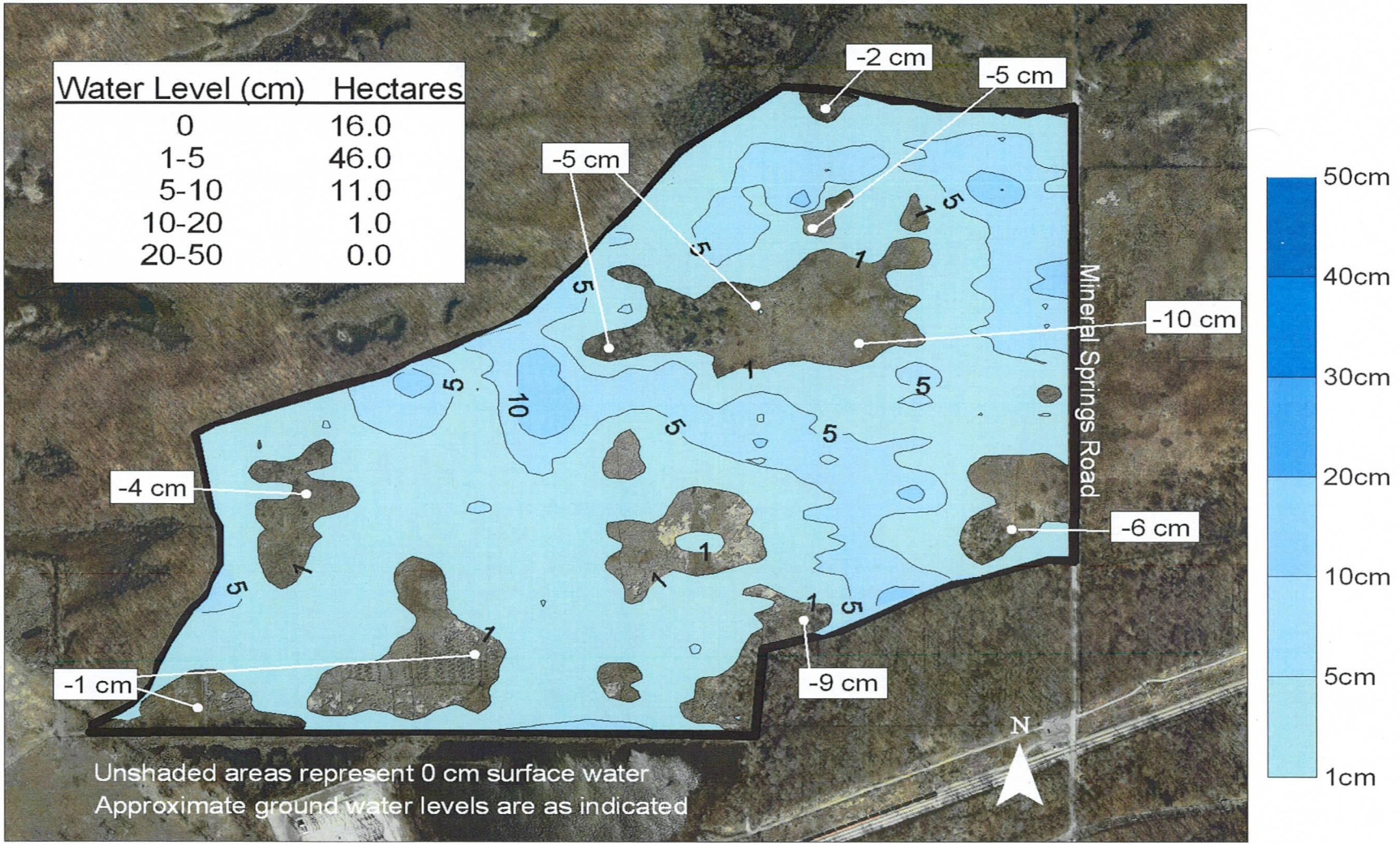
Surface Water Depths (cm)
2 May 2003



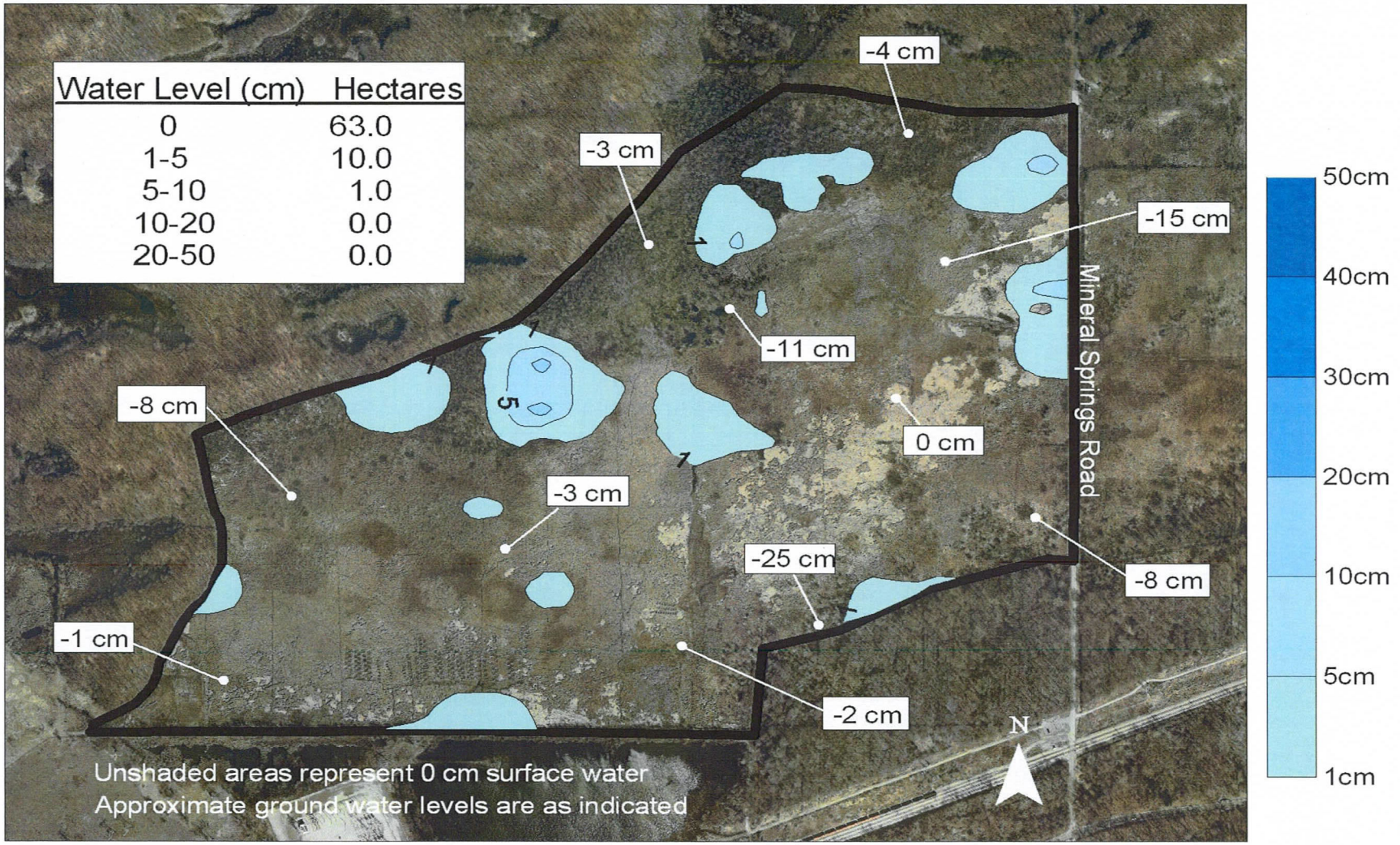
Surface Water Depths (cm)
27 May 2003



Surface Water Depths (cm)
16 June 2003

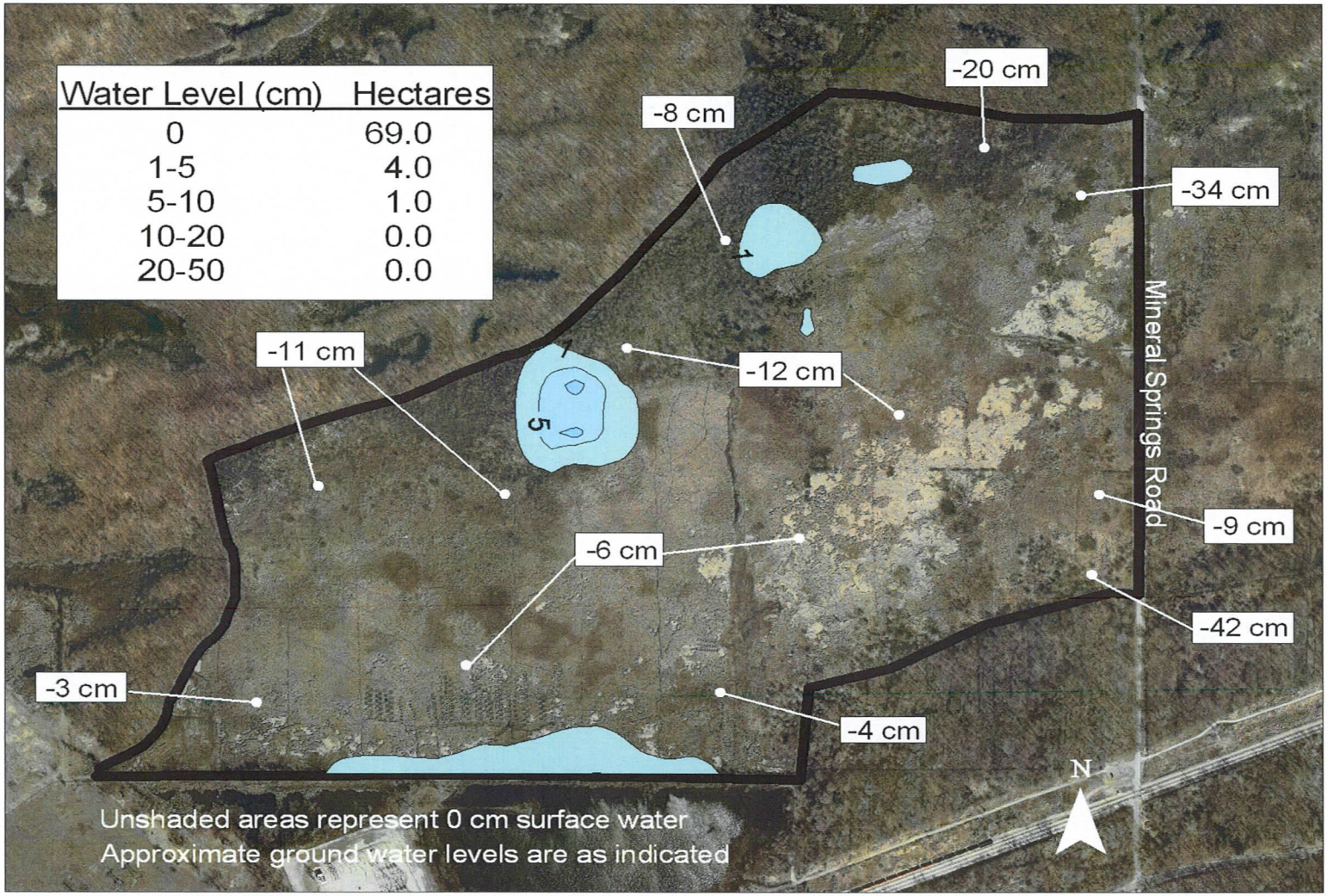


Surface Water Depths (cm)
11 July 2003



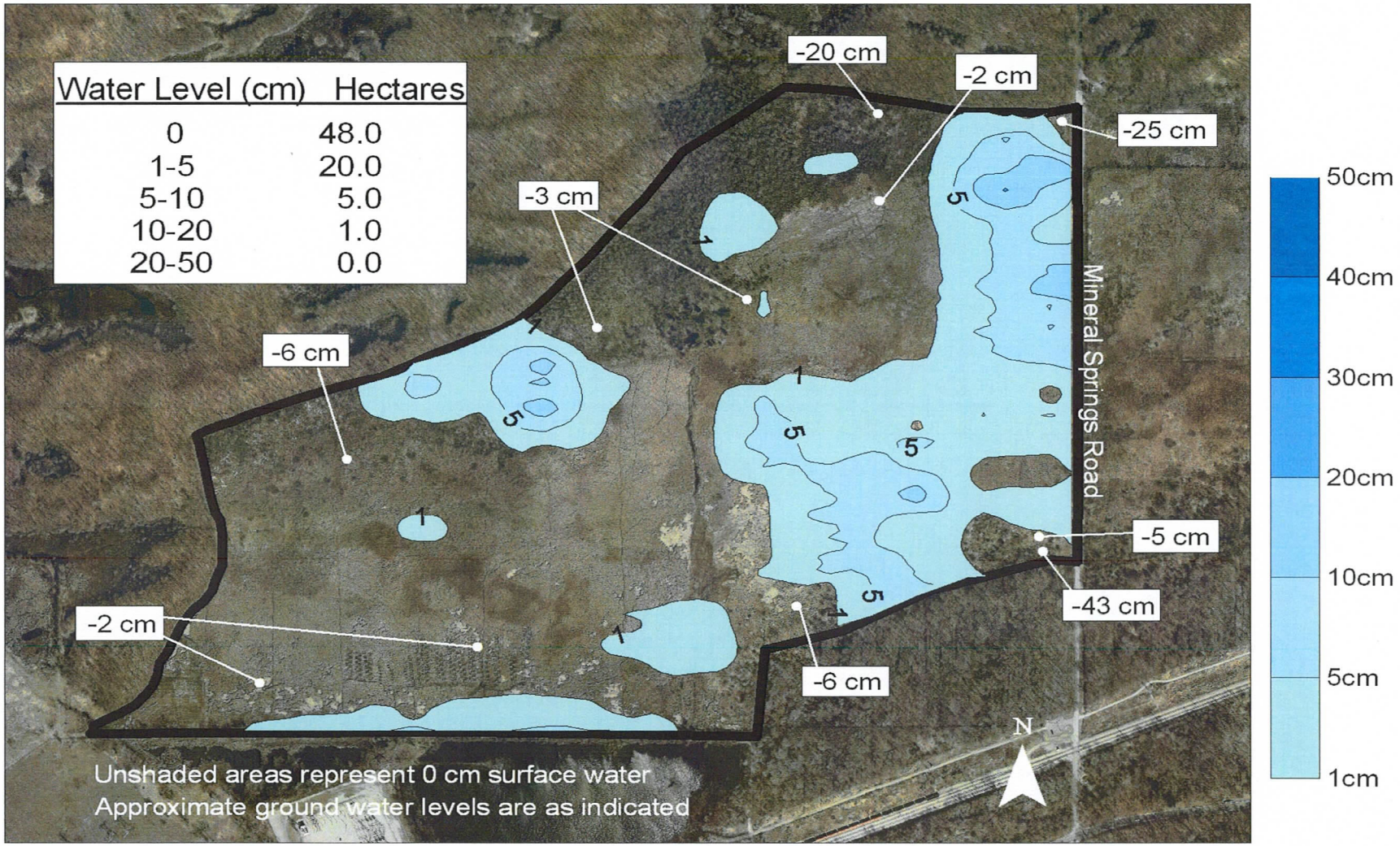
Surface Water Depths (cm)
12 August 2003

0m 250m 500m

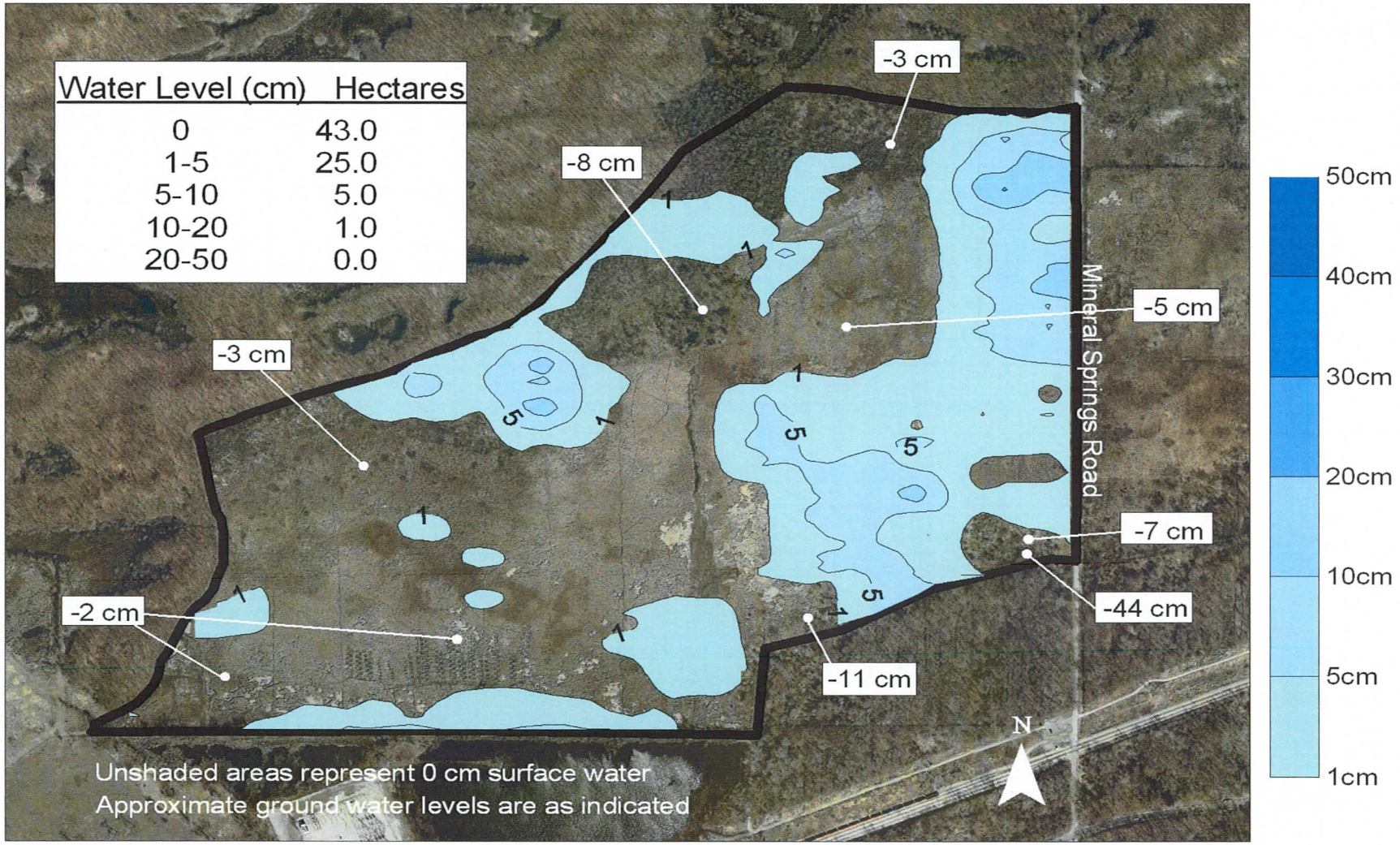


Surface Water Depths (cm)
16 September 2003

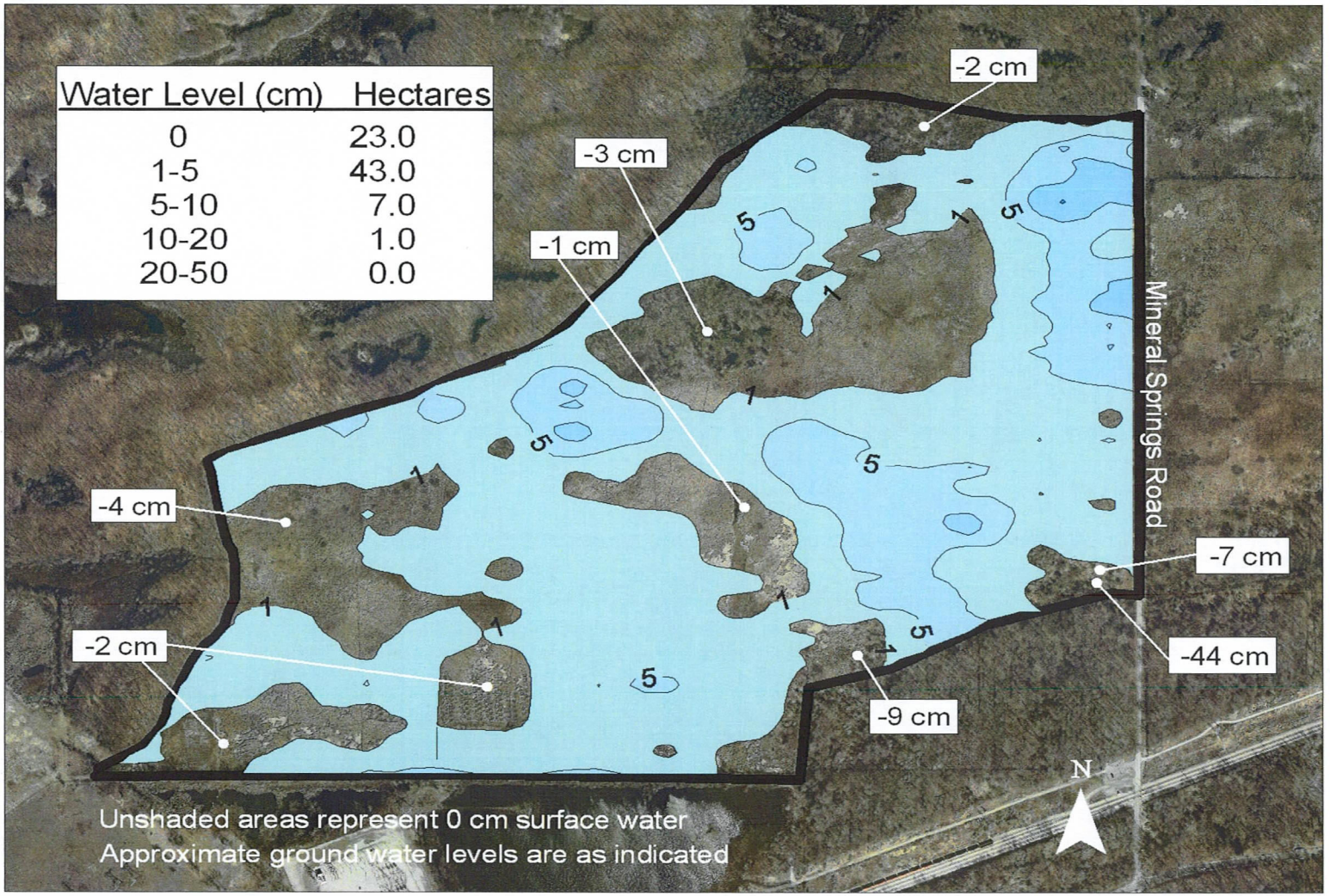
0m 250m 500m



Surface Water Depths (cm)
15 October 2003



Surface Water Depths (cm)
10 November 2003



Surface Water Depths (cm)
9 December 2003

EXHIBITS E:SERIES

Exhibit E:1 Cowles Bog Wetland Complex soil chemistry: Cation exchange capacity (cmol/kg).

Exhibit E:2 Cowles Bog Wetland Complex soil chemistry: Total cations (cmol/kg).

Exhibit E:3 Cowles Bog Wetland Complex soil chemistry: Calcium (cmol/kg).

Exhibit E:4 Cowles Bog Wetland Complex soil chemistry: Magnesium (cmol/kg).

Exhibit E:5 Cowles Bog Wetland Complex soil chemistry: pH.

Exhibit E:6 Cowles Bog Wetland Complex soil chemistry: Hydrogen (% saturation).

Exhibit E:7 Cowles Bog Wetland Complex soil chemistry: Nitrate (ug N/g soil).

Exhibit E:8 Cowles Bog Wetland Complex soil chemistry: Phosphorus (ppb).

Exhibit E:9 Cowles Bog Wetland Complex soil chemistry: Ammonium (ug N/g soil).

Exhibit E:10 Cowles Bog Wetland Complex soil chemistry: Ammonium (mg N/dm^3).

Exhibit E:11 Cowles Bog Wetland Complex soil chemistry: Ammonium (ug N/l).

Exhibit E:12 Cowles Bog Wetland Complex soil chemistry: Nitrate (ug N/l).

Exhibit E:13 Cowles Bog Wetland Complex soil chemistry: Nitrate (mg N/dm^3).

Exhibit E:14 Cowles Bog Wetland Complex soil chemistry: Density (g/cm^3).

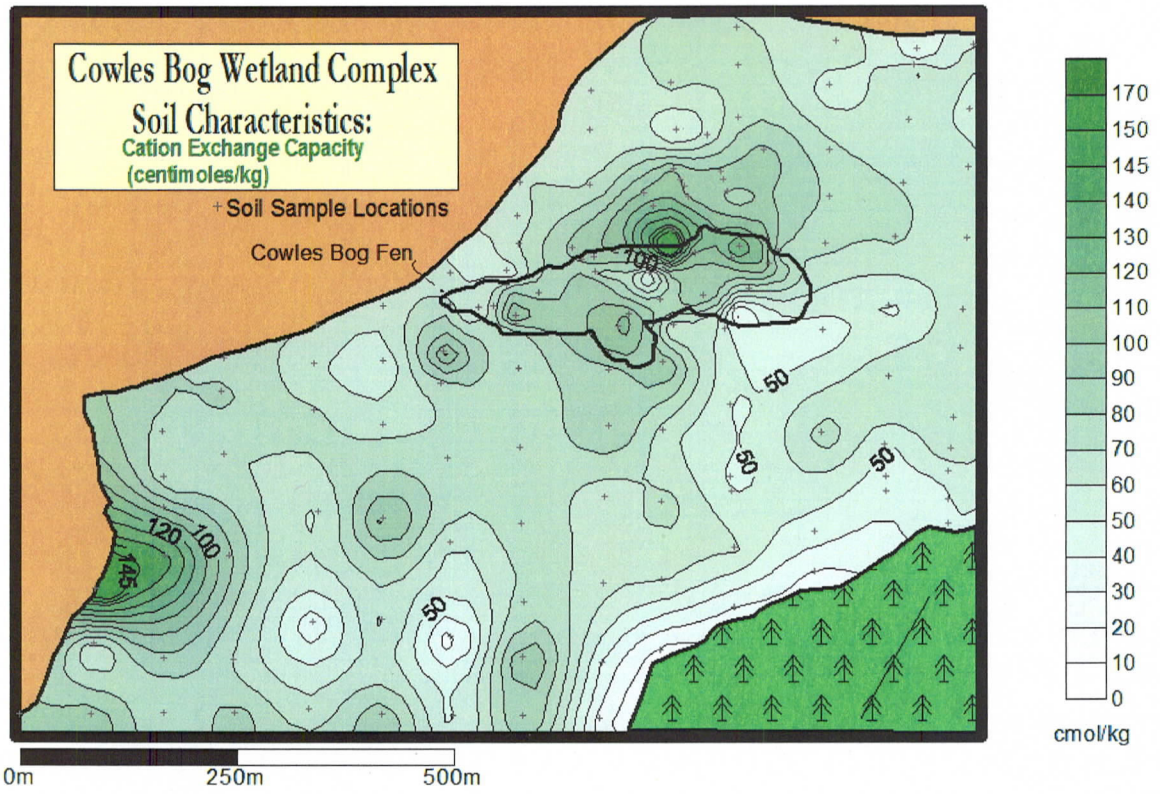
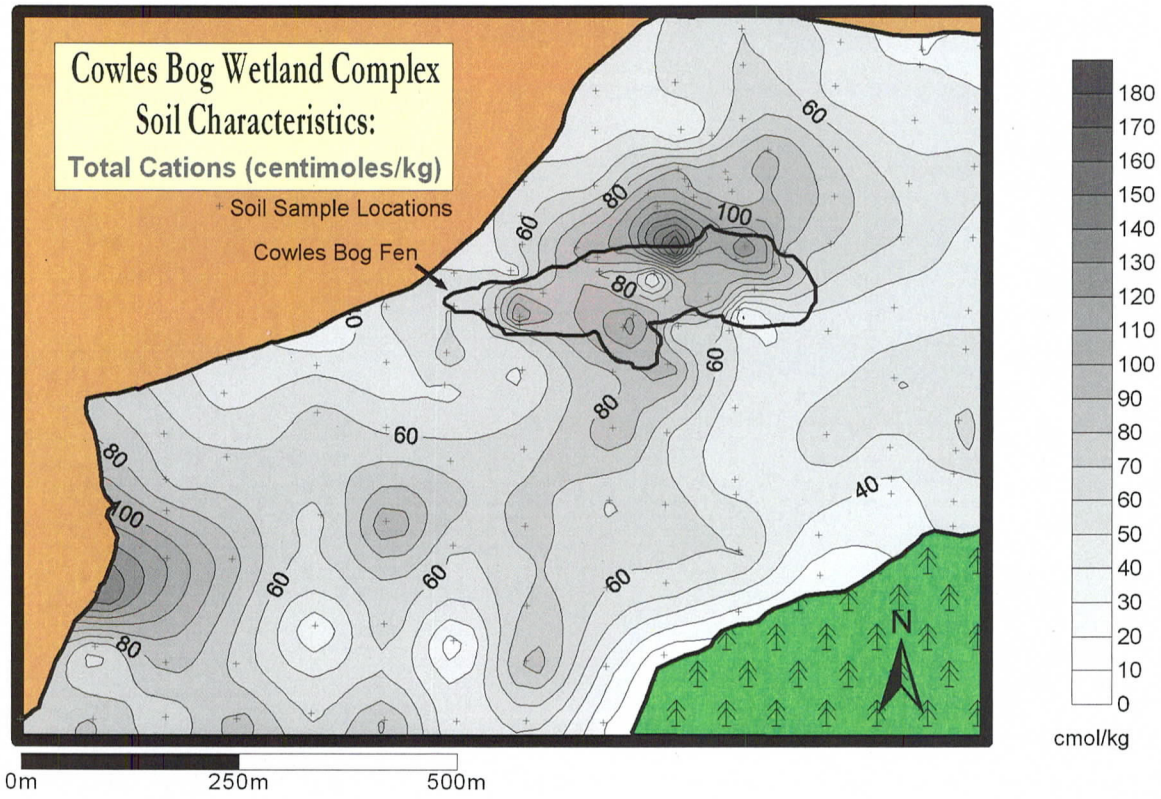


Exhibit E:1 Cation Exchange Capacity

Exhibit E:2 Total Cations



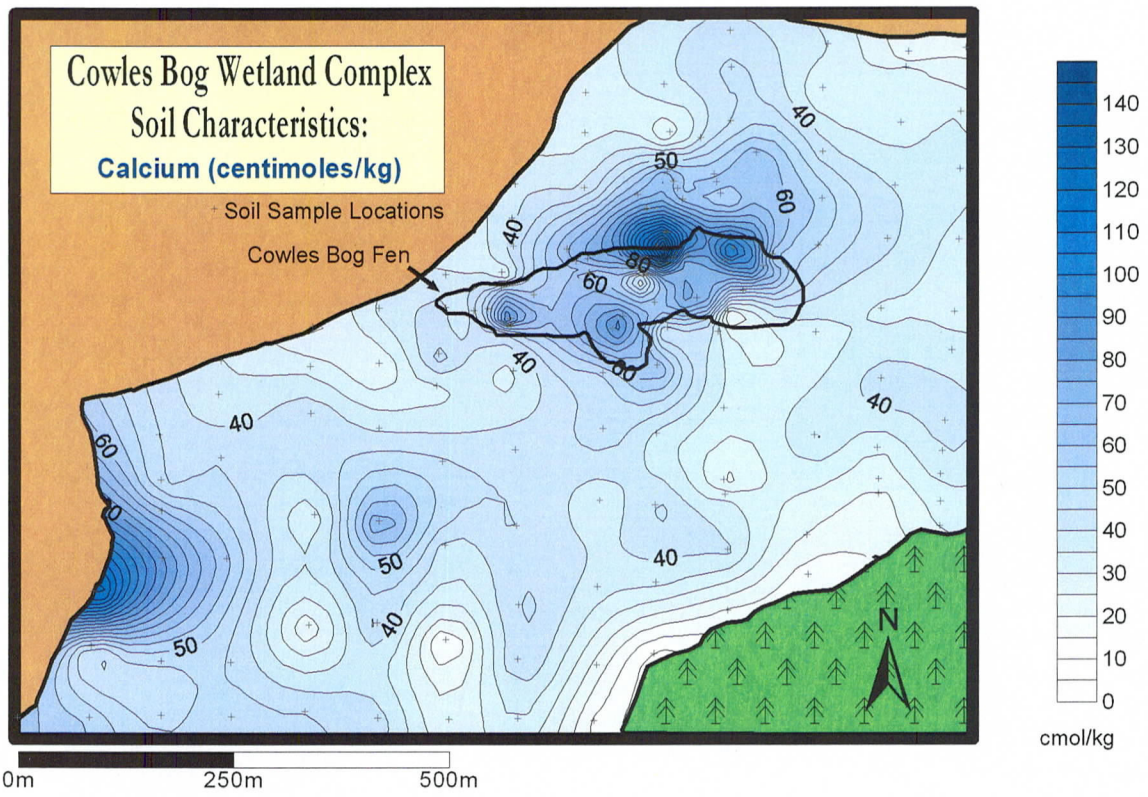
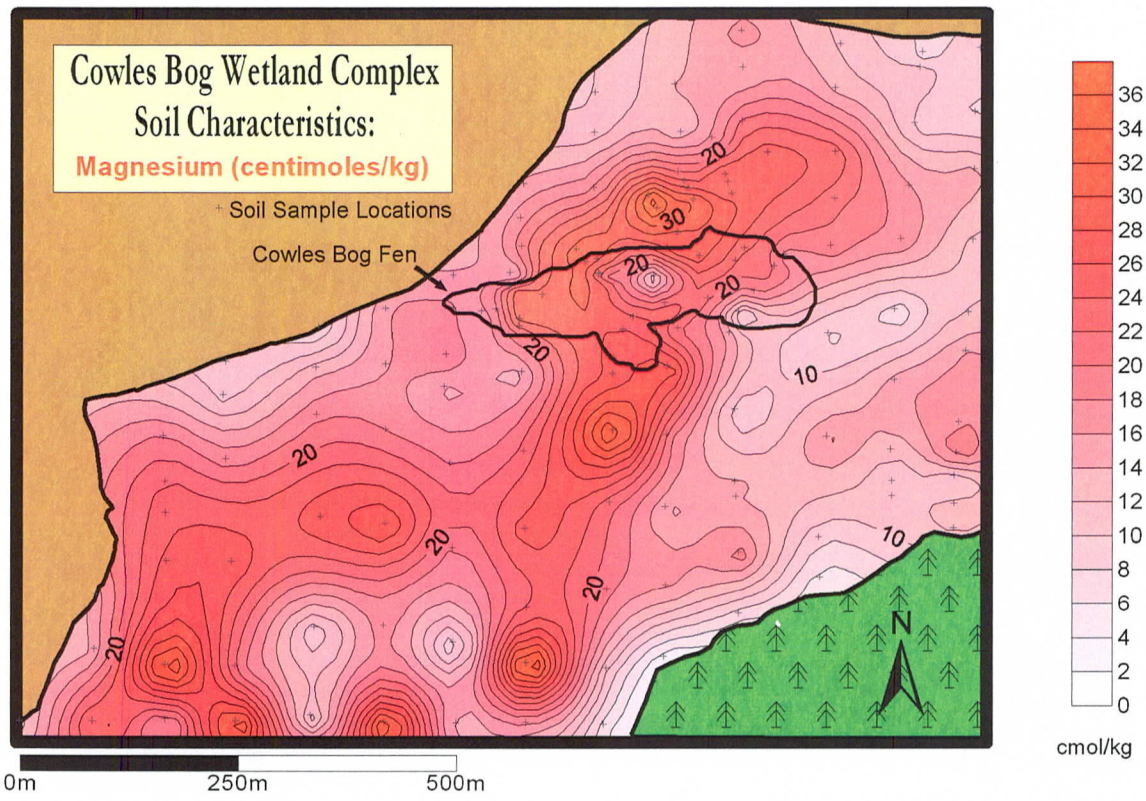


Exhibit E:3 Calcium ↑

Exhibit E:4 Magnesium ↓



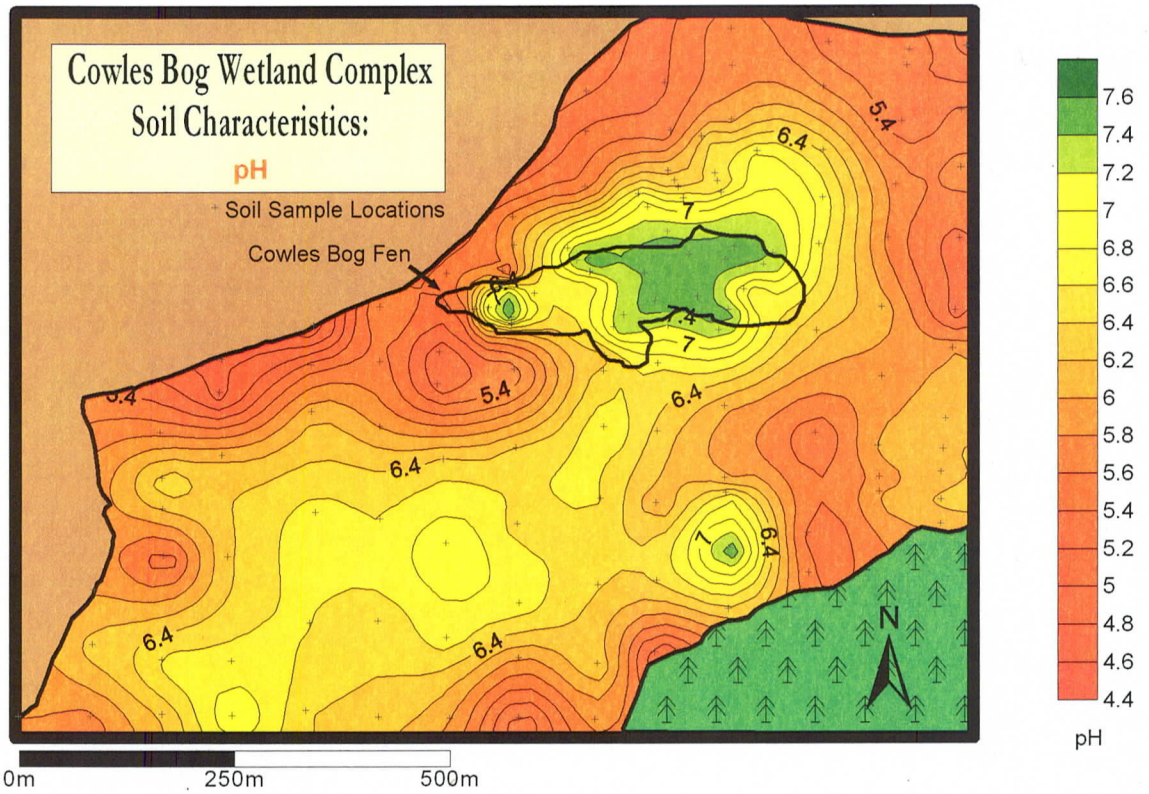
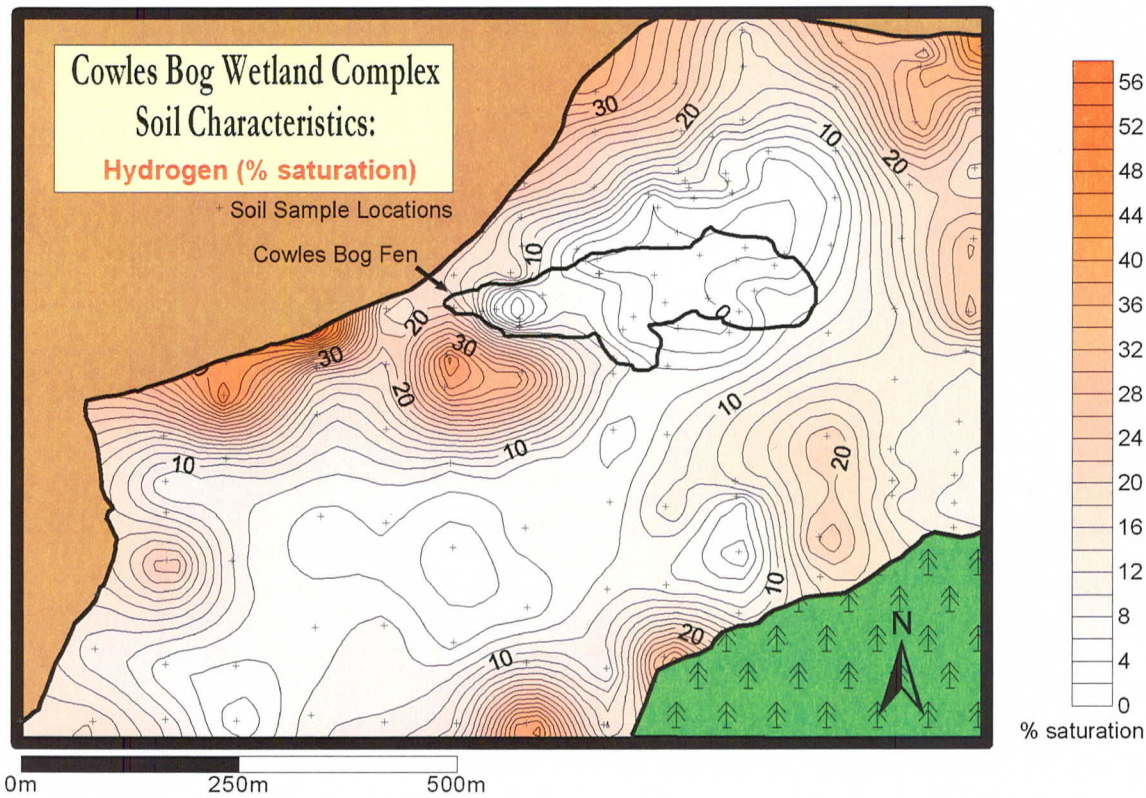


Exhibit E:5 pH ↑

Exhibit E:6 Hydrogen ↓



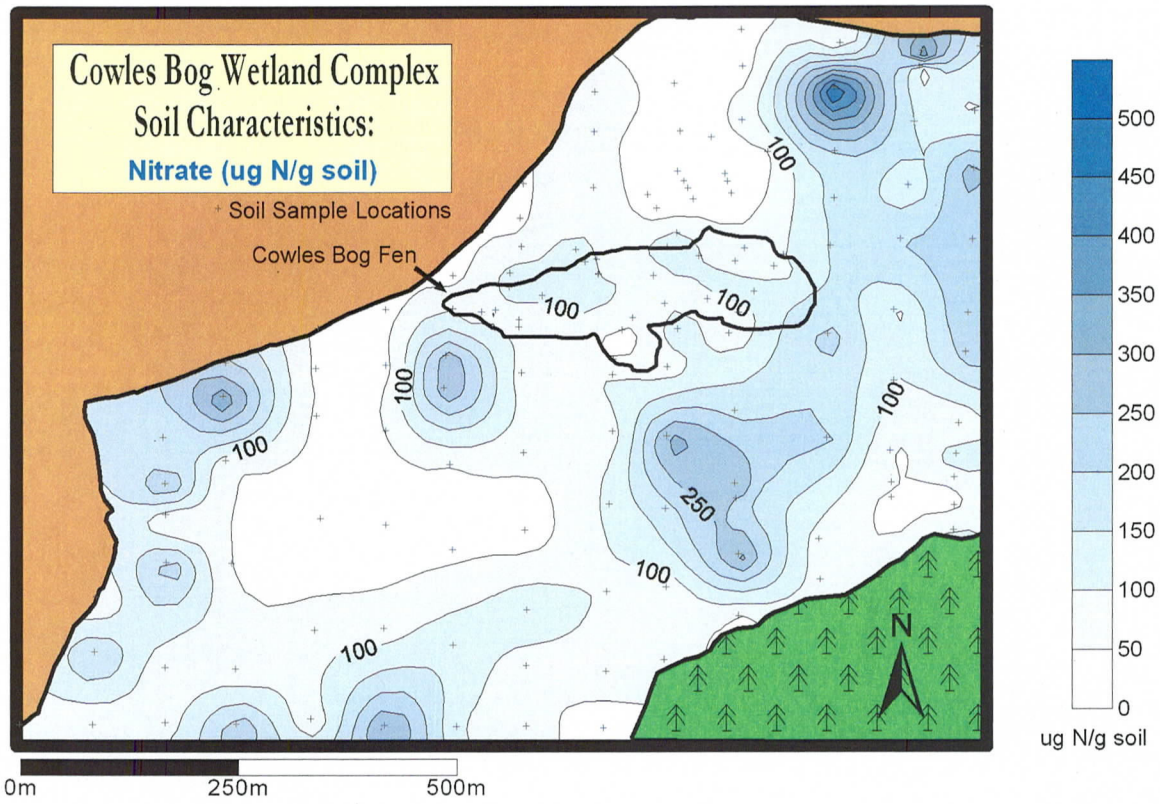
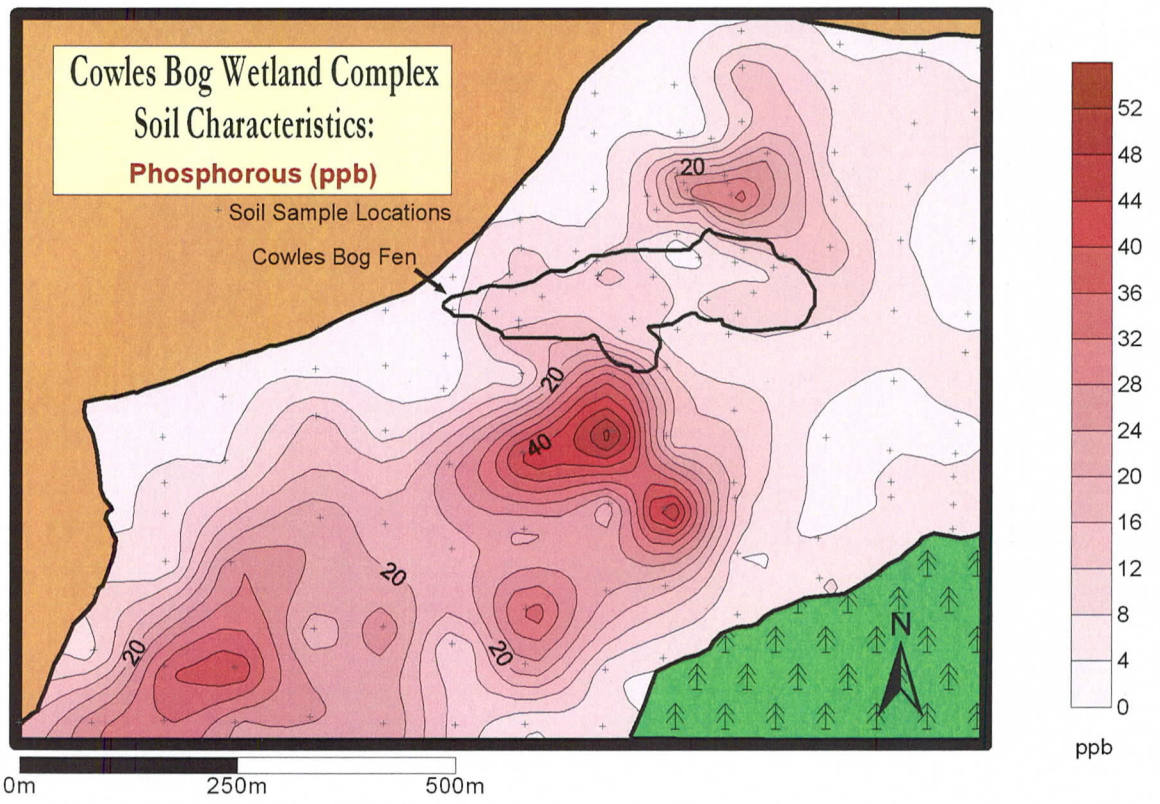


Exhibit E:7 Nitrate ↑

Exhibit E:8 Phosphorus ↓



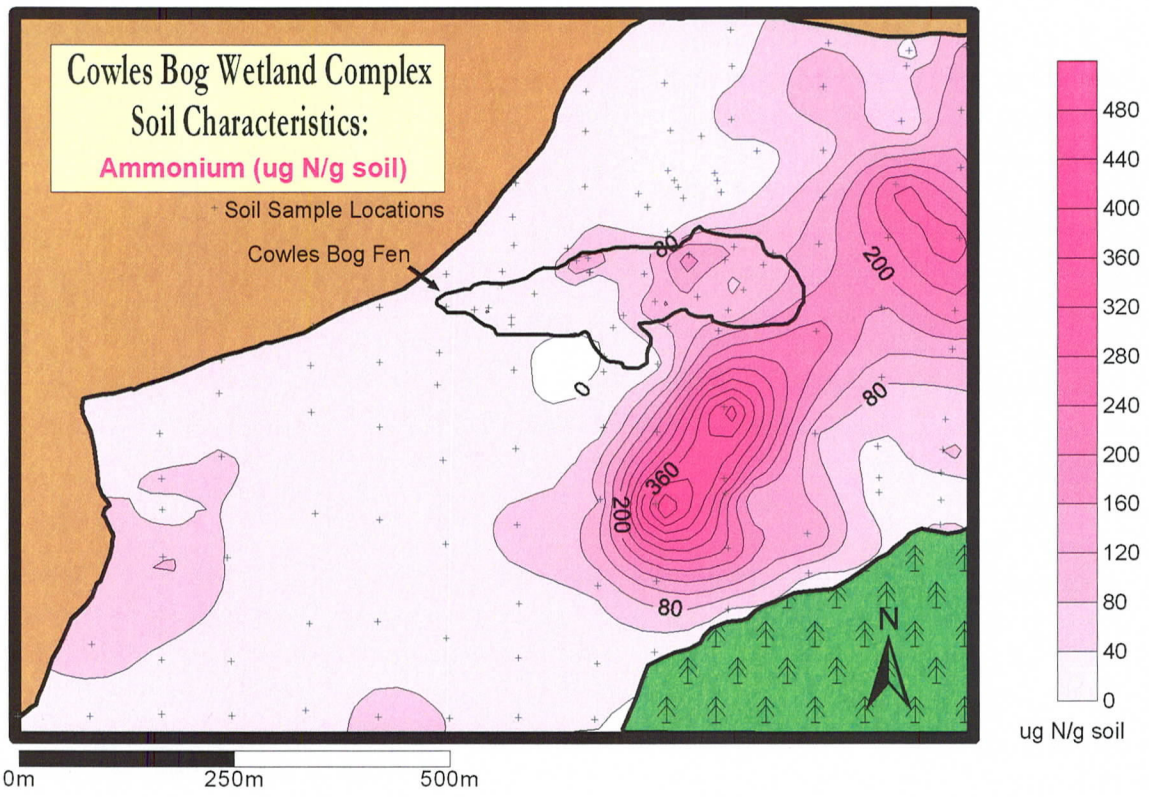
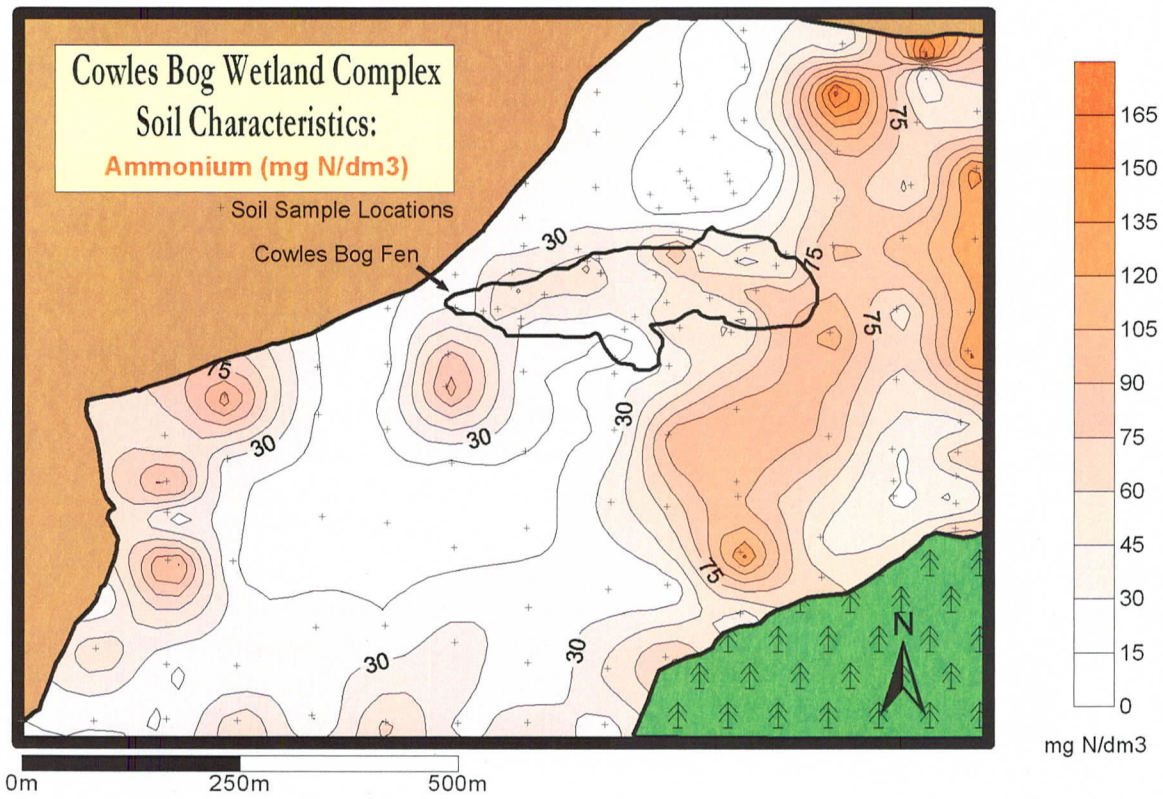


Exhibit E:9 Ammonium (ug N/g soil) **Exhibit 10 Ammonium (mg N/dm3)**



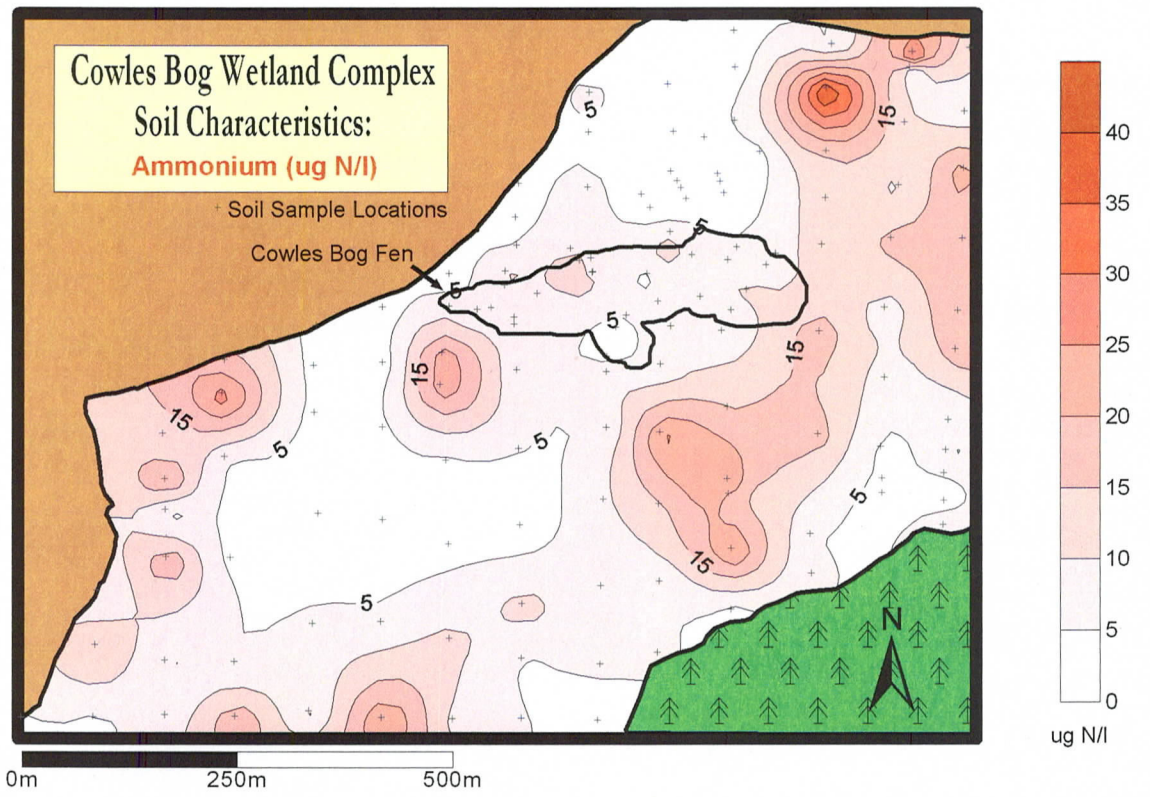
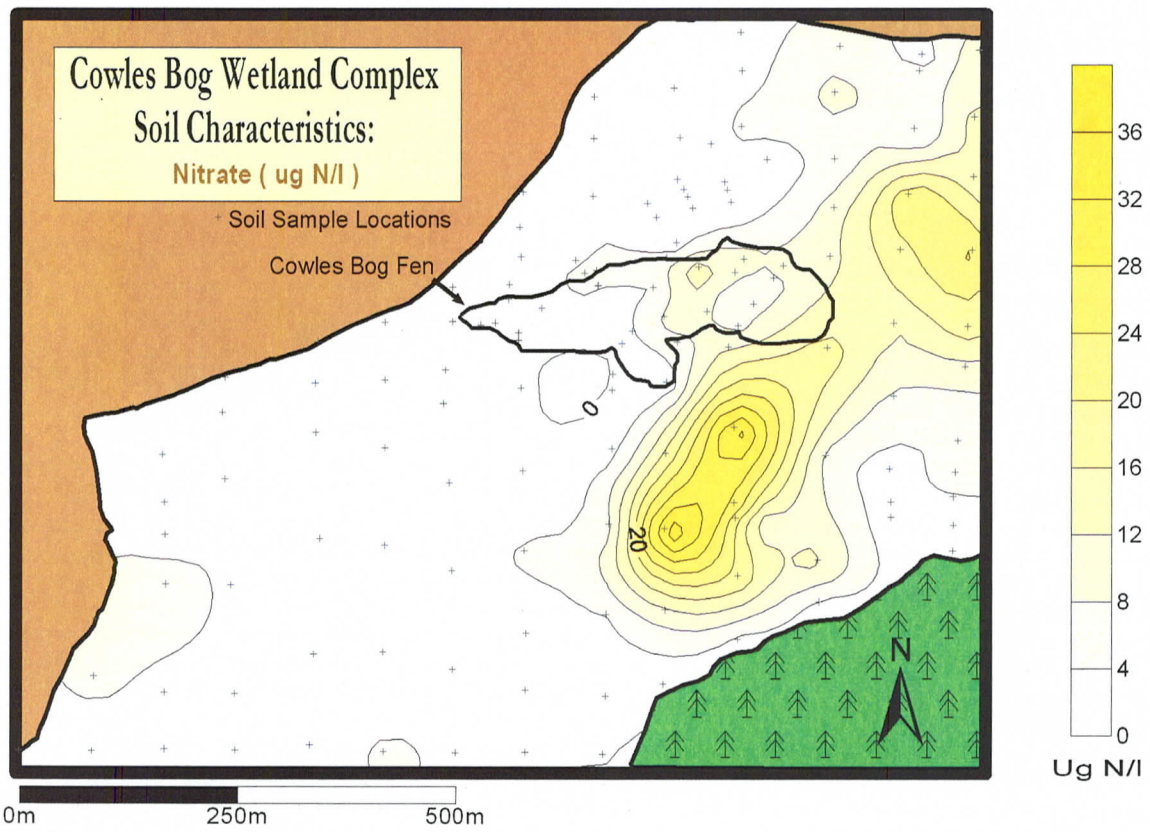


Exhibit E:11 Ammonium (ug N/l)

Exhibit E:12 Nitrate (ug N/l)



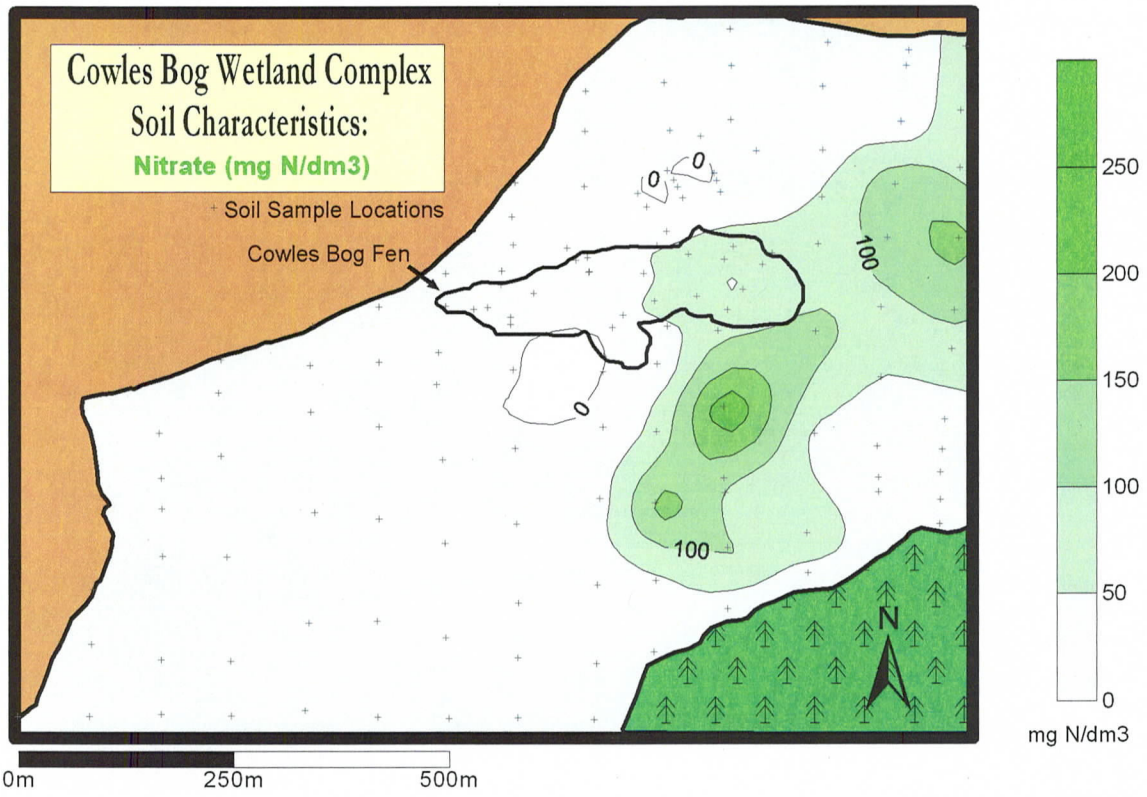


Exhibit 13 Nitrate (mg N/dm3)

Exhibit 14 Density (g/cm3)

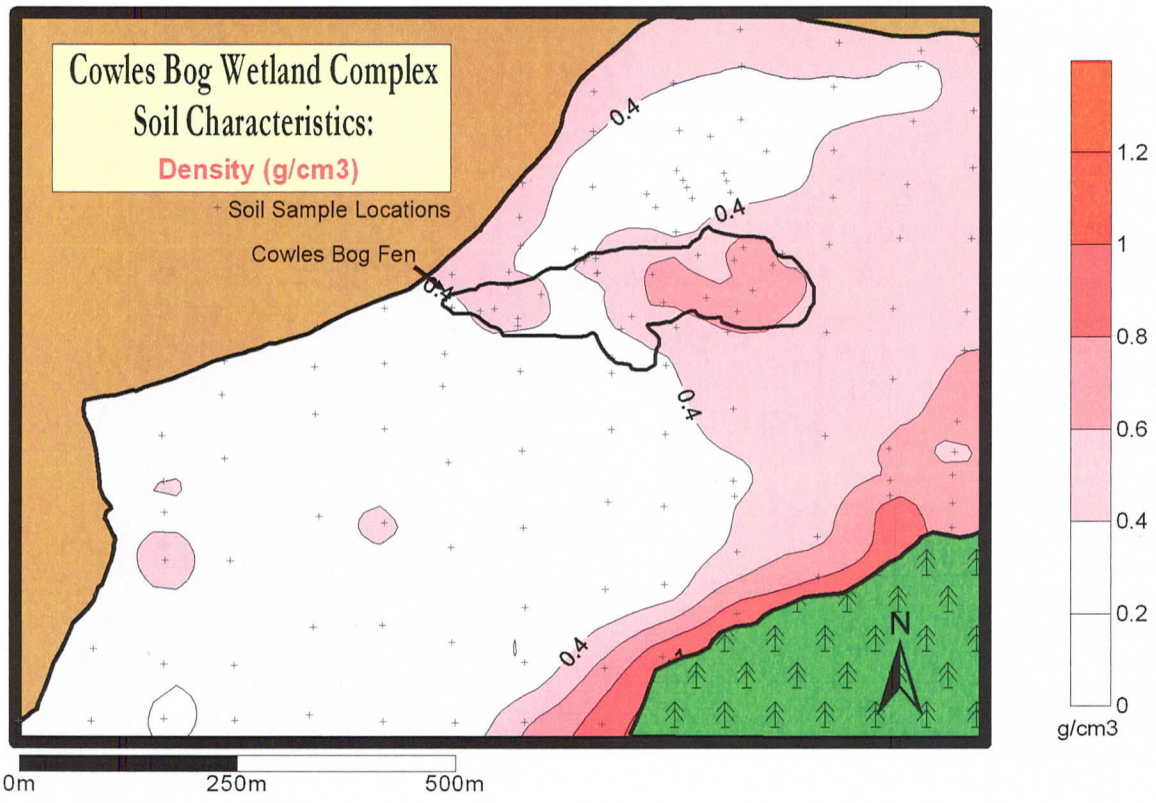


EXHIBIT F:SERIES

Exhibit F:1 Management plots and demonstration planting area in Cowles Bog Wetland Complex.

Exhibit F:1 – Locations of Plots used for Seedbank Response and Herbicide Treatments Experiments and Area Designated for a Visual Presentation of Pre-disturbed Vegetation Structure.

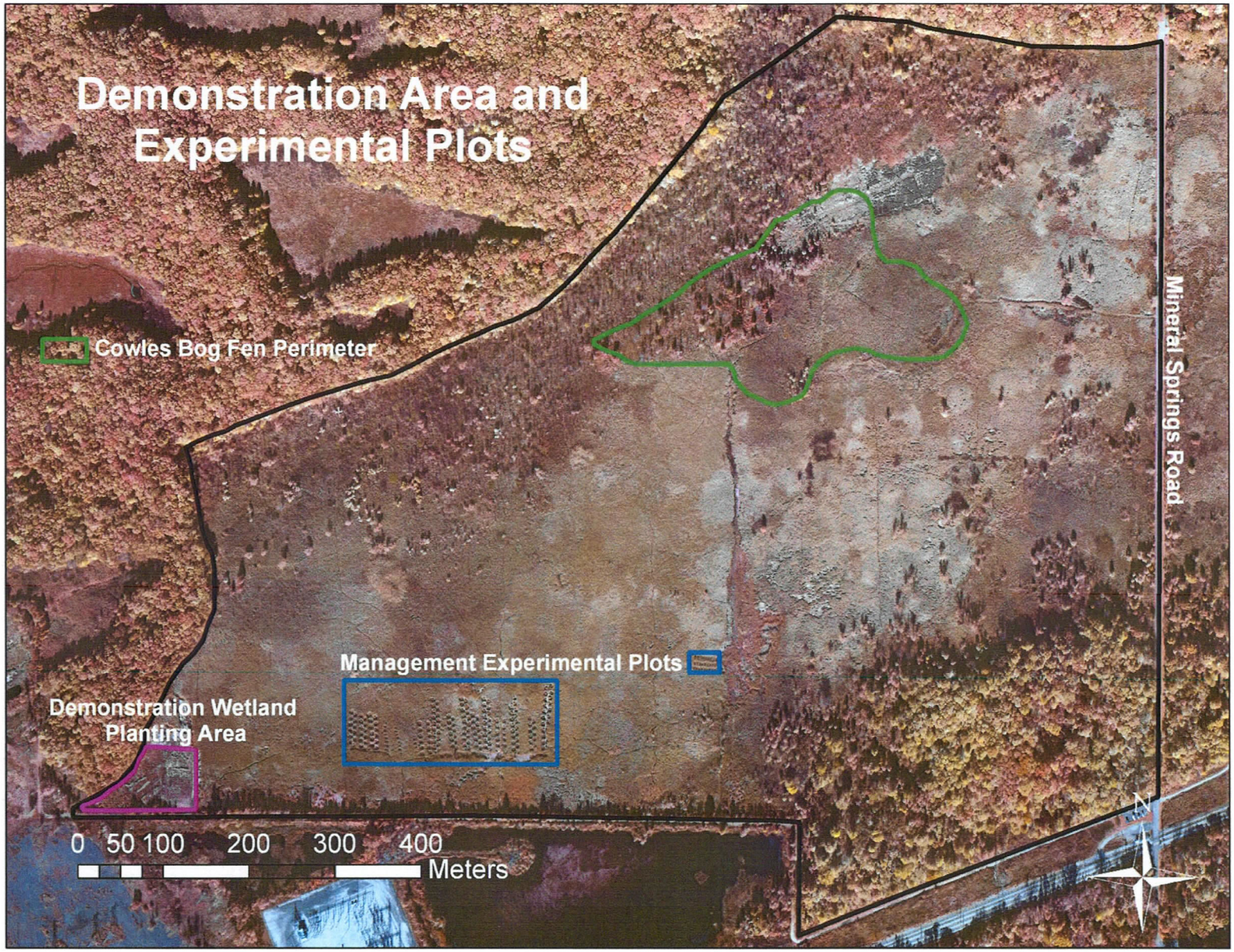
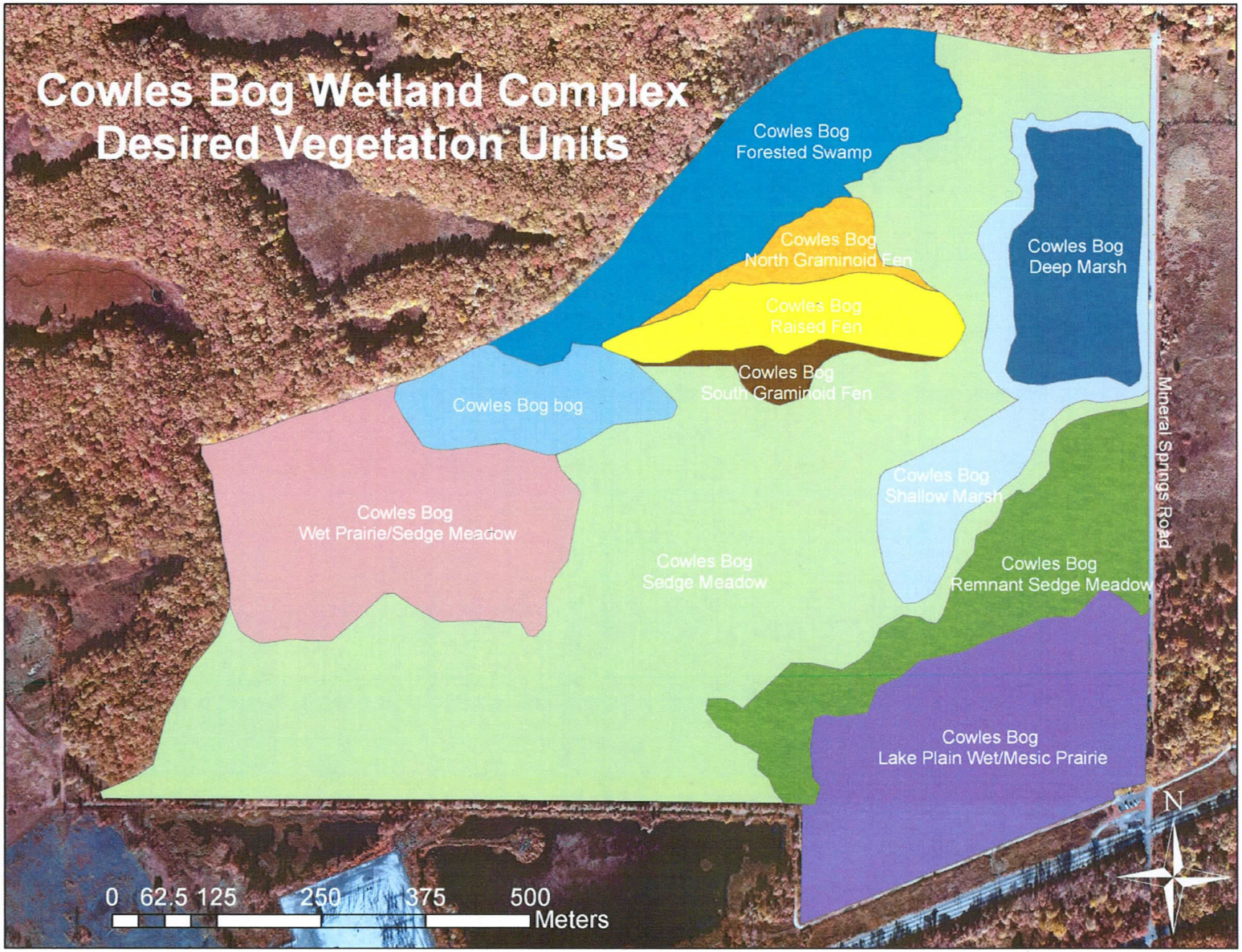


EXHIBIT G:SERIES

Exhibit G:1 Desired vegetation units in Cowles Bog Wetland Complex following restoration.

Exhibit G:1 – Location of Desired Vegetation Units Following Restoration of Cowles Bog Wetland Complex.



Desired Veg. Communities

APPENDIXES SII:B SERIES

Appendix SII:B-1 Species that were observed in Cowles Bog Wetland Complex from 2002-2004.

Appendix SII:B-2 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Total project area.

Appendix SII:B-3 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: West shrub unit.

Appendix SII:B-4 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Forested swamp unit.

Appendix SII:B-5 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: East shrub unit.

Appendix SII:B-6 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Raised fen unit.

Appendix SII:B-7 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: North graminoid fen unit.

Appendix SII:B-8 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: South graminoid fen unit.

Appendix SII:B-9 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Cattail unit.

Appendix SII:B-10 Quantitative assessment of Cowles Bog Wetland Complex's vegetation: Disturbed prairie unit

Appendix SII:B-11 Species that were previously observed in Cowles Bog Wetland Complex, but not observed from 2002-2004.

Appendix SII:B-12 Species that were reported previously in Cowles Bog Wetland Complex, but not observed from 2002-2004.

Appendix SII:B-13 Crosswalk for scientific nomenclature between Integrated Taxonomic Information System and Flora of Chicago.

APPENDIX SII:B-1: SPECIES OBSERVED in COWLES BOG WETLAND COMPLEX; 2002-2004 (WI = wetland indicator; N/A = Native Species versus Non-Native Species; State Status = Status as determine by the State of Indiana in which WL – water list, R – rare, T- threaten, E – endangered.

Scientific Name	Common Name	WI	N/A	State Status	Flowering	Growth Form	Life Cycle	Class
Acer rubrum	red maple	FAC	N		Apr-May	Tree	Perennial	Dicot
Acer saccharinum	silver maple	FACW	N		Mar-Apr	Tree	Perennial	Dicot
Acer saccharum	sugar maple	FACU	N		Apr-May	Tree	Perennial	Dicot
Agrimonia gryposepala	Tall agrimony	FACU+	N		Jun-Sept	Forb	Perennial	Dicot
Agrimonia parviflora	swamp agrimony	FAC+	N		Jul-Sept	Forb	Perennial	Dicot
Agrostis gigantea	redtop	FACW	A		Jun-Sept	Grass	Perennial	Monocot
Agrostis perennans	thin grass	FAC-	N		Jun-Sept	Grass	Perennial	Monocot
Alisma subcordatum	common water plantain	OBL	N		Jun-Sept	Forb	Perennial	Monocot
Alnus incana ssp. rugosa	speckled alder	OBL	N	WL	Mar-Apr	Tree	Perennial	Dicot
Amelianchiar arborea	Serviceberry	FACU	N		Apr	Shrub	Perennial	Dicot
Amphicarpaea bracteata	upland hog peanut	FAC	N		Aug-Sept	Forb	Annual	Dicot
Angelica atropurpurea	great angelica	OBL	N		May-Jun	Forb	Perennial	Dicot
Apios americana	ground nut	FACW	N		Aug-Sept	Vine	Perennial	Dicot
Apocynum sibiricum	Dogbane	FAC+	N		May-Aug	Forb	Perennial	Dicot
Arisaema triphyllum	jack-in-the-pulpit	FACW-	N		Apr-Jul	Forb	Perennial	Monocot
Asclepias incarnata	swamp milkweed	OBL	N		Jun-Aug	Forb	Perennial	Dicot
Aster sagittifolius	arrow-leaved aster	UPL	N		Aug-Sept	Forb	Perennial	Dicot
Berberis thunbergii	japanese barberry	FACU-	A		Apr-May	Forb	Perennial	Dicot
Betula alleghaniensis	yellow birch	FAC	N		Apr-May	Tree	Perennial	Dicot
Betula papyrifera	paper birch	FACU+	N	WL	Apr-May	Tree	Perennial	Dicot
Betula pumila	dwarf birch	OBL	N		May	Shrub	Perennial	Dicot
Bidens cernua	Nodding bur marigold	OBL	N		Jun-Oct	Forb	Annual	Dicot
Bidens connata	purple-stemmed tickseed	OBL	N		Aug-Oct	Forb	Annual	Dicot
Bidens coronata	Tall swamp marigold	OBL	N		Jul-Sept	Forb	Annual	Dicot
Bidens frondosa	Common beggar's ticks	FACW	N		Aug-Oct	Forb	Annual	Dicot
Bidens tripartite	swamp tickseed	FACW+	N		Sept	Forb	Annual	Dicot
Boehmeria cylindrica	False nettle	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Botrychium dissectum	Cut-leaved grape fern	FAC	N		Sept-Oct	Fern	Perennial	Filicinae
Bromus ciliatus	Fringed brome	FACW	N		Jun-Jul	Grass	Perennial	Monocot
Calamagrostis canadensis	Blue joint grass	OBL	N		Jun	Grass	Perennial	Monocot

Appexdix SII:B-1 continued								
Caltha palustris	Marsh marigold	OBL	N		Apr-Jun	Forb	Perennial	Dicot
Campanula aparinoides	Marsh bellflower	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Cardamine bulbosa	Bulbous cress	OBL	N		Apr-Jun	Forb	Perennial	Dicot
Cardamine pennsylvanica	Pennsylvania bitter cress	FACW+	N		May- Oct	Forb	Annual,	Dicot
Carex alata	Winged oval sedge	OBL	N	WL	Jun	Sedge	Perennial	Monocot
Carex annectens	Large yellow fox sedge	FACW	N		Jun	Sedge	Perennial	Monocot
Carex aquatilis	Long-bracted tussock sedge	OBL	N		Apr-Jun	Sedge	Perennial	Monocot
Carex atherodes	Hairy-leaved lake sedge	OBL	N	E	May -Jun	Sedge	Perennial	Monocot
Carex blanda	Common wood sedge	FAC	N		Apr-Jun	Sedge	Perennial	Monocot
Carex bromoides	Brome hummock sedge	FACW+	N		Apr-May	Sedge	Perennial	Monocot
Carex comosa	Bristly sedge	OBL	N		Jun	Sedge	Perennial	Monocot
Carex crinita	Fringed sedge	FACW+	N		May	Sedge	Perennial	Monocot
Carex cristatella	Crested oval sedge	FACW+	N		May-Jun	Sedge	Perennial	Monocot
Carex echinata	Large -fruited star sedge	OBL	N	E	Jun	Sedge	Perennial	Monocot
Carex howei	Atlantic star sedge	OBL	N		Jun-Aug	Sedge	Perennial	Monocot
Carex hystericina	Porcupine sedge	OBL	N		May-Jun	Sedge	Perennial	Monocot
Carex interior	Prairie star sedge	OBL	N		May	Sedge	Perennial	Monocot
Carex intumescens	Shining bur sedge	FACW+	N		May-Jun	Sedge	Perennial	Monocot
Carex lacustris	Common lake sedge	OBL	N		May-Jun	Sedge	Perennial	Monocot
Carex lasiocarpa	Narrow-leaved woolly sedge	OBL	N		May	Sedge	Perennial	Monocot
Carex leptalea	Slender sedge	OBL	N	WL	May	Sedge	Perennial	Monocot
Carex limosa	Muck sedge	OBL	N	E	May	Sedge	Perennial	Monocot
Carex lupulina	Common hop sedge	OBL	N		Jul	Sedge	Perennial	Monocot
Carex lurida	Bottlebrush sedge	OBL	N		May- Jun	Sedge	Perennial	Monocot
Carex pellita	Broad-leaved woolly sedge	OBL	N		Apr-Jun	Sedge	Perennial	Monocot
Carex projecta	Loose-headed oval sedge	FACW+	N		Jun-Jul	Sedge	Perennial	Monocot
Carex radiata	Straight-styled wood sedge	NI	N		Apr-May	Sedge	Perennial	Monocot
Carex rosea	Curly-styled wood sedge	UPL	N		Apr-Jun	Sedge	Perennial	Monocot
Carex sartwellii	Running marsh sedge	FACW+	N		Apr-May	Sedge	Perennial	Monocot
Carex scoparia	Lance-fruited oval sedge	FACW	N		Jun	Sedge	Perennial	Monocot
Carex seorsa	Swamp star sedge	FACW+	N	R	Jun	Sedge	Perennial	Monocot
Carex squarrosa	Narrow-leaved cattail	OBL	N		May- Jun	Sedge	Perennial	Monocot
Carex stipata	Common fox sedge	OBL	N		Apr-May	Sedge	Perennial	Monocot

Appexdix SII:B-1 continued								
Carex stricta	Common tussock sedge	OBL	N		Apr-Jun	Sedge	Perennial	Monocot
Carex swanii	Downy green sedge	FACU	N		May- Jun	Sedge	Perennial	Monocot
Carex tenera	Narrow-leaved oval sedge	FAC+	N		May- Jun	Sedge	Perennial	Monocot
Carex tribuloides	Awl-fruited oval sedge	FACW+	N		May-Jul	Sedge	Perennial	Monocot
Carex utriculata	Common yellow lake sedge	OBL	N		May- Jun	Sedge	Perennial	Monocot
Carex vulpinoidea	Brown fox sedge	OBL	N		Jun	Sedge	Perennial	Monocot
Catalpa speciosa	Hardy catalpa	FACU	A		May-Jul	Tree	Perennial	Dicot
Celastrus orbiculatus	Oriental bittersweet	UPL	A		Jun	Shrub	Perennial	Dicot
Cephalanthus occidentalis	Buttonbush	OBL	N		Jul-Aug	Shrub	Perennial	Dicot
Chelone glabra	Turtlehead	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Cicuta bulbifera	Bulblet-bearing water hemlock	OBL	N		Jul-Aug	Forb	Perennial	Dicot
Cinna arundinacea	Common wood reed	FACW	N		Aug-Sept	Grass	Perennial	Monocot
Circaea lutetiana	Enchanter's nightshade	FACU	N		Jun-Aug	Forb	Perennial	Dicot
Cirsium arvense	Field thistle, Canada	UPL	A		Jun-Oct	Forb	Perennial	Dicot
Cirsium muticum	Swamp thistle	OBL	N		Aug-Oct	Forb	Biennial	Dicot
Clematis virginiana	Virgin's bower	FAC	N		Jul-Sept	Vine	Perennial	Dicot
Comarum palustris	Marsh cinquefoil	OBL	N		Jun	Forb	Perennial	Dicot
Convolvulus arvensis	Field bindweed	UPL	A		Jun-Sep	Vine	Perennial	Dicot
Convolvulus sepium	Hedge bindweed	FAC	N		Jun-Sep	Forb	Perennial	Dicot
Coptis trifolia	Goldthread	FACW	N	WL	Apr-May	Forb	Perennial	Dicot
Corallorhiza maculata	Spotted coral root	FACU-	N		Jul-Aug	Forb	Perennial	Monocot
Cornus florida	flowering dogwood	FACU-	N		Apr-Jun	Shrub	Perennial	Dicot
Cornus obliqua	Silky dogwood	FACW+	N		May-Jul	Tree	Perennial	Dicot
Cornus racemosa	Gray dogwood	FACW-	N		Jun-Jul	Shrub	Perennial	Dicot
Cornus sericea	Red-osier dogwood	FACW	N		May- Jun	Shrub	Perennial	Dicot
Cryptotaenia canadensis	Honewort	FAC	N		Jun-Sep	Forb	Perennial	Dicot
Cuscuta gronovii	Common dodder	NI	N		Jul-Sept	Vine	Perennial	Dicot
Cypripedium acaule	Moccasin Flower	FACW	N	WL	May- Jun	Forb	Perennial	Monocot
Decodon verticillatus	Swamp loosestrife	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Dichanthelium clandestinum	Deer-tongue grass	FACW	N		Jun -Jul	Grass	Perennial	Monocot
Doellingeria umbellata	flat-top aster	FACW	N		Aug -Sept	Forb	Perennial	Dicot
Dryopteris carthusiana	Spinulose shield fern	FACW-	N		May-Nov	Fern	Perennial	Filicinae
Dryopteris cristata	Crested wood fern	OBL	N		May-Nov	Fern	Perennial	Filicinae

Appexdix SII:B-1continued								
Dryopteris noveboracensis	New York fern	FAC+	N		Jul–Nov	Fern	Perennial	Filicinae
Echinochloa crusgalli	Barnyard grass	FACW	N		Jul-Sept	Grass	Annual	Monocot
Elaeagnus umbellata	Autumn olive	UPL	A		May-Jun	Shrub	Perennial	Dicot
Eleocharis erythropoda	Red-rooted spike rush	OBL	N		May- Jun	Rush	Perennial	Dicot
Eleocharis palustris	Great spike rush	OBL	N		Jul	Rush	Perennial	Dicot
Eleocharis rostellata	Wicket spike rush	OBL	N		Jun	Rush	Perennial	Dicot
Epilobium coloratum	Cinnamon willow	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Epilobium leptophyllum	Fen willow herb	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Epipactis helleborine	Helleborine orchid	UPL	A		Jul	Forb	Perennial	Monocot
Equisetum arvense	Horsetail	FAC	N		Apr-May	Fern-Ally	Perennial	Equisetinae
Erechtites hieracifolia	Fireweed	FACU	N		Aug-Oct	Forb	Annual	Dicot
Erigeron philadelphicus	Marsh fleabane	FACW	N		May-Jul	Forb	Biennial	Dicot
Eupatorium maculatum	Spotted joe pye weed	OBL	N		Jun-Sept	Forb	Perennial	Dicot
Eupatorium perfoliatum	Common boneset	FACW+	N		Jul-Sept	Forb	Perennial	Dicot
Euthamia graminifolia v nuttallii	Hairy grass-leaved goldenrod	FACW-	N		Jul-Sept	Forb	Perennial	Dicot
Euthamia gymnospermoides	grass-leaved goldenrod	FACW-	N		Aug-Oct	Forb	Perennial	Dicot
Fragaria virginiana	Wild strawberry	FAC-	N		Apr-Jun	Forb	Perennial	Dicot
Fraxinus americana	White ash	FACW	N		Apr-May	Tree	Perennial	Dicot
Fraxinus nigra	Black ash	FACW+	N		Apr-May	Tree	Perennial	Dicot
Fraxinus pennsylvanica var sub.	Green ash	FAC	N		Apr-May	Tree	Perennial	Dicot
Fraxinus pensylvanica	Red ash	FACW	N		Apr-May	Tree	Perennial	Dicot
Galium aparine	Annual bedstraw	FACU	N		Apr-Jun	Forb	Annual	Dicot
Galium labradoricum	Bog bedstraw	OBL	N		May	Forb	Perennial	Dicot
Galium obtusum	Wild madder	FACW+	N		Jun- Aug	Forb	Perennial	Dicot
Galium tinctorium	Stiff bedstraw	OBL	N		Jun- Sept	Forb	Perennial	Dicot
Galium trifidum	Small bedstraw	FACW+	N		Jun- Sept	Forb	Perennial	Dicot
Galium triflorum	Sweet-scented bedstraw	FACU+	N		Jun- Sept	Forb	Perennial	Dicot
Geum canadense	White avens	FAC	N		Jun- Aug	Forb	Perennial	Dicot
Geum laciniatum	Northern rough avens	FACW	N		Jun-Jul	Forb	Perennial	Dicot
Glyceria canadensis	Rattlesnake grass	OBL	N			Grass	Perennial	Monocot
Glyceria striata	Fowl meadow grass	OBL	N		May- Jun	Grass	Perennial	Monocot
Helianthus grosseserratus	Sawtooth sunflower	FACW-	N		Jul-Oct	Forb	Perennial	Dicot
Hypericum kalmianum	Kalm's St. John's wort	FACW-	N	WL	Jun -Aug	Forb	Perennial	Dicot

Appexdix SII:B-1 continued								
Ilex verticillata	Winterberry	FACW+	N		Jun	Shrub	Perennial	Dicot
Impatiens capensis	Spotted touch-me-not	FACW	N		Jul-Sept	Forb	Annual	Dicot
Iris virginica	Blue flag	OBL	N		May-Jul	Forb	Perennial	Monocot
Juncus balticus	Lake shore rush	OBL	N	R	May-Sept	Rush	Perennial	Monocot
Juncus canadensis	Canadian rush	OBL	N		Jul-Sept	Rush	Perennial	Monocot
Juncus dudleyi	Dudley's rush	FAC	N		May-Jul	Rush	Perennial	Monocot
Juncus effusus	Common rush	OBL	N		Jun - Jul	Rush	Perennial	Monocot
Larix laricina	Tamarack	FACW	N		Apr-May	Tree	Perennial	Gymnosperm
Lathyrus palustris	Marsh vetchling	FACW	N		Jun- Sept	Forb	Perennial	Dicot
Leersia oryzoides	Rice cut grass	OBL	N		Jul-Sept	Grass	Perennial	Monocot
Leersia virginica	White grass	FACW	N		Jul-Sept	Grass	Perennial	Monocot
Lemna minor	Small duckweed	OBL	N		Jul-Sept	Forb	Perennial	Monocot
Ligustrum vulgare	Common privet	FAC-	A		Jun- July	Shrub	Perennial	Dicot
Lindera benzoin	Spicebush	FACW-	N		Apr-May	Shrub	Perennial	Dicot
Liparis loeselii	Green twayblade	FACW+	N		Jun	Forb	Perennial	Monocot
Lobelia kalmii	Bog lobelia	OBL	N		Jul-Oct	Forb	Perennial	Dicot
Lobelia siphilitica	Great blue lobelia	FACW+	N		Jul-Oct	Forb	Perennial	Dicot
Lonicera dioica	Red honeysuckle	FACU	N		May- Jun	Shrub	Perennial	Dicot
Lonicera japonica	Japanese honeysuckle	FACU	A		Jun -Aug	Shrub	Perennial	Dicot
Ludwigia palustris	Marsh purslane	OBL	N		Jul-Aug	Forb	Perennial	Dicot
Lycopus americanus	Common water horehound	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Lycopus rubellus	Stalked water horehound	OBL	N		Sept	Forb	Perennial	Dicot
Lycopus uniflorus	Northern bugle weed	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Lysimachia ciliata	Fringed loosestrife	FACW	N		Jul-Aug	Forb	Perennial	Dicot
Lysimachia terrestris	Swamp candles	OBL	N		Jun-Jul	Forb	Perennial	Dicot
Lysimachia thyrsiflora	Tufted loosestrife	OBL	N		Jun	Forb	Perennial	Dicot
Lythrum salicaria	Purple loosestrife	OBL	A		Jun -Sept	Forb	Perennial	Dicot
Maianthemum canadense	Canada mayflower	FAC	N		May -Jun	Forb	Perennial	Monocot
Maianthemum stellata	Starry false solomon's seal	FAC-	N		Apr-Jun	Forb	Perennial	Monocot
Menispermum canadense	Moonseed	FAC+	N		Jun-Jul	Forb	Perennial	Dicot
Mentha arvensis	Wild mint	FACW+	N		Jul-Sept	Forb	Perennial	Dicot
Mimulus ringens	Monkey flower	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Mitchella repens	Partridge berry	FACU+	N		Jun	Forb	Perennial	Dicot

Appexdix SII:B-1 continued								
Monarda fistulosa	Wild bergamot	FACU	N		Jul-Oct	Forb	Perennial	Dicot
Morus alba	White mulberry	FAC	A		May -Jun	Tree	Perennial	Dicot
Muhlenbergia frondosa	Common satin grass	FACW	N		Aug-Sept	Grass	Perennial	Monocot
Muhlenbergia mexicana	Leafy satin grass	FACW	N		Sept	Grass	Perennial	Monocot
Myosotis laxa	Small forget-me-not	OBL	N	E	May-Sept	Forb	Annual	Dicot
Nuphar lutea	Yellow pond lily	OBL	N		May-Sept	Forb	Perennial	Dicot
Nyssa sylvatica	Black gum, sour gum	FAC	N		May-Jul	Tree	Perennial	Dicot
Onoclea sensibilis	Sensitive fern	FACW	N		Sept -Oct	Fern	Perennial	Filicinae
Osmunda cinnamomea	Cinnamon fern	FACW	N		May- Jun	Fern	Perennial	Filicinae
Osmunda regalis	Royal fern	OBL	N		May-Jul	Fern	Perennial	Filicinae
Oxypolis rigidior	Cowbane	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Packera aurea	Golden ragwort	FACW	N		Apr–Aug	Forb	Perennial	Dicot
Panicum dichotomiflorum	Knee grass	FACW-	N		Aug-Oct	Grass	Annual	Monocot
Parnassia glauca	Grass of parnassus	OBL	N		Aug- Oct	Forb	Perennial	Dicot
Parthenocissus quinquefolia	Virginia creeper	FAC-	N		Jul-Aug	Forb	Perennial	Dicot
Pedicularis lanceolata	Fen betony	FACW+	N		Aug-Sept	Forb	Perennial	Dicot
Peltandra virginica	Arrow arum	OBL	N		Jun- Jul	Forb	Perennial	Monocot
Penthorum sedoides	Ditch stonecrop	OBL	N		Jun- Sept	Forb	Perennial	Dicot
Phalaris arundinacea	Reed canary grass	FACW+	A		May-Jul	Grass	Perennial	Monocot
Photinia floribunda	chokeberry	FACW-	N		Apr-Jun	Shrub	Perennial	Dicot
Phragmites australis	Common reed	FACW+	A		Sept- Oct	Grass	Perennial	Monocot
Physocarpus opulifolius	Ninebark	FACW-	N		Jun	Shrub	Perennial	Dicot
Pilea fontana	Bog clearweed	FACW	N		Jul - Sept	Forb	Perennial	Dicot
Pinus banksiana	jack pine	FACU	N	R	May-Jun	Tree	Perennial	Gymnosperm
Pinus strobus	White pine	FACU	N	R		Tree	Perennial	Gymnosperm
Plantago major	Common plantain	FAC+	A		Jun-Sept	Forb	Perennial	Dicot
Plantago rugelii	Red-stalked plantain	FAC	N		Jun-Sept	Forb	Perennial	Dicot
Platanthera clavellata	Club-spur orchid	OBL	N	WL	Jul-Aug	Forb	Perennial	Monocot
Poa pratensis	Kentucky blue grass	FAC-	A		May -Jun	Grass	Perennial	Monocot
Podophyllum peltatum	May apple	FACU	N		May-Jun	Forb	Perennial	Dicot
Polygonum amphibium	Water knotweed	OBL	N		Jun–Sept	Forb	Perennial	Dicot
Polygonum arifolium	Halberd-leaved tear-thumb	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Polygonum punctatum	Smartweed	OBL	N		Aug-Sept	Forb	Annual	Dicot

Appexdix SII:B-1 continued								
Polygonum sagittatum	Arrow-leaved tear-thumb	OBL	N		Aug- Oct	Forb	Perennial	Dicot
Polygonum scandens	Climbing false buckwheat	FAC	N		Aug-Sept	Forb	Perennial	Dicot
Polygonum virginianum	Woodland knotweed	FAC	N		Jul - Oct	Forb	Perennial	Dicot
Populus deltoides	Eastern cottonwood	FAC+	N		Apr-May	Tree	Perennial	Dicot
Populus tremuloides	Quaking aspen	FAC	N		Mar-May	Tree	Perennial	Dicot
Potentilla norvegica	Rough cinquefoil	FAC	N		Jun- Oct	Forb	Perennial	Dicot
Potentilla simplex	Common cinquefoil	FACU-	N		Ma -Jun	Forb	Perennial	Dicot
Prenanthes alba	White lettuce	FACU	N		Aug-Oct	Forb	Perennial	Dicot
Prunella vulgaris v. lanceolata	Self-heal	FAC	N		Jun-Oct	Forb	Perennial	Dicot
Prunus serotina	Wild black cherry	FACU	N		May- Jun	Tree	Perennial	Dicot
Prunus virginianum	Choke cherry	FACU	N		Apr-Jul	Shrub	Perennial	Dicot
Pycnanthemum virginianum	Common mountain mint	FACW+	N		Jul-Oct	Forb	Perennial	Dicot
Quercus alba	White oak	FAC	N		Apr-Jun	Tree	Perennial	Dicot
Quercus bicolor	Swamp white oak	FACW+	N		May	Tree	Perennial	Dicot
Quercus palustris	Pin oak	FACW	N		Apr–May	Tree	Perennial	Dicot
Quercus rubra	Red oak	FACU	N		Apr-May	Tree	Perennial	Dicot
Quercus velutina	Black oak	UPL	N		Apr-Jun	Tree	Perennial	Dicot
Ranunculus abortivus	Small-flowered buttercup	FACW-	N		Apr-Jul	Forb	Perennial	Dicot
Ranunculus hispidus v. nitidus	Swamp buttercup	FACW+	N		Mar- Jun	Forb	Perennial	Dicot
Ranunculus pensylvanicus	Bristly buttercup	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Ranunculus recurvatus	Hooked buttercup	FACW	N		May- Jun	Forb	Perennial	Dicot
Ranunculus sceleratus	Cursed buttercup	OBL	N		May-Sept	Forb	Perennial	Dicot
Rhamnus alnifolia	Alder buckthorn	OBL	N	WL	May–Jun	Shrub	Perennial	Dicot
Ribes americanum	Wild black currant	FACW	N		Apr-May	Shrub	Perennial	Dicot
Ribes cynosbati	Prickly wild gooseberry	UPL	N		Apr-May	Shrub	Perennial	Dicot
Ribes hirtellum	Northern gooseberry	FACW	N	WL	May	Shrub	Perennial	Dicot
Robinia pseudoacacia	Black locust	FACU-	A		May- Jun	Tree	Perennial	Dicot
Rosa multiflora	Multiflora rose	FACU	A		Jun	Shrub	Perennial	Dicot
Rosa palustris	Swamp rose	OBL	N		Jun- Aug	Shrub	Perennial	Dicot
Rubus hispidus	Swamp dewberry	FACW	N		May-Aug	Shrub	Perennial	Dicot
Rubus idaeus strigosus	Red raspberry	FACU-	N		May- Sept	Shrub	Perennial	Dicot
Rubus occidentalis	Black raspberry	UPL	N		May- Jun	Shrub	Perennial	Dicot
Rubus pensylvanicus	Yankee blackberry	FACU	N		May- Jun	Shrub	Perennial	Dicot

Appexdix SII:B-1 continued								
Rubus pubescens	Dwarf raspberry	FACW+	N		Apr-Jun	Shrub	Perennial	Dicot
Rumex crispus	Curly dock	FAC+	A		Jun-Jul	Forb	Perennial	Dicot
Rumex obtusifolius	Bitter dock	FACW	A		Jun-Jul	Forb	Perennial	Dicot
Rumex orbiculatus	Great water dock	OBL	N		Jun-Aug	Forb	Perennial	Dicot
Sagittaria latifolia	Common arrowhead	OBL	N		Jul-Sept	Forb	Perennial	Monocot
Salix alba	White willow	FACW	A		Apr	Tree	Perennial	Dicot
Salix amygdaloides	Peach-leaved willow	FACW	N		May	Shrub	Perennial	Dicot
Salix bebbiana	Beaked willow	FACW+	N		May	Shrub	Perennial	Dicot
Salix candida	Hoary willow	OBL	N		May	Shrub	Perennial	Dicot
Salix discolor	Pussy willow	FACW	N		Apr-May	Shrub	Perennial	Dicot
Salix eriocephala	Heart-leaved willow	FACW	N	T	Apr-May	Shrub/tree	Perennial	Dicot
Salix fragilis	Crack willow	FAC+	A		May	Shrub	Perennial	Dicot
Salix glaucophylloides	Blue-leaved willow	FACW	N		May	Shrub	Perennial	Dicot
Salix interior	Sandbar willow	OBL	N		Apr-Jul	Shrub	Perennial	Dicot
Salix nigra	Black willow	OBL	N		May	Tree	Perennial	Dicot
Salix petiolaris	Meadow willow	FACW+	N		May	Shrub	Perennial	Dicot
Salix rubens	Hybrid crack willow	FACW+	A			Tree	Perennial	Dicot
Salix sericea	Silky willow	OBL	N		May	Shrub	Perennial	Dicot
Salix X conifer	Pussy willow	FACW	N		Apr-May	Shrub	Perennial	Dicot
Sambucus nigra ssp. canadensis	Elderberry	FACW-	N		Jun- Aug	Shrub	Perennial	Dicot
Sarracenia purpurea	Pitcher plant	OBL	N	WL	May- Jun	Forb	Perennial	Dicot
Sassafras albidum	Sassafras	FACU	N		Apr-Jun	Tree	Perennial	Dicot
Saxifraga pensylvanica	Swamp saxifrage	FACW	N		May- Jun	Forb	Perennial	Dicot
Schoenoplectus acutus	Hard-stemmed bulrush	OBL	N		Apr-Aug	Rush	Perennial	Monocot
Schoenoplectus fluviatilis	River bulrush	OBL	N		May-Jul	Rush	Perennial	Monocot
Schoenoplectus pungens	Chairmaker's rush	OBL	N		MaySept	Rush	Perennial	Monocot
Scirpus atrovirens	Dark green rush	OBL	N		Jun-Aug	Rush	Perennial	Monocot
Scirpus cyperinus	Wool grass	OBL	N		Jun-Sept	Rush	Perennial	Monocot
Scutellaria galericulata	Marsh skullcap	OBL	N		Jun-Sept	Forb	Perennial	Dicot
Scutellaria lateriflora	Mad-dog skullcap	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Sium suave	Tall water parsnip	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Smilax rotundifolia	Green brier	UPL	N		May-Jun	Forb	Perennial	Monocot
Smilax tamnoides v hispida	Bristly green brier	UPL	N		May-Jun	Forb	Perennial	Monocot

Appexdix SII:B-1 continued								
Solanum dulcamara	Bittersweet nightshade	FAC	A		Jun-Sept	Forb	Perennial	Dicot
Solidago caesia	Blue-stemmed goldenrod	FACU	N		Sept-Oct	Forb	Perennial	Dicot
Solidago canadensis v. scabra	Tall goldenrod	FACU	N		Jun-Oct	Forb	Perennial	Dicot
Solidago gigantea	Late goldenrod	FACW	N		Aug-Sept	Forb	Perennial	Dicot
Solidago patula	Swamp goldenrod	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Solidago rugosa	Rough goldenrod	FAC+	N		Aug-Oct	Forb	Perennial	Dicot
Solidago uliginosa	Bog goldenrod	OBL	N		Aug-Oct	Forb	Perennial	Dicot
Sonchus arvensis ssp. uliginosus	Common sow thistle	FAC-	A		Jun-Oct	Forb	Perennial	Dicot
Sparganium eurycarpum	Common bur reed	OBL	N		Jun-Aug	Forb	Perennial	Monocot
Sphenopholis intermedia	Slender wedge grass	FAC	N		May-Jul	Grass	Perennial	Monocot
Spiraea alba	Meadowsweet	FACW+	N		Jun-Sept	Shrub	Perennial	Dicot
Stachys palustris	Woundwort	OBL	N		Jun-Aug	Forb	Perennial	Dicot
Stachys tenuifolia v. hispida	Marsh hedge nettle	FACW+	N		Jun-Sept	Forb	Perennial	Dicot
Symphyotrichum lateriflorum	side-flowering aster	FACW-	N		Aug-Oct	Forb	Perennial	Dicot
Symphyotrichum boreale	rush aster	OBL	N	R	Aug-Oct	Forb	Perennial	Dicot
Symphyotrichum lanceolatum	white panicled aster	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Symphyotrichum praealtum	willow aster	FACW	N		Sept-Oct	Forb	Perennial	Dicot
Symphyotrichum puniceum	bristly aster	OBL	N		Aug-Oct	Forb	Perennial	Dicot
Symplocarpus foetidus	Skunk cabbage	OBL	N		Apr-May	Forb	Perennial	Monocot
Taraxacum officinale	Common dandelion	FACU	A		Apr-Jan	Forb	Perennial	Dicot
Taxodium distichum	Baldcypress	OBL	A			Tree	Perennial	Dicot
Thalictrum dasycarpum	Purple meadow rue	FACW-	N		Jun-Jul	Forb	Perennial	Dicot
Thelypteris palustris	Marsh shield fern	FACW+	N		Aug-Oct	Fern	Perennial	Filicinae
Thuja occidentalis	Eastern white cedar	FACW	N	E		Tree	Perennial	Gymnosperm
Toxicodendron radicans	Poison ivy	FAC+	N		May -Jun	Vine	Perennial	Dicot
Toxicodendron vernix	Poison sumac	OBL	N		Jun	Shrub	Perennial	Dicot
Triadenum virginicum	Marsh St. John's wort	OBL	N		Jul-Aug	Forb	Perennial	Dicot
Trientalis borealis	Starflower	FAC+	N		May-Jun	Forb	Perennial	Dicot
Typha angustifolia	narrow-leaf cattail	OBL	A		Jun-Aug	Forb	Perennial	Monocot
Typha X glauca (hybrid)	Hybrid Cattail	OBL	A		Jun-Jul	Forb	Perennial	Monocot
Ulmus americana	American elm	FACW-	N		Mar- May	Tree	Perennial	Dicot
Ulmus rubra	Slippery elm	FAC	N		Mar - Apr	Tree	Perennial	Dicot
Urtica dioica spp. gracilis	Tall nettle	FAC+	N		Jul - Sept	Forb	Perennial	Dicot

Appexdix SII:B-1 continued								
Vaccinium corymbosum	Highbush blueberry	FACW	N		Apr - May	Shrub	Perennial	Dicot
Verbena hastata	Blue vervain	FACW+	N		Jul - Sept	Forb	Perennial	Dicot
Vernonia fasciculata	Common ironweed	FACW	N		Jul - Sept	Forb	Perennial	Dicot
Viburnum lentago	Nannyberry	FAC+	N		May - Jun	Shrub	Perennial	Dicot
Viburnum prunifolium	Black haw	FACU	N		May - Jun	Shrub	Perennial	Dicot
Vinca minor	Periwinkle	UPL	A		Apr-Jun	Forb	Perennial	Dicot
Viola macloskeyi ssp. Pallens	Smooth white violet	OBL	N		Apr - May	Forb	Perennial	Dicot
Viola sororia	Common blue violet	FAC-	N		Apr - Jun	Forb	Perennial	Dicot
Vitis labrusca	Fox grape	FACU	N		May	Vine	Perennial	Dicot
Vitis riparia	Riverbank grape	FACW-	N		May - Jun	Vine	Perennial	Dicot
Zizania aquatica	Wild rice	OBL	N		Jul - Sept	Grass	Annual	Monocot

APPENDIX SII:B-2: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – TOTAL PROJECT AREA				
Trees- Diameter at Breast Height of Seven cm or Greater				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
Acer rubrum	0.60	244.81	7.47	138.9
Acer saccharum	0.00	17.83	0.03	3.6
Alnus incana ssp. rugosa	0.02	1.52	0.16	3.0
Betula alleghaniensis	0.21	29.78	1.51	30.1
Betula papyrifera	0.03	5.10	0.17	4.4
Cephalanthus occidentalis	0.01	1.28	0.06	1.3
Fraxinus americana	0.03	1.96	0.27	4.2
Fraxinus nigra	0.01	1.28	0.06	1.2
Fraxinus pensylvanica	0.01	3.16	0.05	1.4
Larix laricina	0.04	16.81	0.30	7.8
Lindernia benzoin	0.01	0.22	0.03	0.6
Morus alba	0.00	0.89	0.04	0.5
Nyssa sylvatica	0.01	3.54	0.19	2.7
Pinus strobus	0.01	9.59	0.10	2.9
Populus deltoides	0.01	7.64	0.09	2.5
Populus tremuloides	0.06	19.01	0.51	11.3
Prunus serotina	0.08	31.90	0.40	13.8
Quercus alba	0.01	11.31	0.05	2.8
Quercus palustris	0.00	0.26	0.03	0.4
Quercus rubra	0.00	8.06	0.04	1.9
Quercus velutina	0.00	0.00	0.00	0.0
Robinia pseudoacacia	0.02	26.76	0.11	7.2
Salix amygdaloides	0.02	29.99	0.46	10.3
Salix discolor	0.04	4.81	0.24	5.4
Salix eriocephala	0.01	2.73	0.03	1.1
Salix fragilis	0.01	1.21	0.05	1.0
Salix myricoides v. myricoides	0.01	0.68	0.04	0.8
Salix nigra	0.01	5.72	0.18	3.2
Sassafras albidum	0.06	20.35	0.51	11.6
Thuja occidentalis	0.08	22.56	0.53	13.3
Toxicodendron vernix	0.02	1.15	0.07	2.3
Ulmus americana	0.00	1.51	0.03	0.8
Ulmus rubra	0.05	7.32	0.23	6.3
Viburnum lentago	0.01	0.77	0.08	1.5
Total	**1.49**	**541.52**	**14.10**	

Shrubs and Woody Vines			
Scientific Name	**Cover**	**Frequency**	**Importance**
Acer rubrum	0.56	6.98	7.46
Acer saccharinum	0.01	0.10	0.10
Alnus incana ssp. rugosa	1.51	6.58	11.86
Amelanchier arborea	0.00	0.20	0.14
Berberis thunbergii	0.00	0.10	0.08
Betula alleghaniensis	0.21	3.59	3.43
Betula papyrifera	0.05	1.10	0.99
Betula pumila	0.02	0.70	0.56
Celastrus orbiculatus	0.04	0.50	0.54
Cephalanthus occidentalis	0.80	3.39	6.21
Cornus obliqua	1.03	8.57	10.87
Cornus racemosa	0.16	2.29	2.32

Appendix SII:B-2 (shrubs and woody vines) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Cornus sericea ssp. sericea	0.94	10.97	12.02
Elaeagnus umbellata	0.00	0.20	0.14
Fraxinus americana	0.03	0.70	0.63
Fraxinus nigra	0.04	0.50	0.53
Ilex verticillata	2.33	10.57	18.62
Larix laricina	0.03	0.50	0.48
Ligustrum vulgare	0.00	0.10	0.07
Lindera benzoin	6.87	19.34	46.87
Lonicera japonica	0.25	1.30	2.13
Lonicera dioica	0.02	0.30	0.29
Menispermum canadense	0.00	0.10	0.07
Parthenocissus quinquefolia	0.08	3.49	2.74
Photinia floribunda	0.05	2.29	1.79
Populus deltoides	0.02	0.10	0.15
Populus tremuloides	0.03	1.00	0.80
Prunus serotina	0.19	1.30	1.83
Prunus virginiana	0.03	0.30	0.36
Quercus bicolor	0.01	0.10	0.10
Quercus palustris	0.00	0.10	0.07
Rhamnus alnifolia	0.00	0.10	0.07
Ribes americanum	0.02	1.10	0.81
Ribes cynosbati	0.00	0.20	0.15
Rosa multiflora	0.08	2.89	2.33
Rosa palustris	0.84	10.77	11.38
Rubus idaeus strigosus	0.00	0.40	0.28
Rubus occidentalis	0.00	0.20	0.14
Rubus pensilvanicus	0.01	0.30	0.26
Salix bebbiana	0.00	0.10	0.07
Salix discolor	0.57	3.09	4.91
Salix eriocephala	0.15	1.00	1.43
Salix interior	0.16	1.50	1.81
Salix myricoides var. myricoides	0.01	0.50	0.38
Salix nigra	0.00	0.10	0.07
Salix petiolaris	0.24	1.00	1.86
Salix rubens	0.02	0.20	0.26
Salix sericea	0.00	0.10	0.07
Sambucus nigra ssp. canadensis	0.01	0.40	0.32
Sassafras albidum	0.04	0.20	0.33
Spiraea alba	0.19	1.00	1.60
Thuja occidentalis	0.01	0.30	0.23
Toxicodendron vernix	1.06	17.75	17.19
Ulmus americana	0.00	0.10	0.08
Ulmus rubra	0.06	1.00	0.97
Vaccinium corymbosum	0.09	2.49	2.11
Viburnum lentago	0.23	2.89	3.10
Viburnum prunifolium	0.00	0.10	0.08
Vitis labrusca	1.15	9.97	12.41
Vitis riparia	0.01	1.40	1.00
Total	**20.29**	**148.45**	

Appendix SII:B-2 continued

Herbaceous Vegetation

Scientific Name	Cover	Frequency	Importance
Acer rubrum	0.03	5.05	0.69
Agrimonia parviflora	0.02	0.32	0.07
Agrostis gigantea	0.00	0.16	0.02
Agrostis perennans	0.00	0.39	0.06
Alisma subcordatum	0.02	0.71	0.12
Alnus incana ssp. rugosa	0.00	0.16	0.03
Amphicarpaea bracteata	0.02	0.87	0.13
Angelica atropurpurea	0.07	0.39	0.15
Apios americana	0.04	1.50	0.25
Apocynum spp	0.09	1.42	0.32
Arisaema triphyllum	0.11	5.13	0.82
Asclepias incarnata	0.04	2.13	0.34
Betula alleghaniensis	0.00	0.24	0.03
Betula pumila	0.05	0.71	0.16
Bidens connata	0.28	6.24	1.20
Bidens coronata	0.02	0.55	0.09
Bidens frondosa	0.00	0.32	0.04
Bidens tripartita	0.00	0.08	0.01
Boehmeria cylindrica	0.80	13.42	2.87
Botrychium dissectum	0.00	0.08	0.01
Bromus ciliatus	0.01	1.03	0.15
Calamagrostis canadensis	1.19	12.87	3.36
Caltha palustris	0.48	6.71	1.55
Calystegia sepium ssp. sepium	0.09	2.68	0.47
Campanula aparinoides	0.06	3.79	0.58
Cardamine bulbosa	0.13	8.76	1.31
Cardamine pensylvanica	0.05	3.00	0.46
Carex alata	0.01	0.24	0.05
Carex annectens	0.01	0.08	0.03
Carex aquatilis	0.69	4.34	1.54
Carex atherodes	0.03	0.87	0.15
Carex blanda	0.00	0.08	0.01
Carex bromoides	0.02	0.55	0.09
Carex comosa	0.21	3.24	0.72
Carex crinita	0.01	0.08	0.02
Carex cristatella	0.05	0.32	0.12
Carex echinata	0.02	0.24	0.06
Carex hystericina	0.12	2.21	0.46
Carex interior	0.10	1.03	0.27
Carex lacustris	0.53	4.50	1.34
Carex lasiocarpa	0.10	2.37	0.44
Carex leptalea	0.05	0.39	0.12
Carex lupulina	0.00	0.08	0.01
Carex lurida	0.00	0.32	0.05
Carex projecta	0.00	0.08	0.01
Carex radiata	0.00	0.08	0.01
Carex rosea	0.01	0.24	0.04
Carex scoparia	0.00	0.08	0.01
Carex seorsa	0.33	5.52	1.19
Carex stipata	0.08	2.45	0.42

Appendix SII:B-2 (Herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Carex stricta	0.58	3.79	1.32
Carex tenera	0.00	0.08	0.01
Carex utriculata	0.01	0.63	0.10
Carex vulpiniodea	0.01	0.08	0.02
Carex wood	0.00	0.16	0.03
Carex spp	0.00	0.32	0.04
Celastrus orbiculatus	0.01	0.47	0.07
Cephalanthus occidentalis	0.03	0.63	0.12
Chelone glabra	0.02	0.71	0.11
Cicuta bulbifera	0.03	2.76	0.40
Cinna arundinacea	0.03	1.10	0.18
Circaea lutetiana	0.01	0.71	0.11
Cirsium arvense	0.14	3.87	0.70
Cirsium muticum	0.11	2.37	0.46
Clematis virginiana	0.12	2.76	0.53
Comarum palustre	0.00	0.08	0.01
Convolvulus arvensis	0.01	1.03	0.15
Coptis trifolia	0.01	0.24	0.04
Corallorhiza maculata	0.00	0.16	0.02
Cornus spp	0.45	7.34	1.59
Cryptotaenia canadensis	0.03	0.79	0.15
Cuscuta gronovii	0.08	7.18	1.04
Decodon verticillatus	0.59	4.97	1.49
Dichanthelium clandestinum	0.01	0.08	0.02
Doellingeria umbellata var. umbellata	0.02	0.63	0.11
Dryopteris cristata	0.00	0.08	0.01
Dryopteris noveboracensis	0.01	0.16	0.03
Dryopteris carthusiana	0.13	3.24	0.60
Echinochloa crusgalli	0.00	0.08	0.01
Eleocharis erythropoda	0.00	0.08	0.01
Eleocharis palustris	0.00	0.08	0.01
Eleocharis rostellata	0.17	1.58	0.45
Elymus spp.	0.00	0.47	0.06
Epilobium coloratum	0.19	8.60	1.38
Epilobium leptophyllum	0.13	6.87	1.07
Epipactis helleborine	0.00	0.08	0.01
Equisetum arvense	0.02	2.05	0.30
Erechtites hieracifolia	0.01	0.87	0.13
Erigeron philadelphicus	0.00	0.08	0.01
Eupatorium maculatum	1.61	18.86	4.73
Eupatorium perfoliatum	0.11	2.37	0.46
Euthamia graminifolia var. nuttallii	0.00	0.16	0.02
Fragaria virginiana	0.01	0.39	0.06
Fraxinus spp.	0.03	1.50	0.24
Galium aparine	0.00	0.16	0.02
Galium labradoricum	0.01	0.39	0.06
Galium obtusum	0.05	5.52	0.78
Galium tinctorium	0.07	4.03	0.61
Galium trifidum	0.04	1.66	0.26
Galium triflorum	0.27	8.92	1.54
Galium spp	0.01	1.74	0.23

Appendix SII:B-2 (Herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Geum canadense	0.06	2.76	0.44
Geum laciniatum	0.01	0.32	0.06
Glyceria spp.	0.01	0.95	0.14
Glyceria striata	0.55	12.00	2.33
Grass spp.	0.01	0.79	0.12
Ilex verticillata	0.04	1.82	0.28
Impatiens capensis	5.41	50.59	14.26
Iris virginica	0.04	0.63	0.14
Juncus balticus	0.00	0.08	0.01
Juncus canadensis	0.00	0.08	0.01
Juncus effusus	0.01	0.55	0.09
Lathyrus palustris	0.03	2.05	0.30
Leersia oryzoides	0.96	14.52	3.24
Leersia virginica	0.02	0.16	0.05
Lemna minor	0.22	3.71	0.79
Lindera benzoin	1.79	16.89	4.74
Liparis loeselii	0.01	1.10	0.16
Lobelia kalmii	0.00	0.32	0.04
Lobelia siphilitica	0.04	1.42	0.24
Lonicera japonica	0.01	0.24	0.04
Ludwigia palustris	0.01	0.16	0.04
Lycopus americanus	0.12	2.92	0.54
Lycopus rubellus	0.08	2.21	0.40
Lycopus spp.	0.03	1.18	0.19
Lycopus uniflorus	0.37	11.84	2.05
Lysimachia ciliata	0.00	0.08	0.01
Lysimachia terrestris	0.01	0.32	0.06
Lysimachia thyrsiflora	0.27	9.94	1.66
Maianthemum canadense	0.11	5.68	0.88
Maianthemum stellata	0.01	0.71	0.10
Mentha arvensis	0.36	6.31	1.33
Mimulus ringens	0.02	0.39	0.08
Mitchella repens	0.01	0.32	0.05
Monarda fistulosa	0.00	0.08	0.01
Muhlenbergia frondosa	0.01	0.08	0.03
Muhlenbergia mexicana	0.22	2.84	0.67
Myosotis laxa	0.15	2.21	0.50
Nuphar lutea ssp. advena	0.00	0.16	0.03
Onoclea sensibilis	2.23	17.84	5.49
Osmunda cinnamomea	0.69	3.00	1.38
Osmunda regalis	0.25	1.97	0.61
Oxypolis rigidior	0.00	1.03	0.14
Packera aureus	0.05	0.79	0.18
Parnassia glauca	0.07	0.55	0.18
Parthenocissus quinquefolia	0.26	12.39	1.97
Pedicularis lanceolata	0.02	0.47	0.09
Peltandra virginica	0.06	1.10	0.23
Penthorum sedoides	0.01	0.16	0.03
Phalaris arundinacea	0.02	0.24	0.06
Photinia floribunda	0.05	0.87	0.18
Phragmites australis	1.01	12.23	3.02

Appendix SII:B-2 (Herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Physocarpus opulifolius	0.01	0.32	0.05
Pilea fontana	4.58	54.62	13.59
Platanthera clavellata	0.01	0.87	0.12
Poa pratensis	0.01	0.24	0.04
Polygonum amphibium	0.14	2.45	0.52
Polygonum arifolium	0.04	0.71	0.15
Polygonum punctatum	0.28	8.76	1.52
Polygonum sagittatum	0.31	13.02	2.11
Polygonum scandens	0.01	0.08	0.02
Polygonum virginianum	0.01	0.63	0.10
Populus deltoides	0.00	0.16	0.02
Populus tremuloides	0.01	0.32	0.05
Potentilla norvegica	0.00	0.08	0.01
Potentilla simplex	0.00	0.47	0.07
Prenanthes alba	0.00	0.08	0.01
Prunella vulgaris ssp. lanceolata	0.00	0.08	0.01
Prunus serotina	0.00	0.24	0.03
Pycnanthemum virginianum	0.01	0.63	0.09
Quercus spp	0.00	0.24	0.03
Quercus rubra	0.00	0.08	0.01
Ranunculus abortivus	0.00	0.16	0.02
Ranunculus pensylvanicus	0.00	0.08	0.01
Ranunculus recurvatus	0.02	2.21	0.31
Ranunculus sceleratus	0.01	0.55	0.09
Rhamnus alnifolia	0.01	0.24	0.04
Ribes americanum	0.07	2.21	0.38
Ribes hirtellum	0.04	1.26	0.21
Rosa multiflora	0.08	1.66	0.33
Rosa palustris	0.12	4.34	0.73
Rubus hispidus	0.00	0.24	0.03
Rubus idaeus	0.04	1.34	0.24
Rubus occidentalis	0.00	0.08	0.01
Rubus pensilvanicus	0.01	0.39	0.06
Rubus pubescens	0.10	2.76	0.50
Rumex crispus	0.04	0.71	0.15
Rumex obtusifolius	0.01	0.47	0.08
Rumex spp	0.09	2.13	0.40
Sagittaria latifolia	0.06	0.71	0.17
Salix amygdaloides	0.03	0.08	0.05
Salix discolor	0.04	0.32	0.10
Sambucus nigra ssp. canadensis	0.02	0.95	0.15
Sassafras albidum	0.01	0.24	0.04
Schoenoplectus acutus var. acutus	0.06	1.03	0.22
Schoenoplectus fluviatilis	0.02	0.39	0.08
Schoenoplectus pungens var. pungens	0.00	0.08	0.01
Scirpus atrovirens	0.02	0.39	0.08
Scirpus cyperinus	0.08	0.47	0.18
Scutellaria galericulata	0.49	12.15	2.27
Scutellaria lateriflora	0.36	13.97	2.31
Sium suave	0.04	1.50	0.26
Smilax tamnoides	0.01	0.39	0.06

Appendix SII:B-2 (Herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Solanum dulcamara	0.18	5.45	0.96
Solidago canadensis var. scabra	0.02	0.39	0.08
Solidago gigantea	0.69	6.31	1.81
Solidago patula	0.73	11.68	2.55
Solidago rugosa	0.00	0.08	0.01
Solidago uliginosa	0.02	0.47	0.09
Sonchus arvensis ssp. uliginosus	0.00	0.16	0.02
Sparganium eurycarpum	0.04	0.47	0.12
Sphagnum spp.	0.14	0.79	0.30
Sphenopholis intermedia	0.00	0.24	0.03
Stachys palustris	0.02	0.87	0.14
Stachys tenuifolia	0.01	0.55	0.08
Symphyotrichum boreale	0.05	1.66	0.29
Symphyotrichum lanceolatum var. lanceolatum	0.18	4.74	0.87
Symphyotrichum lateriflorum var. lateriflorum	0.65	11.60	2.43
Symphyotrichum praealtum var. praealtum	0.03	0.08	0.05
Symphyotrichum puniceum var. puniceum	0.09	3.79	0.62
Symplocarpus foetidus	7.65	24.47	14.11
Taraxacum officinale	0.00	0.55	0.08
Thalictrum dasycarpum	0.19	4.42	0.85
Thelypteris palustris var. pubescens	1.36	20.44	4.57
Toxicodendron radicans ssp. radicans	0.03	1.89	0.29
Toxicodendron vernix	0.12	3.08	0.57
Triadenum virginicum	0.01	0.87	0.13
Trientalis borealis	0.02	0.47	0.09
Typha X glauca (hybrid)	22.15	76.40	41.58
Ulmus rubra	0.02	0.63	0.11
Urtica dioica ssp. gracilis	0.63	10.81	2.29
Verbena hastata	0.01	0.63	0.10
Vernonia fasciculata	0.00	0.08	0.01
Viburnum lentago	0.01	0.63	0.10
Viola spp	0.25	10.81	1.75
Vitis riparia	0.03	0.95	0.16
Vitis labrusca	0.19	1.97	0.53
Total	69.74		

APPENDIX SII:B-3: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – WEST SHRUB UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	0.85	131.82	6.12	131.85
Alnus incana ssp. rugosa	0.05	2.73	0.20	4.71
Betula alleghaniensis	0.52	48.40	2.40	59.91
Betula papyrifera	0.26	38.94	1.27	35.16
Cephalanthus occidentalis	0.06	4.03	0.31	6.75
Fraxinus pensylvanica	0.01	1.75	0.13	1.99
Larix laricina	0.02	17.39	0.10	7.47
Populus deltoides	0.02	0.86	0.29	3.29
Populus tremuloides	0.07	10.51	0.58	11.32
Salix amygdaloides	0.00	0.00	0.02	0.18
Salix discolor	0.05	7.75	0.44	8.52
Salix eriocephala	0.02	16.51	0.06	6.85
Salix fragilis	0.00	0.00	0.06	0.45
Salix nigra	0.02	17.22	0.13	7.28
Toxicodendron vernix	0.01	0.46	0.02	0.70
Ulmus americana	0.01	0.50	0.06	0.99
Ulmus rubra	0.06	15.93	0.57	12.58
Total	**2.03**	**314.80**	**12.78**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	1.37	20.61	10.12
Acer saccharinum	0.06	0.76	0.39
Alnus incana ssp. rugosa	4.84	22.90	20.79
Amelanchier arborea	0.00	0.76	0.24
Betula alleghaniensis	0.85	13.74	6.58
Betula papyrifera	0.39	8.40	3.65
Betula pumila	0.13	4.58	1.76
Cephalanthus occidentalis	0.48	0.76	1.60
Cornus obliqua	1.05	17.56	8.27
Cornus racemosa	0.14	3.05	1.32
Cornus sericea ssp. sericea	1.02	16.79	7.97
Fraxinus nigra	0.19	1.53	1.01
Ilex verticillata	9.32	40.46	38.93
Lindera benzoin	0.29	7.63	3.13
Parthenocissus quinquefolia	0.32	7.63	3.22
Photinia floribunda	0.25	12.98	4.62
Populus tremuloides	0.16	3.05	1.38
Quercus palustris	0.00	0.76	0.24
Ribes americanum	0.02	0.76	0.29
Ribes spp.	0.02	0.76	0.29
Rosa palustris	2.26	33.59	16.55
Rubus idaeus strigosus	0.00	0.76	0.24
Salix discolor	1.99	6.87	7.79
Salix interior	0.94	1.53	3.15
Salix petiolaris	0.76	1.53	2.65
Toxicodendron vernix	3.63	53.44	26.47
Unknown	0.01	0.76	0.25
Vaccinium corymbosum	0.60	15.27	6.30

Appendix SII:B-3 (shrubs and woody vines) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Viburnum lentago	0.11	1.53	0.79
Vitis labrusca	3.53	30.53	19.29
Vitis riparia	0.01	2.29	0.72
Total	**34.78**		
Herbaceous Vegetation			
Acer rubrum	0.11	10.45	1.08
Agrimonia parviflora	0.02	0.75	0.10
Agrostis perennans	0.00	0.75	0.07
Alnus incana ssp. rugosa	0.02	0.75	0.10
Amphicarpaea bracteata	0.03	1.49	0.17
Apios americana	0.10	2.99	0.40
Asclepias incarnata	0.08	4.48	0.50
Betula pumila	0.18	3.73	0.57
Bidens connata	0.71	14.93	2.26
Bidens coronata	0.07	2.24	0.29
Bidens tripartita	0.02	0.75	0.10
Boehmeria cylindrica	1.31	22.39	3.69
Calamagrostis canadensis	1.97	19.40	4.26
Caltha palustris	0.92	13.43	2.39
Calystegia sepium ssp. sepium	0.24	2.24	0.51
Campanula aparinoides	0.13	6.72	0.77
Cardamine bulbosa	0.14	9.70	1.06
Cardamine pensylvanica	0.14	7.46	0.86
Carex alata	0.02	0.75	0.10
Carex aquatilis	0.19	5.22	0.72
Carex bromoides	0.13	3.73	0.50
Carex comosa	0.17	8.21	0.96
Carex lacustris	0.13	2.24	0.37
Carex lasiocarpa	0.01	2.24	0.22
Carex leptalea	0.13	0.75	0.23
Carex seorsa	1.87	25.37	4.68
Carex spp	0.00	0.75	0.07
Carex stipata	0.03	1.49	0.17
Carex stricta	0.28	0.75	0.42
Carex utriculata	0.00	0.75	0.07
Celastrus orbiculatus	0.02	0.75	0.10
Chelone glabra	0.05	2.24	0.26
Cicuta bulbifera	0.08	5.22	0.58
Cirsium muticum	0.03	2.24	0.24
Corallorhiza maculata	0.01	1.49	0.14
Cornus spp	0.12	8.21	0.89
Cuscuta gronovii	0.05	3.73	0.41
Decodon verticillatus	1.36	9.70	2.61
Doellingeria umbellata var. umbellata	0.03	1.49	0.17
Dryopteris carthusiana	0.07	2.99	0.36
Epilobium coloratum	0.07	6.72	0.70
Epilobium leptophyllum	0.18	11.19	1.24
Equisetum arvense	0.07	6.72	0.70
Erechtites hieracifolia	0.03	1.49	0.17
Eupatorium maculatum	1.52	20.90	3.83
Eupatorium perfoliatum	0.03	2.24	0.24

Appendix SII:B-3 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Euthamia graminifolia var. nuttallii	0.01	1.49	0.14
Galium obtusum	0.05	5.97	0.60
Galium spp	0.02	4.48	0.43
Galium tinctorium	0.06	5.22	0.55
Galium trifidum	0.01	1.49	0.14
Galium triflorum	0.04	1.49	0.19
Glyceria spp.	0.04	3.73	0.39
Glyceria striata	0.38	17.91	2.11
Grass spp	0.11	4.48	0.54
Ilex verticillata	0.13	7.46	0.84
Impatiens capensis	3.50	55.97	9.53
Juncus effusus	0.02	0.75	0.10
Lathyrus palustris	0.03	3.73	0.38
Leersia oryzoides	0.67	20.90	2.75
Lemna minor	0.03	7.46	0.71
Lindera benzoin	0.07	5.97	0.63
Lycopus americanus	0.24	5.97	0.85
Lycopus rubellus	0.22	4.48	0.69
Lycopus spp	0.16	3.73	0.55
Lycopus uniflorus	1.25	35.07	4.77
Lysimachia thyrsiflora	0.49	24.63	2.86
Maianthemum canadense	0.07	7.46	0.77
Mimulus ringens	0.00	0.75	0.07
Mitchella repens	0.01	1.49	0.14
Muhlenbergia mexicana	0.00	0.75	0.07
Myosotis laxa	0.20	7.46	0.93
Onoclea sensibilis	6.96	46.27	13.04
Osmunda cinnamomea	4.28	14.93	6.79
Osmunda regalis	1.56	11.19	3.00
Oxypolis rigidior	0.00	0.75	0.07
Parthenocissus quinquefolia	0.39	19.40	2.26
Penthorum sedoides	0.06	1.49	0.21
Photinia floribunda	0.43	6.72	1.15
Phragmites australis	0.43	9.70	1.42
Pilea fontana	5.87	74.63	14.23
Platanthera clavellata	0.04	4.48	0.46
Polygonum punctatum	0.06	5.22	0.55
Polygonum sagittatum	0.10	10.45	1.08
Populus tremuloides	0.02	0.75	0.10
Pycnanthemum virginianum	0.08	4.48	0.51
Ranunculus recurvatus	0.00	0.75	0.07
Ribes americanum	0.18	5.97	0.76
Rosa multiflora	0.02	0.75	0.10
Rosa palustris	0.45	17.91	2.20
Rubus idaeus	0.15	4.48	0.60
Rubus pubescens	0.03	2.24	0.24
Rumex crispus	0.02	0.75	0.10
Rumex spp	0.14	5.97	0.72
Sagittaria latifolia	0.26	1.49	0.47
Salix amygdaloides	0.28	0.75	0.42
Schoenoplectus pungens var. pungens	0.00	0.75	0.07

Appendix SII:B-3 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Scutellaria galericulata	1.96	32.09	5.40
Scutellaria lateriflora	0.51	33.58	3.70
Sium suave	0.07	6.72	0.70
Smilax tamnoides	0.02	0.75	0.10
Solanum dulcamara	0.37	14.93	1.82
Solidago patula	0.81	18.66	2.72
Sphagnum	1.28	5.97	2.16
Stachys palustris	0.05	2.99	0.33
Stachys tenuifolia	0.00	0.75	0.07
Symphyotrichum lanceolatum var. lanceolatum	0.20	6.72	0.86
Symphyotrichum puniceum var. puniceum	0.22	8.21	1.03
Symplocarpus foetidus	10.14	45.52	17.02
Taraxacum officinale	0.00	0.75	0.07
Thalictrum dasycarpum	0.00	0.75	0.07
Thelypteris palustris var. pubescens	3.06	41.79	7.69
Toxicodendron radicans ssp. radicans	0.04	5.22	0.53
Toxicodendron vernix	0.18	10.45	1.18
Trientalis borealis	0.13	1.49	0.31
Typha X glauca (hybrid) & T. angustifolia	14.40	79.85	25.55
Ulmus rubra	0.02	0.75	0.10
Urtica dioica ssp. gracilis	0.75	13.43	2.17
Verbena hastata	0.00	0.75	0.07
Viola spp	0.22	5.22	0.75
Vitis riparia	0.13	0.75	0.23
Vitis labrusca	1.57	7.46	2.67
Total	**78.66**		

APPENDIX SII:B-4: RESULTS OF QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – FORESTED SWAMP UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	3.81	845.77	30.48	178.03
Alnus incana ssp. rugosa	0.27	18.63	2.15	9.65
Amelanchier arborea	0.00	0.00	0.05	0.09
Betula alleghaniensis	1.82	265.71	13.81	73.61
Fraxinus nigra	0.02	0.69	0.05	0.39
Fraxinus pensylvanica	0.10	46.94	0.46	5.77
Larix laricina	0.03	29.70	0.45	3.52
Nyssa sylvatica	0.03	8.13	0.56	2.17
Pinus strobus	0.03	27.89	0.33	3.15
Prunus serotina	0.00	0.00	0.28	0.54
Quercus palustris	0.00	0.00	0.05	0.09
Salix amygdaloides	0.05	76.12	1.27	8.71
Salix discolor	0.05	11.36	0.38	2.29
Thuja occidentalis	0.03	2.38	0.05	0.76
Ulmus americana	0.00	0.00	0.05	0.09
Ulmus rubra	0.34	43.28	1.47	11.12
Viburnum lentago	0.00	0.00	0.01	0.02
Total	**6.58**	**1376.62**	**51.89**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	2.89	35.38	17.56
Alnus incana ssp. rugosa	9.52	26.15	29.85
Betula alleghaniensis	1.12	20.00	8.74
Cephalanthus occidentalis	0.27	1.54	1.09
Cornus obliqua	1.75	9.23	6.85
Cornus sericea ssp. sericea	0.30	7.69	3.07
Cornus spp.	0.01	1.54	0.49
Elaeagnus umbellata	0.00	1.54	0.48
Fraxinus nigra	0.12	3.08	1.22
Ilex verticillata	14.40	55.38	50.07
Lindera benzoin	5.20	52.31	28.08
Parthenocissus quinquefolia	0.01	1.54	0.49
Photinia floribunda	0.05	3.08	1.06
Rosa multiflora	0.11	6.15	2.15
Rosa palustris	0.10	4.62	1.66
Rubus idaeus strigosus	0.01	1.54	0.49
Rubus pensylvanicus	0.01	1.54	0.49
Salix bebbiana	0.00	1.54	0.48
Salix discolor	0.05	1.54	0.58
Sambucus nigra ssp. canadensis	0.05	3.08	1.08
Thuja occidentalis	0.05	1.54	0.58
Toxicodendron vernix	1.92	20.00	10.59
Ulmus rubra	0.74	7.69	4.08
Unknown	0.02	3.08	1.01
Vaccinium corymbosum	0.11	6.15	2.15
Viburnum lentago	0.15	6.15	2.24
Vitis labrusca	4.68	30.77	20.23
Vitis riparia	0.12	9.23	3.14

Appendix **SII:B-4** (shrubs and woody vines) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Total	**43.74**	**3.23**	
Herbaceous Vegetation			
Acer rubrum	0.07	20.55	2.02
Alisma subcordatum	0.18	4.11	0.69
Amphicarpaea bracteata	0.04	2.74	0.33
Apios americana	0.37	13.70	1.90
Betula alleghaniensis	0.02	4.11	0.42
Bidens connata	2.09	42.47	7.48
Boehmeria cylindrica	2.06	34.25	6.67
Bromus ciliatus	0.01	1.37	0.14
Caltha palustris	3.37	41.10	9.54
Cardamine bulbosa	0.70	28.77	3.85
Cardamine pensylvanica	0.41	23.29	2.86
Carex blanda	0.01	1.37	0.14
Carex comosa	0.55	6.85	1.58
Carex lacustris	0.52	4.11	1.26
Carex seorsa	1.51	36.99	6.00
Carex spp	0.02	4.11	0.42
Carex stipata	0.21	2.74	0.60
Celastrus orbiculatus	0.01	1.37	0.14
Chelone glabra	0.04	1.37	0.20
Cicuta bulbifera	0.01	2.74	0.28
Cinna arundinacea	0.01	2.74	0.28
Cirsium muticum	0.28	2.74	0.73
Coptis trifolia	0.01	2.74	0.28
Cornus spp	0.48	2.74	1.07
Cryptotaenia canadensis	0.04	1.37	0.20
Cuscuta gronovii	0.02	4.11	0.42
Decodon verticillatus	1.96	9.59	4.22
Doellingeria umbellata var. umbellata	0.04	1.37	0.20
Dryopteris cristata	0.04	1.37	0.20
Dryopteris carthusiana	0.09	4.11	0.53
Eleocharis rostellata	0.01	1.37	0.14
Epilobium coloratum	0.05	4.11	0.47
Epilobium leptophyllum	0.05	2.74	0.34
Equisetum arvense	0.04	1.37	0.20
Eupatorium maculatum	0.08	2.74	0.39
Eupatorium perfoliatum	0.01	1.37	0.14
Fraxinus spp	0.10	5.48	0.67
Galium triflorum	0.07	6.85	0.75
Geum canadense	0.02	4.11	0.42
Glyceria spp.	0.07	6.85	0.75
Glyceria striata	0.37	34.25	3.80
Grass spp	0.01	2.74	0.28
Ilex verticillata	0.08	10.96	1.16
Impatiens capensis	3.64	65.75	12.27
Lathyrus palustris	0.01	1.37	0.14
Leersia oryzoides	2.88	42.47	8.82
Lemna minor	0.06	5.48	0.60
Lindera benzoin	0.27	19.18	2.23
Liparis loeselii	0.00	2.74	0.26

Appendix **SII:B-4** (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Lycopus rubellus	0.54	10.96	1.93
Lycopus spp	0.01	2.74	0.28
Lycopus uniflorus	0.01	2.74	0.28
Lysimachia thyrsiflora	0.23	12.33	1.54
Maianthemum canadense	1.11	38.36	5.44
Mitchella repens	0.11	2.74	0.44
Myosotis laxa	0.16	5.48	0.78
Onoclea sensibilis	2.64	30.14	7.27
Osmunda cinnamomea	4.16	21.92	9.09
Osmunda regalis	0.01	1.37	0.14
Packera aureus	0.35	9.59	1.48
Parnassia glauca	0.04	1.37	0.20
Parthenocissus quinquefolia	0.30	9.59	1.40
Peltandra virginica	0.10	1.37	0.30
Platanthera clavellata	0.03	5.48	0.55
Phragmites australis	0.14	2.74	0.50
Pilea fontana	1.14	60.27	7.53
Polygonum arifolium	0.73	12.33	2.38
Polygonum punctatum	0.01	1.37	0.14
Polygonum sagittatum	0.26	6.85	1.08
Prunella vulgaris ssp. Lanceolata	0.04	1.37	0.20
Ranunculus recurvatus	0.12	9.59	1.09
Ranunculus sceleratus	0.05	2.74	0.34
Rosa palustris	0.01	1.37	0.14
Rubus pubescens	0.17	8.22	1.05
Rumex spp	0.01	1.37	0.14
Scutellaria galericulata	0.22	10.96	1.39
Scutellaria lateriflora	0.92	39.73	5.25
Solanum dulcamara	0.49	12.33	1.97
Solidago gigantea	0.04	1.37	0.20
Solidago patula	1.36	35.62	5.60
Sphagnum	0.11	2.74	0.44
Symphyotrichum boreale	0.04	1.37	0.20
Symphyotrichum lanceolatum var. lanceolatum	0.25	10.96	1.45
Symphyotrichum lateriflorum var. lateriflorum	0.95	23.29	3.77
Symphyotrichum puniceum var. puniceum	0.08	2.74	0.39
Symplocarpus foetidus	16.16	63.01	33.28
Thalictrum dasycarpum	0.01	1.37	0.14
Thelypteris palustris var. pubescens	0.50	15.07	2.25
Toxicodendron radicans ssp. radicans	0.16	5.48	0.78
Toxicodendron vernix	0.19	5.48	0.83
Trientalis borealis	0.02	4.11	0.42
Typha X glauca & T. angustifolia	0.84	15.07	2.83
Urtica dioica ssp. Gracilis	0.34	2.74	0.84
Viola spp	0.62	24.66	3.34
Vitis riparia	0.05	2.74	0.34
Vitis labrusca	0.04	1.37	0.20
Total	**58.88**		

APPENDIX SII:B-5: RESULTS OF QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – EAST SHRUB UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	0.03	6.88	0.34	15.40
Betula alleghaniensis	0.01	0.44	0.04	1.89
Cephalanthus occidentalis	0.01	0.21	0.04	1.77
Fraxinus nigra	0.01	2.86	0.11	4.29
Nyssa sylvatica	0.00	0.00	0.02	0.27
Populus tremuloides	0.17	60.68	1.67	92.19
Prunus serotina	0.01	1.74	0.05	3.79
Quercus alba	0.00	0.00	0.02	0.27
Quercus bicolor	0.00	0.00	0.02	0.27
Quercus palustris	0.01	0.90	0.04	2.12
Salix amygdaloides	0.08	92.57	1.60	90.40
Salix discolor	0.08	9.96	0.47	28.99
Salix fragilis	0.04	6.20	0.21	13.68
Salix myricoides var. myricoides	0.03	3.48	0.19	11.05
Salix nigra	0.05	10.98	0.72	26.93
Sassafras albidum	0.00	0.00	0.03	0.55
Taxodium distichum	0.00	0.00	0.09	1.60
Ulmus rubra	0.02	2.02	0.03	4.55
Total	**0.53**	**198.90**	**5.68**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	0.02	0.52	0.53
Alnus rugosa	0.02	0.52	0.53
Betula lutea	0.02	0.52	0.53
Celastrus orbiculatus	0.09	0.52	1.00
Cephalanthus occidentalis	3.60	14.95	35.05
Cornus obliqua	3.60	16.49	36.37
Cornus racemosa	0.54	5.15	7.76
Cornus stolonifera	0.55	10.31	12.18
Ilex verticillata	0.02	1.03	0.99
Lindera benzoin	0.34	4.64	6.06
Populus tremuloides	0.02	1.55	1.42
Rhamnus alnifolia	0.00	0.52	0.45
Ribes spp.	0.00	0.52	0.45
Rosa multiflora	0.11	2.06	2.44
Rosa palustris	2.45	22.68	34.47
Rubus idaeus strigosus	0.00	0.52	0.45
Rubus occidentalis	0.00	0.52	0.45
Rubus pensylvanicus	0.05	1.03	1.21
Salix discolor	1.17	4.64	11.19
Salix eriocephala	0.70	3.09	6.95
Salix glaucophylloides	0.02	0.52	0.53
Salix interior	0.21	6.70	7.00
Salix nigra	0.00	0.52	0.45
Salix petiolaris	0.53	2.06	5.06
Salix rubens	0.04	0.52	0.68
Sambucus nigra ssp. canadensis	0.04	1.03	1.12

Appendix SII:B-5 (shrubs and woody vines) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Spiraea spp.	0.98	5.15	10.45
Toxicodendron vernix	0.20	3.09	3.88
Viburnum lentago	0.60	2.58	5.90
Vitis labrusca	0.22	3.09	3.97
Vitis riparia	0.00	0.52	0.45
Total	**16.12**		
Herbaceous Vegetation			
Acer rubrum	0.05	2.93	0.40
Alisma subcordatum	0.08	2.93	0.44
Amphicarpaea bracteata	0.06	3.41	0.48
Angelica atropurpurea	0.01	0.49	0.08
Apios americana	0.05	2.44	0.35
Apocynum spp	0.01	0.49	0.08
Asclepias incarnata	0.10	2.44	0.43
Bidens connata	0.17	5.85	0.91
Boehmeria cylindrica	0.70	14.63	2.65
Calamagrostis canadensis	2.39	37.07	7.59
Caltha palustris	0.01	0.49	0.08
Calystegia sepium ssp. Sepium	0.17	6.34	0.97
Campanula aparinoides	0.08	6.83	0.89
Cardamine bulbosa	0.02	1.95	0.25
Cardamine pensylvanica	0.03	1.46	0.21
Carex aquatilis	3.00	14.63	5.91
Carex atherodes	0.10	4.39	0.65
Carex comosa	0.11	1.46	0.32
Carex lacustris	2.01	15.12	4.57
Carex lasiocarpa	0.27	2.93	0.71
Carex lupulina	0.00	0.49	0.06
Carex scoparia	0.01	0.49	0.08
Carex stipata	0.21	6.83	1.07
Carex stricta	3.19	18.54	6.63
Carex tenera	0.00	0.49	0.06
Carex utriculata	0.05	1.95	0.29
Carex vulpinoidea	0.04	0.49	0.11
Celastrus orbiculatus	0.03	1.46	0.21
Cephalanthus occidentalis	0.16	2.93	0.56
Chelone glabra	0.00	0.49	0.06
Cicuta bulbifera	0.06	5.37	0.70
Circaea lutetiana	0.07	1.95	0.31
Cirsium arvense	0.04	0.49	0.11
Cirsium muticum	0.02	0.98	0.13
Clematis virginiana	0.00	0.98	0.12
Convolvulus arvensis	0.05	3.41	0.46
Coptis trifolia	0.04	0.49	0.11
Cornus spp	0.19	7.32	1.10
Cuscuta gronovii	0.03	6.34	0.77
Decodon verticillatus	0.60	7.32	1.69
Dichanthelium clandestinum	0.04	0.49	0.11
Dryopteris carthusiana	0.07	1.46	0.26
Epilobium coloratum	0.30	12.68	1.87
Epilobium leptophyllum	0.07	3.90	0.54

Appendix SII:B-5 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Equisetum arvense	0.04	3.90	0.50
Erechtites hieracifolia	0.02	0.98	0.13
Eupatorium maculatum	2.50	24.39	6.32
Eupatorium perfoliatum	0.18	2.44	0.53
Galium obtusum	0.17	20.00	2.51
Galium spp	0.02	4.39	0.52
Galium tinctorium	0.26	11.71	1.70
Galium trifidum	0.01	1.95	0.24
Galium triflorum	0.02	0.98	0.13
Geum canadense	0.05	1.46	0.24
Glyceria spp.	0.01	0.49	0.08
Glyceria striata	0.51	7.32	1.55
Ilex verticillata	0.01	0.49	0.08
Impatiens capensis	3.91	61.95	12.58
Iris virginica	0.27	2.93	0.71
Juncus balticus	0.01	0.49	0.08
Juncus effusus	0.07	2.93	0.43
Lathyrus palustris	0.06	4.88	0.64
Leersia oryzoides	0.86	23.41	3.88
Lemna minor	0.69	8.78	1.97
Lindera benzoin	0.13	2.93	0.52
Lonicera spp.	0.00	0.49	0.06
Ludwigia palustris	0.09	0.98	0.24
Lycopus americanus	0.08	2.93	0.44
Lycopus rubellus	0.02	0.98	0.13
Lycopus spp	0.00	0.98	0.12
Lycopus uniflorus	0.57	17.07	2.74
Lysimachia terrestris	0.01	0.49	0.08
Lysimachia thyrsiflora	0.32	9.76	1.57
Maianthemum stellatum	0.01	0.49	0.08
Mentha arvensis	1.40	20.00	4.26
Mimulus ringens	0.05	0.98	0.18
Nuphar lutea ssp. advena	0.03	0.98	0.15
Onoclea sensibilis	6.21	28.78	12.08
Osmunda regalis	0.45	1.46	0.81
Parthenocissus quinquefolia	0.10	7.80	1.03
Peltandra virginica	0.35	5.85	1.16
Photinia floribunda	0.00	0.49	0.06
Phragmites australis	0.13	1.95	0.40
Pilea fontana	2.81	60.98	10.91
Polygonum amphibium	0.87	14.63	2.90
Polygonum punctatum	0.84	21.95	3.68
Polygonum sagittatum	1.10	34.63	5.49
Polygonum virginianum	0.02	0.98	0.13
Populus deltoides	0.02	0.98	0.13
Populus tremuloides	0.02	0.98	0.13
Potentilla norvegica	0.00	0.49	0.06
Potentilla simplex	0.01	0.49	0.08
Prenanthes alba	0.01	0.49	0.08
Pycnanthemum virginianum	0.00	0.49	0.06
Quercus spp	0.00	0.49	0.06

Appendix SII:B-5 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Ranunculus sceleratus	0.01	0.49	0.08
Rhamnus alnifolia	0.00	0.49	0.06
Ribes americanum	0.01	1.46	0.18
Rosa multiflora	0.12	1.95	0.39
Rosa palustris	0.33	9.27	1.52
Rubus idaeus	0.02	0.98	0.13
Rubus occidentalis	0.00	0.49	0.06
Rubus pensylvanicus	0.01	0.49	0.08
Rubus pubescens	0.11	1.46	0.33
Rumex crispus	0.10	1.95	0.37
Rumex spp	0.26	3.90	0.82
Sagittaria latifolia	0.18	3.41	0.64
Sambucus nigra ssp. Canadensis	0.02	2.44	0.31
Sassafras albidum	0.04	0.49	0.11
Schoenoplectus acutus var acutus	0.00	0.98	0.11
Schoenoplectus fluviatilis	0.05	0.98	0.18
Scirpus atrovirens	0.10	0.98	0.25
Scirpus cyperinus	0.50	2.44	0.99
Scutellaria galericulata	0.97	19.51	3.59
Scutellaria lateriflora	0.91	20.00	3.57
Sium suave	0.19	3.41	0.66
Solanum dulcamara	0.32	8.29	1.40
Solidago canadensis var. scabra	0.10	1.46	0.31
Solidago gigantea	0.21	4.39	0.79
Solidago patula	0.03	1.46	0.21
Sonchus arvensis ssp. uliginosus	0.01	0.49	0.08
Sparganium eurycarpum	0.27	2.93	0.71
Symphyotrichum lanceolatum var. lanceolatum	0.16	5.37	0.83
Symphyotrichum lateriflorum var. lateriflorum	0.00	0.98	0.12
Symphyotrichum puniceum var. puniceum	0.09	3.90	0.57
Symplocarpus foetidus	0.96	7.32	2.19
Taraxacum officinale	0.01	0.49	0.08
Thalictrum dasycarpum	0.02	0.98	0.13
Thelypteris noveboracensis	0.05	0.98	0.18
Thelypteris palustris var. pubescens	1.50	18.05	4.17
Toxicodendron radicans ssp. Radicans	0.01	0.49	0.08
Toxicodendron vernix	0.01	0.49	0.08
Typha X glauca & T. angustifolia	22.06	87.32	41.25
Urtica dioica ssp. Gracilis	0.45	7.32	1.47
Verbena hastata	0.06	2.93	0.42
Vernonia fasciculata	0.00	0.49	0.06
Viola spp	0.01	2.93	0.35
Vitis labrusca	0.00	0.98	0.11
Total	**70.39**		

APPENDIX SII:B-6: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – RAISED FEN UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	0.42	186.64	5.16	86.31
Betula alleghaniensis	0.13	51.25	2.39	29.97
Cephalanthus occidentalis	0.01	5.89	0.06	1.87
Fraxinus americana	0.23	14.95	2.23	27.99
Fraxinus nigra	0.01	2.70	0.15	1.79
Larix laricina	0.03	18.77	0.39	7.44
Morus alba	0.01	7.35	0.34	3.74
Pinus strobus	0.03	59.71	0.48	14.87
Populus tremuloides	0.01	0.60	0.05	0.86
Prunus serotina	0.02	3.96	0.07	2.03
Quercus velutina	0.00	0.00	0.00	0.02
Salix discolor	0.04	3.73	0.30	4.68
Thuja occidentalis	0.64	185.26	4.34	93.61
Toxicodendron vernix	0.17	8.31	0.51	13.61
Ulmus rubra	0.03	5.61	0.08	3.32
Viburnum lentago	0.07	4.38	0.59	7.89
Total	**1.83**	**559.10**	**17.14**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	0.09	1.67	1.44
Alnus incana ssp. rugosa	0.31	0.83	1.87
Berberis thunbergii	0.03	0.83	0.64
Betula alleghaniensis	0.06	0.83	0.80
Cornus obliqua	0.09	2.50	2.00
Cornus racemosa	0.25	5.00	4.28
Cornus sericea ssp. sericea	2.91	15.83	22.65
Fraxinus americana	0.27	5.83	4.90
Ilex verticillata	0.08	3.33	2.48
Lindera benzoin	13.54	40.00	83.71
Lonicera dioica	0.15	0.83	1.16
Lonicera japonica	1.95	6.67	12.62
Menispermum canadense	0.00	0.83	0.55
Parthenocissus quinquefolia	0.15	10.00	7.08
Populus tremuloides	0.00	0.83	0.55
Prunus serotina	0.05	1.67	1.28
Ribes americanum	0.01	1.67	1.11
Ribes cynosbati	0.03	0.83	0.64
Rosa multiflora	0.03	2.50	1.75
Rubus occidentalis	0.00	0.83	0.55
Salix eriocephala	0.00	0.83	0.55
Solanum dulcamara	0.07	2.50	1.91
Thuja occidentalis	0.03	1.67	1.19
Toxicodendron vernix	2.26	27.50	27.33
Ulmus rubra	0.03	1.67	1.19
Ulmus spp.	0.03	0.83	0.64
Unknown	0.02	1.67	1.14
Viburnum lentago	0.53	5.83	6.03
Vitis labrusca	0.30	8.33	6.65

Appendix SII:B-6 (shrubs and woody vines) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Vitis spp.	0.05	1.67	1.28
Total	**23.33**		
Herbaceous Vegetation			
Acer rubrum	0.02	6.43	0.66
Angelica atropurpurea	0.34	1.61	0.50
Apocynum spp	0.44	6.02	1.05
Arisaema triphyllum	0.55	25.30	3.09
Asclepias incarnata	0.00	0.80	0.08
Bidens connata	0.01	2.41	0.25
Bidens frondosa	0.00	0.80	0.08
Boehmeria cylindrica	0.61	14.46	2.07
Botrychium dissectum	0.01	0.40	0.05
Bromus ciliatus	0.00	0.80	0.08
Calamagrostis canadensis	0.40	2.81	0.69
Caltha palustris	0.07	3.21	0.40
Calystegia sepium ssp. sepium	0.13	5.62	0.70
Campanula aparinoides	0.01	1.61	0.17
Cardamine bulbosa	0.16	17.67	1.93
Cardamine pensylvanica	0.02	1.61	0.18
Carex bromoides	0.00	0.40	0.04
Carex comosa	0.16	4.02	0.56
Carex crinita	0.03	0.40	0.07
Carex cristatella	0.28	1.20	0.40
Carex hystericina	0.27	4.42	0.72
Carex interior	0.08	1.20	0.21
Carex lasiocarpa	0.17	2.41	0.42
Carex lurida	0.02	1.61	0.18
Carex projecta	0.01	0.40	0.05
Carex radiata	0.00	0.40	0.04
Carex rosea	0.01	0.40	0.05
Carex seorsa	0.05	1.61	0.21
Carex stipata	0.02	0.80	0.10
Chelone glabra	0.01	0.40	0.05
Cicuta bulbifera	0.00	0.40	0.04
Cinna arundinacea	0.02	2.81	0.31
Circaea lutetiana	0.02	2.01	0.22
Cirsium arvense	0.67	17.67	2.44
Cirsium muticum	0.18	6.83	0.86
Clematis virginiana	0.56	11.65	1.73
Convolvulus arvensis	0.01	1.61	0.17
Cornus spp	1.00	7.63	1.78
Cryptotaenia canadensis	0.16	3.61	0.53
Cuscuta gronovii	0.26	15.66	1.82
Doellingeria umbellata var. umbellata	0.03	0.40	0.07
Dryopteris carthusiana	0.17	5.62	0.74
Elymus spp.	0.01	2.41	0.25
Epilobium coloratum	0.09	7.63	0.85
Epilobium leptophyllum	0.01	0.40	0.05
Epipactis helleborine	0.00	0.40	0.04
Equisetum arvense	0.00	0.80	0.08
Eupatorium maculatum	4.03	34.54	7.54

Appendix SII:B-6 (herbaceous vegetation) continued.

Scientific Name	Cover	Frequency	Importance
Eupatorium perfoliatum	0.22	3.61	0.59
Fragaria virginiana	0.00	0.80	0.08
Fraxinus spp	0.11	3.61	0.47
Galium spp	0.00	0.40	0.04
Galium trifidum	0.01	0.80	0.09
Galium triflorum	1.28	36.95	4.99
Geum canadense	0.21	10.04	1.22
Geum laciniatum	0.06	1.61	0.22
Glyceria striata	0.80	18.88	2.69
Ilex verticillata	0.00	0.40	0.04
Impatiens capensis	12.24	57.43	18.18
Juncus canadensis	0.00	0.40	0.04
Lathyrus palustris	0.01	1.20	0.13
Leersia oryzoides	1.28	9.24	2.22
Leersia virginica	0.10	0.80	0.18
Lindera benzoin	5.64	40.96	9.82
Liparis loeselii	0.06	4.42	0.50
Lobelia siphilitica	0.12	5.22	0.65
Lonicera spp.	0.01	0.40	0.05
Lycopus americanus	0.28	5.22	0.81
Lycopus rubellus	0.03	1.61	0.19
Lycopus spp	0.00	0.40	0.04
Lycopus uniflorus	0.14	5.62	0.71
Lysimachia ciliata	0.01	0.40	0.05
Lysimachia thyrsiflora	0.01	0.80	0.09
Maianthemum canadense	0.09	8.03	0.89
Maianthemum stellatum	0.02	2.81	0.30
Mentha arvensis	0.01	0.80	0.09
Monarda fistulosa	0.00	0.40	0.04
Muhlenbergia mexicana	0.55	6.83	1.24
Myosotis laxa	0.01	0.40	0.05
Onoclea sensibilis	0.12	5.22	0.64
Oxypolis rigidior	0.00	0.40	0.04
Packera aureus	0.16	1.20	0.29
Parthenocissus quinquefolia	0.66	32.93	3.96
Pedicularis lanceolata	0.04	0.80	0.12
Phragmites australis	2.23	25.30	4.80
Pilea fontana	10.65	69.08	17.72
Platanthera clavellata	0.01	0.40	0.05
Poa pratensis	0.01	0.80	0.09
Polygonum punctatum	0.20	8.43	1.05
Polygonum sagittatum	0.29	18.07	2.10
Polygonum scandens	0.03	0.40	0.07
Quercus spp	0.01	0.40	0.05
Ranunculus abortivus	0.00	0.80	0.08
Ranunculus pensylvanicus	0.00	0.40	0.04
Ranunculus recurvatus	0.07	7.23	0.79
Ranunculus sceleratus	0.00	0.40	0.04
Rhamnus alnifolia	0.03	0.80	0.11
Ribes americanum	0.06	4.02	0.46
Ribes hirtellum	0.04	2.01	0.25

Appendix SII:B-6 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Rosa palustris	0.02	2.01	0.22
Rubus idaeus	0.11	2.41	0.35
Rubus pubescens	0.03	1.61	0.19
Rumex obtusifolius	0.03	1.20	0.15
Salix discolor	0.16	0.80	0.25
Sambucus nigra ssp. canadensis	0.06	2.01	0.26
Scirpus atrovirens	0.00	0.40	0.04
Scutellaria galericulata	0.09	6.02	0.69
Scutellaria lateriflora	0.16	10.84	1.25
Sium suave	0.00	0.40	0.04
Smilax tamnoides	0.03	1.61	0.19
Solanum dulcamara	0.10	4.82	0.59
Solidago gigantea	2.50	20.08	4.54
Solidago patula	1.81	24.10	4.25
Sonchus arvensis ssp. uliginosus	0.00	0.40	0.04
Sphenopholis intermedia	0.01	0.80	0.09
Stachys palustris	0.01	0.40	0.05
Stachys tenuifolia	0.04	1.61	0.20
Symphyotrichum lanceolatum var. lanceolatum	0.49	6.02	1.10
Symphyotrichum lateriflorum var. lateriflorum	2.37	35.34	5.94
Symphyotrichum puniceum var. puniceum	0.06	2.01	0.26
Symplocarpus foetidus	25.10	60.64	31.57
Taraxacum officinale	0.00	0.80	0.08
Thalictrum dasycarpum	0.93	19.28	2.87
Thelypteris palustris var. pubescens	0.61	14.86	2.11
Toxicodendron radicans ssp. radicans	0.05	2.81	0.34
Toxicodendron vernix	0.01	0.40	0.05
Typha X glauca & T. angustifolia	12.54	71.49	19.88
Ulmus rubra	0.08	2.01	0.28
Urtica dioica ssp. gracilis	1.12	25.30	3.67
Viburnum lentago	0.06	2.81	0.35
Viola spp	0.54	26.10	3.15
Vitis riparia	0.03	3.21	0.36
Vitis labrusca	0.10	4.02	0.50
Total	**98.35**		

APPENDIX SII:B-7: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – NORTH GRAMINOID FEN UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Betula alleghaniensis	0.21	15.90	1.18	25.53
Fraxinus americana	0.03	4.53	0.09	3.43
Fraxinus nigra	0.15	10.28	0.60	15.74
Larix laricina	0.85	303.58	6.18	174.94
Pinus strobus	0.03	18.11	0.51	10.71
Salix discolor	0.24	15.43	0.54	20.96
Salix eriocephala	0.09	16.65	0.31	11.45
Toxicodendron vernix	0.06	2.43	0.18	5.28
Ulmus rubra	0.29	31.36	0.99	31.97
Total	**1.94**	**418.26**	**10.57**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	0.25	6.25	4.36
Alnus incana ssp. rugosa	0.13	9.38	4.29
Betula alleghaniensis	0.34	9.38	6.26
Cornus obliqua	0.08	15.63	5.97
Cornus sericea ssp. sericea	3.81	59.38	54.40
Elaeagnus umbellata	0.02	3.13	1.19
Fraxinus nigra	0.25	6.25	4.36
Larix laricina	0.91	15.63	13.44
Lindera benzoin	1.36	9.38	15.43
Lonicera	0.67	15.63	11.33
Lonicera dioica	0.05	6.25	2.53
Parthenocissus quinquefolia	0.03	6.25	2.39
Populus tremuloides	0.02	3.13	1.19
Ribes cynosbati	0.02	3.13	1.19
Rosa palustris	0.03	6.25	2.39
Salix discolor	0.89	25.00	16.46
Salix eriocephala	0.02	3.13	1.19
Salix myricoides var. myricoides	0.13	9.38	4.29
Toxicodendron vernix	1.77	65.63	38.07
Ulmus rubra	0.09	3.13	1.90
Viburnum lentago	0.22	12.50	6.18
Vitis spp.	0.02	3.13	1.19
Total	**11.08**		

Herbaceous Vegetation

Acer rubrum	0.02	7.78	0.73
Agrimonia parviflora	0.01	1.11	0.11
Agrostis gigantea	0.01	2.22	0.22
Agrostis perennans	0.01	3.33	0.32
Apocynum spp	0.03	1.11	0.14
Arisaema triphyllum	0.01	2.22	0.21
Asclepias incarnata	0.04	10.00	0.95
Betula pumila	0.44	4.44	0.98
Bidens connata	0.11	5.56	0.65
Bidens frondosa	0.01	2.22	0.21
Boehmeria cylindrica	3.30	24.44	6.54
Bromus ciliatus	0.19	10.00	1.15

Appendix SII:B-7 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Calamagrostis canadensis	0.08	4.44	0.50
Caltha palustris	1.44	24.44	4.10
Calystegia sepium ssp. sepium	0.03	1.11	0.14
Campanula aparinoides	0.14	6.67	0.78
Cardamine bulbosa	0.14	17.78	1.80
Cardamine pensylvanica	0.01	1.11	0.11
Carex alata	0.17	2.22	0.42
Carex comosa	0.71	7.78	1.64
Carex cristatella	0.01	1.11	0.11
Carex echinata	0.26	3.33	0.64
Carex hystericina	0.86	17.78	2.74
Carex interior	1.11	11.11	2.46
Carex lasiocarpa	0.01	1.11	0.11
Carex leptalea	0.46	3.33	0.90
Carex rosea	0.03	1.11	0.14
Carex stipata	0.18	7.78	0.94
Chelone glabra	0.03	1.11	0.14
Cicuta bulbifera	0.01	1.11	0.11
Cinna arundinacea	0.27	4.44	0.75
Cirsium arvense	0.04	3.33	0.36
Cirsium muticum	0.04	2.22	0.25
Clematis virginiana	0.09	2.22	0.32
Convolvulus arvensis	0.03	1.11	0.14
Cornus spp	1.29	25.56	4.01
Cuscuta gronovii	0.12	7.78	0.86
Decodon verticillatus	0.94	4.44	1.64
Doellingeria umbellata var. umbellata	0.07	3.33	0.40
Dryopteris carthusiana	0.09	2.22	0.32
Eleocharis rostellata	2.32	16.67	4.55
Epilobium coloratum	0.02	4.44	0.43
Epilobium leptophyllum	0.22	7.78	0.99
Erigeron philadelphicus	0.01	1.11	0.11
Eupatorium maculatum	1.62	32.22	5.03
Eupatorium perfoliatum	0.12	3.33	0.46
Fragaria virginiana	0.09	3.33	0.42
Fraxinus spp	0.08	5.56	0.61
Galium labradoricum	0.13	4.44	0.57
Galium triflorum	0.17	11.11	1.22
Geum canadense	0.01	2.22	0.22
Glyceria striata	1.23	25.56	3.93
Triadenum virginicum	0.03	6.67	0.64
Ilex verticillata	0.17	2.22	0.42
Impatiens capensis	1.37	28.89	4.40
Iris virginica	0.01	1.11	0.11
Lathyrus palustris	0.01	1.11	0.11
Leersia oryzoides	3.18	27.78	6.68
Lemna minor	0.08	1.11	0.21
Lindera benzoin	1.31	20.00	3.53
Liparis loeselii	0.01	1.11	0.11
Lobelia kalmii	0.02	4.44	0.42
Lobelia siphilitica	0.22	5.56	0.79

Appendix SII:B-7 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Lycopus americanus	0.24	5.56	0.82
Lycopus rubellus	0.12	3.33	0.46
Lycopus uniflorus	0.26	21.11	2.25
Lysimachia thyrsiflora	0.07	6.67	0.69
Maianthemum canadense	0.22	13.33	1.50
Mentha arvensis	0.04	3.33	0.36
Muhlenbergia mexicana	0.98	14.44	2.59
Myosotis laxa	0.84	5.56	1.61
Onoclea sensibilis	0.89	16.67	2.67
Oxypolis rigidior	0.05	10.00	0.96
Parnassia glauca	0.98	5.56	1.79
Parthenocissus quinquefolia	0.41	13.33	1.74
Pedicularis lanceolata	0.04	2.22	0.25
Peltandra virginica	0.01	1.11	0.11
Phragmites australis	1.12	14.44	2.78
Physocarpus opulifolius	0.11	4.44	0.54
Pilea fontana	2.03	52.22	7.38
Poa pratensis	0.03	1.11	0.14
Polygonum punctatum	0.01	2.22	0.22
Polygonum sagittatum	0.01	2.22	0.22
Populus tremuloides	0.01	1.11	0.11
Ranunculus sceleratus	0.03	1.11	0.14
Ribes americanum	0.18	4.44	0.64
Ribes hirtellum	0.26	10.00	1.25
Rosa multiflora	0.08	1.11	0.21
Rosa palustris	0.04	3.33	0.36
Rubus pubescens	0.59	15.56	2.19
Rumex obtusifolius	0.07	3.33	0.40
Rumex spp	0.01	1.11	0.11
Salix discolor	0.12	2.22	0.36
Sambucus nigra ssp. canadensis	0.01	1.11	0.11
Scirpus atrovirens	0.01	1.11	0.11
Scutellaria galericulata	0.23	20.00	2.11
Scutellaria lateriflora	0.23	13.33	1.51
Solanum dulcamara	0.04	3.33	0.36
Solidago canadensis var. scabra	0.03	1.11	0.14
Solidago gigantea	1.93	14.44	3.83
Solidago patula	2.81	32.22	6.60
Solidago uliginosa	0.21	4.44	0.68
Sphenopholis intermedia	0.01	1.11	0.11
Symphyotrichum boreale	0.54	17.78	2.31
Symphyotrichum lanceolatum var. lanceolatum	0.13	8.89	0.97
Symphyotrichum lateriflorum var. lateriflorum	1.62	34.44	5.24
Symphyotrichum praealtum var. praealtum	0.42	1.11	0.65
Symphyotrichum puniceum var. puniceum	0.39	17.78	2.12
Symplocarpus foetidus	4.57	27.78	8.51
Taraxacum officinale	0.01	1.11	0.11
Thalictrum dasycarpum	0.12	3.33	0.46
Thelypteris palustris var. pubescens	3.35	41.11	8.11
Toxicodendron radicans ssp. radicans	0.04	3.33	0.36
Toxicodendron vernix	0.58	13.33	1.96

Appendix SII:B-7 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Trientalis borealis	0.03	1.11	0.14
Typha X glauca & T. angustifolia	21.14	84.44	35.35
Ulmus rubra	0.01	1.11	0.11
Urtica dioica ssp. gracilis	1.62	15.56	3.53
Viola spp.	0.99	34.44	4.41
Vitis riparia	0.03	1.11	0.14
Vitis labrusca	0.03	1.11	0.14
Total	**76.26**		

APPENDIX SII:B-8: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – SOUTH GRAMINOID FEN UNIT				
Trees- Diameter at Breast Height of Seven cm or Greater				
Scientific Name	**Density**	**Basal area**	**Cover**	**Importance**
No trees were present				
Shrubs and Woody Vines				
Scientific Name		**Cover**	**Frequency**	**Importance**
Cornus obliqua		1.07	14.29	31.25
Cornus sericea ssp. sericea		3.57	28.57	87.50
Toxicodendron vernix		0.93	42.86	53.75
Viburnum lentago		0.14	28.57	27.50
Total		**5.71**		
Herbaceous Vegetation				
Acer rubrum		0.02	4.00	0.45
Apocynum spp		0.12	4.00	0.60
Asclepias incarnata		0.02	4.00	0.45
Bidens coronata		0.14	8.00	1.05
Boehmeria cylindrica		0.26	12.00	1.65
Boehmeria cylindrica		0.02	4.00	0.45
Campanula aparinoides		0.08	16.00	1.79
Cardamine bulbosa		0.36	16.00	2.22
Cardamine pensylvanica		0.12	4.00	0.60
Carex aquatilis		0.78	20.00	3.27
Carex comosa		1.00	8.00	2.35
Carex lasiocarpa		0.48	20.00	2.82
Chelone glabra		0.02	4.00	0.45
Cicuta bulbifera		0.02	4.00	0.45
Cirsium muticum		0.70	4.00	1.47
Clematis virginiana		0.02	4.00	0.45
Cornus spp		0.80	24.00	3.72
Cuscuta gronovii		0.14	8.00	1.05
Dryopteris carthusiana		0.12	4.00	0.60
Eleocharis erythropoda		0.12	4.00	0.60
Epilobium leptophyllum		0.06	12.00	1.35
Equisetum arvense		0.14	8.00	1.05
Eupatorium maculatum		1.74	36.00	6.39
Eupatorium perfoliatum		0.66	16.00	2.67
Galium tinctorium		0.14	8.00	1.05
Galium trifidum		0.12	4.00	0.60
Glyceria spp.		0.02	4.00	0.45
Glyceria striata		0.16	12.00	1.50
Triadenum virginicum		0.02	4.00	0.45
Impatiens capensis		11.48	68.00	24.43
Lathyrus palustris		0.02	4.00	0.45
Leersia oryzoides		0.72	8.00	1.92
Lindera benzoin		0.50	20.00	2.85
Lycopus uniflorus		0.98	40.00	5.67
Lysimachia thyrsiflora		0.12	4.00	0.60
Maianthemum canadense		0.02	4.00	0.45
Mentha arvensis		0.14	8.00	1.05
Muhlenbergia mexicana		0.70	4.00	1.47
Myosotis laxa		0.02	4.00	0.45

Appendix SII:B-8 (herbaceous vegetation) continued.			
Scientific Name	**Cover**	**Frequency**	**Importance**
Onoclea sensibilis	0.90	24.00	3.87
Oxypolis rigidior	0.02	4.00	0.45
Parthenocissus quinquefolia	0.18	16.00	1.95
Pedicularis lanceolata	0.32	8.00	1.32
Phragmites australis	3.20	40.00	9.01
Pilea fontana	9.74	64.00	21.38
Polygonum punctatum	0.04	8.00	0.90
Polygonum sagittatum	0.02	4.00	0.45
Ribes americanum	0.30	4.00	0.87
Ribes hirtellum	0.42	8.00	1.47
Rubus idaeus	0.26	12.00	1.65
Rubus pubescens	0.12	4.00	0.60
Schoenoplectus acutus var. acutus	1.60	16.00	4.09
Scutellaria galericulata	0.78	20.00	3.27
Scutellaria lateriflora	0.14	8.00	1.05
Sium suave	0.12	4.00	0.60
Solanum dulcamara	0.02	4.00	0.45
Solidago gigantea	0.38	16.00	2.25
Solidago patula	0.04	8.00	0.90
Solidago uliginosa	0.12	4.00	0.60
Stachys palustris	0.14	8.00	1.05
Symphyotrichum lanceolatum var. lanceolatum	0.44	12.00	1.92
Symphyotrichum lateriflorum var. lateriflorum	0.72	8.00	1.92
Symphyotrichum puniceum var. puniceum	0.12	4.00	0.60
Symplocarpus foetidus	6.80	24.00	12.77
Thelypteris palustris var. pubescens	1.70	36.00	6.33
Toxicodendron vernix	0.26	12.00	1.65
Typha X glauca & T. angustifolia	13.54	96.00	30.46
Urtica dioica ssp. gracilis	0.46	16.00	2.37
Viola spp	0.30	20.00	2.54
Total	**66.30**		

APPENDIX SII:B-9: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – CATTAIL UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	0.01	0.51	0.02	12.14
Populus tremuloides	0.04	5.82	0.22	111.48
Salix amygdaloides	0.01	20.08	0.17	103.03
Salix discolor	0.01	0.47	0.03	13.45
Salix eriocephala	0.00	0.00	0.02	3.63
Salix nigra	0.01	3.68	0.07	30.58
Ulmus americana	0.00	0.17	0.02	7.63
Ulmus rubra	0.01	1.07	0.03	18.06
Total	**0.10**	**36.19**	**0.60**	

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubrum	0.10	1.38	6.89
Alnus incana ssp. rugosa	0.59	3.86	30.42
Amelanchier arborea	0.00	0.28	0.67
Betula pumila	0.00	0.28	0.67
Cephalanthus occidentalis	0.06	0.83	3.98
Cornus obliqua	0.18	4.13	15.89
Cornus racemosa	0.01	0.83	2.26
Cornus sericea ssp. sericea	0.52	6.34	33.19
Ilex verticillata	0.32	2.20	16.64
Lindera benzoin	0.03	0.55	2.30
Parthenocissus quinquefolia	0.02	1.65	4.51
Photinia floribunda	0.04	1.10	3.89
Populus tremuloides	0.00	0.28	0.67
Ribes americanum	0.02	1.38	3.85
Ribes spp.	0.00	0.28	0.67
Rosa palustris	0.17	4.13	15.59
Rubus idaeus strigosus	0.00	0.28	0.67
Salix discolor	0.15	1.10	8.09
Salix eriocephala	0.05	0.55	3.06
Salix myricoides var. myricoides	0.01	0.28	0.92
Salix petiolaris	0.11	1.10	6.37
Salix rubens	0.05	0.28	2.39
Salix sericea	0.00	0.28	0.67
Toxicodendron vernix	0.25	8.82	28.98
Ulmus rubra	0.01	0.28	0.92
Unknown	0.01	0.28	0.92
Vaccinium corymbosum	0.01	0.28	0.92
Viburnum lentago	0.00	0.55	1.34
Vitis riparia	0.01	1.10	2.67
Total	**2.72**		

Herbaceous Vegetation

Acer rubrum	0.00	1.00	0.22
Agrimonia parviflora	0.05	0.50	0.19
Alnus incana ssp. rugosa	0.01	0.25	0.07
Asclepias incarnata	0.03	0.75	0.21
Bidens connata	0.15	1.25	0.52
Bidens coronata	0.02	0.50	0.14

Appendix SII:B-9 (herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Boehmeria cylindrica	0.17	3.49	1.03
Calamagrostis canadensis	1.61	12.47	5.33
Caltha palustris	0.22	1.50	0.68
Calystegia sepium ssp. sepium	0.02	0.75	0.19
Campanula aparinoides	0.07	2.74	0.71
Cardamine bulbosa	0.05	1.75	0.46
Cardamine pensylvanica	0.00	0.50	0.11
Carex aquatilis	0.52	3.24	1.55
Carex atherodes	0.03	0.50	0.15
Carex comosa	0.14	0.75	0.40
Carex lacustris	0.51	4.99	1.92
Carex lasiocarpa	0.03	2.24	0.54
Carex leptalea	0.00	0.25	0.06
Carex seorsa	0.12	1.25	0.47
Carex stipata	0.03	1.00	0.27
Carex stricta	0.11	2.24	0.66
Carex utriculata	0.02	0.75	0.20
Celastrus orbiculatus	0.00	0.25	0.06
Cephalanthus occidentalis	0.01	0.50	0.12
Chelone glabra	0.01	0.25	0.07
Cicuta bulbifera	0.04	2.99	0.71
Cirsium muticum	0.01	0.50	0.13
Comarum palustre	0.01	0.25	0.07
Convolvulus arvensis	0.00	0.25	0.06
Cornus spp	0.24	4.24	1.31
Cuscuta gronovii	0.03	4.99	1.13
Decodon verticillatus	0.53	5.99	2.17
Dryopteris carthusiana	0.19	2.99	0.96
Echinochloa crusgalli	0.00	0.25	0.06
Eleocharis palustris	0.01	0.25	0.07
Eleocharis rostellata	0.02	1.00	0.25
Epilobium coloratum	0.37	11.97	3.20
Epilobium leptophyllum	0.24	12.72	3.16
Equisetum arvense	0.00	0.50	0.11
Erechtites hieracifolia	0.01	1.75	0.40
Eupatorium maculatum	0.32	8.73	2.41
Eupatorium perfoliatum	0.02	1.25	0.31
Galium labradoricum	0.00	0.25	0.06
Galium obtusum	0.04	5.24	1.20
Galium spp	0.01	1.50	0.34
Galium tinctorium	0.05	4.49	1.05
Galium trifidum	0.09	2.99	0.79
Galium triflorum	0.00	0.25	0.06
Glyceria striata	0.02	0.25	0.08
Grass spp	0.00	0.50	0.11
Ilex verticillata	0.01	0.25	0.07
Impatiens capensis	4.60	50.62	18.49
Iris virginica	0.00	0.25	0.06
Lathyrus palustris	0.03	1.25	0.32
Leersia oryzoides	0.29	6.73	1.93

Appendix SII:B-9 (herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Lemna minor	0.31	3.49	1.26
Lindera benzoin	0.01	0.50	0.12
Lycopus americanus	0.02	1.25	0.30
Lycopus rubellus	0.02	1.25	0.31
Lycopus spp	0.02	1.25	0.30
Lycopus uniflorus	0.25	5.24	1.54
Lysimachia terrestris	0.03	0.75	0.22
Lysimachia thyrsiflora	0.45	13.72	3.70
Maianthemum canadense	0.00	0.25	0.06
Maianthemum stellatum	0.00	0.25	0.06
Mentha arvensis	0.40	7.98	2.39
Mimulus ringens	0.03	0.50	0.15
Muhlenbergia mexicana	0.03	0.75	0.22
Myosotis laxa	0.18	1.75	0.67
Onoclea sensibilis	0.69	9.73	3.23
Osmunda regalis	0.01	0.25	0.07
Oxypolis rigidior	0.00	0.25	0.06
Parnassia glauca	0.00	0.25	0.06
Parthenocissus quinquefolia	0.06	1.00	0.31
Phalaris arundinacea	0.07	0.75	0.28
Photinia floribunda	0.00	0.25	0.06
Phragmites australis	1.07	11.97	4.35
Pilea fontana	3.08	45.89	14.99
Polygonum amphibium	0.00	0.25	0.06
Polygonum punctatum	0.29	7.98	2.21
Polygonum sagittatum	0.14	6.73	1.68
Pycnanthemum virginianum	0.00	0.25	0.06
Quercus spp	0.00	0.25	0.06
Ranunculus sceleratus	0.01	0.50	0.12
Ribes americanum	0.05	0.50	0.19
Rosa palustris	0.03	0.75	0.21
Rubus pubescens	0.05	1.00	0.30
Rumex crispus	0.08	1.00	0.34
Rumex spp	0.09	2.24	0.63
Sambucus nigra ssp. canadensis	0.01	0.25	0.07
Schoenoplectus acutus var. acutus	0.09	1.75	0.53
Schoenoplectus fluviatilis	0.04	0.75	0.24
Scirpus atrovirens	0.00	0.25	0.06
Scirpus cyperinus	0.01	0.25	0.07
Scutellaria galericulata	0.21	6.23	1.70
Scutellaria lateriflora	0.16	5.24	1.40
Sium suave	0.01	0.25	0.07
Solanum dulcamara	0.11	1.75	0.56
Solidago canadensis var. scabra	0.00	0.25	0.06
Solidago gigantea	0.04	0.25	0.13
Solidago patula	0.01	0.50	0.12
Solidago uliginosa	0.01	0.25	0.07
Stachys palustris	0.03	1.00	0.27
Stachys tenuifolia	0.00	0.50	0.11
Symphyotrichum boreale	0.04	1.00	0.28
Symphyotrichum lanceolatum var. lanceolatum	0.03	1.50	0.37

Appendix SII:B-9 (herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Symphyotrichum puniceum var. puniceum	0.03	1.25	0.32
Symplocarpus foetidus	0.06	1.00	0.32
Taraxacum officinale	0.00	0.50	0.11
Thalictrum dasycarpum	0.00	0.25	0.05
Thelypteris palustris var. pubescens	1.16	17.21	5.62
Triadenum virginicum	0.03	1.00	0.27
Toxicodendron radicans ssp. radicans	0.01	0.25	0.07
Toxicodendron vernix	0.11	0.75	0.35
Typha X glauca & T. angustifolia	40.32	97.51	86.75
Ulmus rubra	0.01	0.25	0.07
Urtica dioica ssp. gracilis	0.34	5.24	1.69
Verbena hastata	0.00	0.25	0.06
Viburnum lentago	0.00	0.25	0.06
Viola spp	0.02	1.00	0.26
Total	**61.51**		

APPENDIX SII:B-10: QUANTITATIVE ASSESSMENT OF COWLES BOG WETLAND COMPLEX's VEGETATION – DISTURBED PRAIRIE UNIT

Trees- Diameter at Breast Height of Seven cm or Greater

Scientific Name	Density	Basal area	Cover	Importance
Acer rubrum	2.19	1678.3	45.34	179.08
Acer saccharum	0.02	198.6	0.28	7.30
Lindera benzoin	0.06	2.4	0.35	1.95
Nyssa sylvatica	0.10	33.7	0.89	4.88
Populus deltoides	0.06	83.8	0.61	4.98
Populus tremuloides	0.03	40.8	0.24	2.46
Prunus serotina	0.80	346.4	4.03	36.03
Quercus alba	0.06	126.0	0.56	6.23
Quercus palustris	0.01	0.9	0.20	0.63
Quercus rubra	0.02	89.8	0.46	4.13
Robinia pseudoacacia	0.25	298.3	1.27	17.27
Sassafras albidum	0.71	226.8	5.62	32.81
Ulmus americana	0.02	15.3	0.16	1.27
Viburnum lentago	0.03	2.7	0.08	1.00
Total	4.36	3144.5	60.10	300.01

Shrubs and Woody Vines

Scientific Name	Cover	Frequency	Importance
Acer rubra	1.49	10.99	8.21
Celastrus orbiculatus	0.26	4.40	2.75
Ilex verticillata	0.61	3.30	2.73
Ligustrum vulgare	0.01	1.10	0.59
Lindernia benzoin	52.37	96.70	135.42
Parthenocissus quinquefolia	0.10	4.40	2.49
Populus deltoides	0.19	1.10	0.89
Prunus serotina	2.08	12.09	9.75
Prunus virginiana	0.36	3.30	2.32
Quercus bicolor	0.08	1.10	0.71
Rosa multiflora	0.49	19.78	11.26
Sassafras albidum	0.45	2.20	1.88
Ulmus Americanus	0.03	1.10	0.63
Viburnum lentago	0.23	3.30	2.12
Viburnum prunifolium	0.03	1.10	0.63
Vitis labrusca	3.37	23.08	17.63
Total	**62.1**		

Herbaceous Vegetation

Acer rubrum	0.03	1.14	0.83
Agrostis perennans	0.03	1.14	0.83
Boehmeria cylindrica	0.19	10.23	6.55
Carex annectens	0.20	1.14	2.17
Carex bromoides	0.03	1.14	0.83
Carex rosea	0.01	1.14	0.60
Carex spp.	0.07	2.27	1.67
Cinna arundinacea	0.03	1.14	0.83
Doellingeria umbellata var. umbellata	0.09	1.14	1.25
Dryopteris carthusiana	0.01	2.27	1.21
Equisetum arvense	0.01	1.14	0.60
Fraxinus americana	0.01	1.14	0.60
Galium aparine	0.04	2.27	1.44

Appendix SII:B-10 (herbaceous vegetation) continued			
Scientific Name	**Cover**	**Frequency**	**Importance**
Geum canadense	0.09	2.27	1.82
Glyceria striata	2.19	15.91	25.56
Lindera benzoin	7.36	64.77	91.52
Lonicera japonica	0.03	1.14	0.83
Muhlenbergia mexicana	0.20	1.14	2.17
Onoclea sensibilis	0.18	11.36	7.08
Osmunda cinnamomea	0.01	2.27	1.21
Osmunda regalis	0.14	5.68	3.90
Parthenocissus quinquefolia	0.06	5.68	3.25
Pilea fontana	0.01	2.27	1.21
Polygonum punctatum	0.01	1.14	0.60
Polygonum virginianum	0.17	6.82	4.73
Potentilla simplex	0.03	5.68	3.02
Prunus serotina	0.02	3.41	1.81
Quercus rubrum	0.01	1.14	0.60
Ranunculus recurvatus	0.01	2.27	1.17
Rosa multiflora	0.78	17.05	14.69
Rubus hispida	0.02	3.41	1.81
Rubus pensylvanicus	0.08	4.55	2.88
Sassafras albidum	0.01	2.27	1.21
Solidago rugosa	0.01	1.14	0.60
Symphyotrichum lateriflorum var. lateriflorum	0.06	7.95	4.43
Thelypteris palustris	0.07	3.41	2.24
Toxicodendron radicans ssp. radicans	0.01	1.14	0.60
Toxicodendron vernix	0.03	1.14	0.83
Vitis labrusca	0.03	1.14	0.83
Total	**12.3**		

APPENDIX SII:B-11 – Plant Species Observed During the Twentieth Century in Cowles Bog Wetland Complex but not Observed During the 2002-2004 Inventory (WI= wetland indicator category; N/A- N=native species, A=non-native species; State Status as Determined by the State of Indiana: WL-watch list, R-rare, T=threaten, E=endangered).

Scientific Name	Common Name	WI	N/A	State Status	Flowering	Growth Form	Life Cycle	Class
Andromeda glaucophylla	Bog rosemary	OBL	N	R	May-Jun	Shrub	Perennial	Dicot
Aralia hispida	Bristly sarsaparilla	UPL	N	E	Jun-Jul	Forb	Perennial	Dicot
Aralia nudicaulis	Wild sarsaparilla	FACU	N		May-Jul	Forb	Perennial	Dicot
Bartonia virginica	Screwstem	FACW+	N		Jul - Sept	Forb	Annual	Dicot
Calamagrostis inexpansa	Bog reed grass	FACW+	N		Jul	Graminoid	Perennial	Monocot
Calopogon tuberosus	Grass pink	OBL	N		Jun-Aug	Forb	Perennial	Monocot
Carex disperma	Two-seeded sedge	OBL	N	E	May-Jul	Graminoid	Perennial	Monocot
Carex sterilis	Fen star sedge	OBL	N		Apr-May	Graminoid	Perennial	Monocot
Carex tetanica	Common stiff sedge	FACW	N		May	Graminoid	Perennial	Monocot
Carex trisperma	Three-seeded bog sedge	OBL	N	WL	May	Graminoid	Perennial	Monocot
Celtis occidentalis	Hackberry	FAC-	N		Apr-May	Tree	Perennial	Dicot
Chamaedaphne calyculata	Leatherleaf	OBL	N		Apr-Jun	Shrub	Perennial	Dicot
Chrysosplenium americanum	Golden saxifrage	OBL	N	T	Apr-May	Forb	Perennial	Dicot
Cladium mariscoides	Twig rush	OBL	N		Jun-Aug	Graminoid	Perennial	Monocot
Convallaria majalis	Lily-of-the-valley	UPL	A		May-Jun	Forb	Perennial	Monocot
Cornus canadensis	Bunchberry	FAC	N	E	May - Jun	Forb	Perennial	Dicot
Cyperus erythrorhizos	Red-rooted nut sedge	OBL	N		Jul-Sept	Graminoid	Annual	Monocot
Cyperus odoratus	False rusty nut sedge	OBL	N		Jul-Sept	Graminoid	Annual	Monocot
Cyperus strigosus	Long-scaled nut sedge	FACW	N		Jul-Sept	Graminoid	Perennial	Monocot
Cypripedium calceolus v. pubescens	Large yellow lady's slipper	FAC+	N	WL	Apr - Jun	Forb	Perennial	Monocot
Cypripedium candidum	White lady's slipper	OBL	N	WL	Apr - Jun	Forb	Perennial	Monocot
Cypripedium reginae	Showy lady's slipper	FACW+	N	WL	May - Jun	Forb	Perennial	Monocot
Cystopteris fragilis	Fragile fern	FACU	N		Jun	Fern	Perennial	Filicinae
Dichanthelium spretum	Sand panic grass	NI	N		Jun-Aug	Graminoid	Perennial	Monocot
Dichanthelium acuminatum v. fasciculatum	Old-field panic grass	FAC-	N		May-Sept	Graminoid	Perennial	Monocot
Drosera intermedia	Narrow-leaved sundew	OBL	N	R	Jul-Sept	Forb	Perennial	Dicot
Drosera rotundifolia	Round-leaved sundew	OBL	N	WL	Jun-Aug	Forb	Perennial	Dicot
Dryopteris intermedia	Florist's wood fern	FAC	N		May-Dec	Fern	Perennial	Filicinae
Dulichium arundinaceum	Three-way sedge	OBL	N		Jul-Aug	Graminoid	Perennial	Monocot

Appendix SII:B-11 continued								
Eleocharis obtusa	Blunt spike rush	OBL	N		May-Sept	Graminoid	Annual	Monocot
Epilobium strictum	Downy willow herb	OBL	N		Jul-Sept	Forb	Perennial	Dicot
Eriophorum virginicum	Rusty cotton grass	OBL	N		Jul-Aug	Graminoid	Perennial	Monocot
Eupatorium purpureum	Purple joe pye weed	UPL	N		Jul-Sept	Forb	Perennial	Dicot
Gaultheria procumbens	Wintergreen	FACU	N		Jul-Aug	Forb	Perennial	Dicot
Gaylussacia baccata	Box huckleberry	FACU	N		Apr-Jun	Shrub	Perennial	Dicot
Gentianopsis crinita	Fringed gentian	FACW+	N		Aug-Nov	Forb	Annual	Dicot
Gentianopsis procera	Small fringed gentian	OBL	N		Sept-Oct	Forb	Annual	Dicot
Juncus brachycephalus	Short-headed rush	OBL	N		Jun-Sept	Graminoid	Perennial	Monocot
Juncus tenuis	Path rush	FAC	N		Jun-Sept	Graminoid	Perennial	Monocot
Juniperus virginiana	Red cedar	FACU	N		Apr	Tree	Perennial	Gymnosperm
Liatris spicata	Marsh blazing star	FAC	N		Jul-Sept	Forb	Perennial	Dicot
Lilium michiganense	Michigan lily	FAC+	N		Jun-Aug	Forb	Perennial	Monocot
Linnaea borealis v. americana	Twinflower	FAC	N	X	Jun	Forb	Perennial	Dicot
Lycopus virginicus	Bugle weed	OBL	N		Aug-Sept	Forb	Perennial	Dicot
Mitella diphylla	Bishop's cap	FACU+	N		Apr-Jun	Forb	Perennial	Dicot
Muhlenbergia glomerata	Marsh wild timothy	FACW+	N		Jul-Sept	Graminoid	Perennial	Monocot
Muhlenbergia racemosa	Upland wild timothy	FACW	A		Sept	Graminoid	Perennial	Monocot
Muhlenbergia sylvatica	Woodland satin grass	FACW	N		Sept	Graminoid	Perennial	Monocot
Nasturtium officinale	Water cress	OBL	A		Apr-Sept	Forb	Perennial	Dicot
Nemopanthus mucronata	Mountain holly	OBL	N	WL	Jun - Oct	Shrub	Perennial	Dicot
Oligeneuron ohiensis	Ohio goldenrod	OBL	N		Jun-Oct	Forb	Perennial	Dicot
Oligeneuron riddellii	Riddell's goldenrod	OBL	N		Sept-Nov	Forb	Perennial	Dicot
Orthilia secunda	One-sided shinleaf	FAC+	N	X		Forb	Perennial	Dicot
Osmorhiza claytonii	Hairy sweet cicely	FACU-	N		May-Jun	Forb	Perennial	Dicot
Pilea pumila	Clearweed	FACW	N		Jul-Oct	Forb	Annual	Dicot
Platanthera blephariglottis	White fringed orchid	OBL	N		Jul-Aug	Forb	Perennial	Monocot
Platanthera ciliaris	Orange fringed orchid	FACW	N	E	Jul-Aug	Forb	Perennial	Monocot
Platanthera hyperborea v. huronensis	Northern bog orchid	FACW+	N	T	Jun - Jul	Forb	Perennial	Monocot
Platanthera psycodes	Purple fringed orchid	FACW	N	R	Jul-Aug	Forb	Perennial	Monocot
Poa paludigena	Bog blue grass	OBL	N	WL	Jun	Graminoid	Perennial	Monocot
Prenanthes racemosus	Glaucous white lettuce	FACW	N		Jul-Oct	Forb	Perennial	Dicot
Prunus pensylvanica	Pin cherry	FACU-	N	R	Apr-Jun	Tree	Perennial	Dicot

Appendix SII:B-11 continued.								
Rhynchospora alba	White beak rush	OBL	N		Jun-Sept	Graminoid	Perennial	Monocot
Rhynchospora capitellata	Brown beak rush	OBL	N		May-Aug	Graminoid	Perennial	Monocot
Ribes triste	Swamp red currant	OBL	N		May-Jun	Shrub	Perennial	Dicot
Rosa carolina	Pasture rose	FACU-	N		Jun-Sept	Shrub	Perennial	Dicot
Rubus alleghiensis	Common blackberry	FACU+	N		May-Jul	Shrub	Perennial	Dicot
Rubus flagellaris	Common dewberry	FACU-	N		May-Jul	Shrub	Perennial	Dicot
Sagittaria graminea	Grass-leaved arrowhead	OBL	N		May-Oct	Forb	Perennial	Dicot
Salix pedicellaris	Bog willow	OBL	N		May	Shrub	Perennial	Dicot
Sambucus racemosa v racemosa	Red-berried elder	FACU+	N		Apr-May	Shrub	Perennial	Dicot
Schoenoplectus tabernaemontani	Great bulrush	OBL	N		May-Aug	Graminoid	Perennial	Monocot
Scleria triglomerata	Tall nut rush	FAC	N		Jun	Graminoid	Perennial	Monocot
Solanum nigrum	Black nightshade	FACU-	N		Jun-Oct	Forb	Annual	Dicot
Solidago canadensis	Canada goldenrod	FACU	N		Jul-Sept	Forb	Perennial	Dicot
Spiraea tomentosa	Hardhack	FACW	N		Jul-Sept	Shrub	Perennial	Dicot
Spiranthes cernua	Nodding ladies' tresses	FACW-	N		Aug-Oct	Forb	Perennial	Monocot
Spirodella polyrhiza	Great duckweed	OBL	N			Forb	Perennial	Monocot
Symphyotrichum laeve v.laeve	Smooth blue aster	UPL	N		Aug-Oct	Forb	Perennial	Dicot
Tilia americana	Basswood	FACU	N		Jun-Jul	Tree	Perennial	Dicot
Triglochin maritima	Common bog arrow grass	OBL	N		May-Sept	Graminoid	Perennial	Monocot
Typha latifolia	Common cattail	OBL	N		Jun-Jul	Forb	Perennial	Monocot
Vaccinium angustifolium	Early low blueberry	FACU	N		Apr-Sept	Shrub	Perennial	Dicot
Vaccinium macrocarpon	Large cranberry	OBL	N	WL	Jun-Aug	Shrub	Perennial	Dicot
Vaccinium pallidum	Late low blueberry	UPL	N		May-Nov	Shrub	Perennial	Dicot
Viola lanceolata	Lance-leaved violet	OBL	N		Apr-Jun	Forb	Perennial	Dicot
Woodwardia virginica	Virginia chain fern	OBL	N		Jun-Jul	Fern	Perennial	Filicinae

Appendix SII:B-12 Species reported by other investigators but not observed during the 2002 through 2004 study (1 = present; 0 = absent; investigators: 1=Kurtz; 2=Lyon; 3=Carter and Stottlemyer; 4=Apfelbaum; 5=Hendrickson and Wilcox; 6=Wilcox et al.; 7=Klick; 8=Cook

		Investigators							
Scientific Name	**Common Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Andromeda polifolia v. glaucophylla	bog rosemary	0	0	0	0	0	0	0	1
Aralia hispida	bristly sarsaparilla	0	0	0	1	0	0	0	0
Aralia nudicaulis	wild sarsaparilla	0	0	1	1	0	0	0	1
Bartonia virginica	screwstem	0	0	0	0	0	0	1	1
Calamagrostis stricta ssp. inexpansa	bog reed grass	0	1	1	0	0	0	0	0
Calopogon tuberosus	grass pink	0	1	0	0	0	0	0	1
Carex disperma	Two-seeded sedge	0	0	0	0	0	0	0	1
Carex sterilis	fen star sedge	0	0	0	0	0	0	0	1
Carex tetanica	common stiff sedge	0	1	0	0	0	0	0	0
Carex trisperma	three-seeded bog sedge	0	0	0	0	0	0	0	1
Celtis occidentalis	hackberry	0	0	1	0	0	0	0	0
Chamaedaphne calyculata	leatherleaf	0	0	0	0	0	0	0	1
Chrysosplenium americanum	golden saxifrage	0	0	0	0	0	0	0	1
Cladium mariscoides	twig rush	0	0	0	0	0	0	1	1
Convallaria majalis	lily-of-the-valley	0	0	0	1	0	0	0	0
Cornus canadensis	bunchberry	0	1	0	0	0	0	0	1
Cyperus erythrorhizos	red-rooted nut sedge	0	0	0	0	0	0	0	1
Cyperus odoratus	false rusty nut sedge	0	0	0	0	0	0	0	1
Cyperus strigosus	long-scaled nut sedge	0	0	0	0	0	0	0	1
Cypripedium calceolus v. pubescens	large yellow lady's slipper	0	0	0	0	0	0	0	1
Cypripedium candidum	white lady's slipper	0	1	0	0	0	0	1	1
Cypripedium reginae	showy lady's slipper	0	1	0	0	0	0	0	1
Cystopteris fragilis	fragile fern	0	0	0	1	0	0	0	0
Dichanthelium acuminatum v. fasciculatum	old-field panic grass	0	1	0	0	0	0	0	0
Dichanthelium spretum	sand panic grass	0	1	0	0	0	0	0	0
Drosera intermedia	narrow-leaved sundew	0	0	0	0	0	0	0	1

Appendix SII:B-12 continued.									
Drosera rotundifolia	round-leaved sundew	0	0	0	0	0	0	0	1
Dryopteris intermedia	florist's wood fern	0	1	0	0	0	0	0	0
Dulichium arundinaceum	three-way sedge	0	0	0	0	0	0	0	1
Eleocharis obtusa	blunt spike rush	0	1	0	0	0	0	0	0
Epilobium strictum	downy willow herb	0	1	0	0	0	0	0	0
Eriophorum virginicum	rusty cotton grass	0	0	0	0	0	0	0	1
Eupatorium purpureum	purple joe pye weed	0	0	0	1	0	0	0	0
Gaultheria procumbens	wintergreen	1	0	0	0	0	0	0	0
Gaylussacia baccata	box huckleberry	0	0	0	1	0	0	0	0
Gentianopsis crinita	fringed gentian	1	0	0	0	0	0	0	0
Gentianopsis virgata	small fringed gentian	0	1	1	0	1	0	1	1
Juncus brachycephalus	short-headed rush	0	0	0	0	0	0	1	1
Juncus tenuis	path rush	0	0	0	0	0	0	0	1
Juniperus virginiana	red cedar	0	0	0	0	1	0	0	1
Liatris spicata	marsh blazing star	0	0	0	0	0	0	1	0
Lilium michiganense	Michigan lily	0	0	0	1	0	0	0	0
Linnaea borealis v. americana	twinflower	1	1	0	0	0	0	0	1
Lycopus virginicus	bugle weed	0	0	0	1	0	1	0	0
Maianthemum racemosum ssp. racemosum	feathery false solomon's seal	0	0	0	1	0	0	0	0
Mitella diphylla	bishop's cap	1	0	0	0	0	0	0	0
Muhlenbergia glomerata	marsh wild timothy	0	0	0	0	0	0	1	0
Muhlenbergia racemosa	upland wild timothy	0	1	0	0	0	0	0	0
Muhlenbergia sylvatica	woodland satin grass	0	0	0	1	0	0	0	0
Nasturtium officinale	water cress	0	1	0	0	0	0	0	0
Nemopanthus mucronata	mountain holly	0	0	0	0	0	0	0	1
Oligeneuron ohioensis	Ohio goldenrod	0	0	0	0	0	0	1	1
Oligeneuron riddellii	Riddell's goldenrod	0	0	0	0	0	0	1	1
Orthilia secunda	one-sided shinleaf	1	0	0	0	0	0	0	0
Osmorhiza claytonii	hairy sweet cicely	0	0	0	1	0	0	0	1

Appendix SII:B-12 continued.									
Pilea pumila	clearweed	1	1	1	1	0	1	0	1
Platanthera blephariglottis	white fringed orchid	0	0	0	0	0	0	0	1
Platanthera ciliaris	orange fringed orchid	0	0	0	0	0	0	0	1
Platanthera hyperborea v. huronensis	northern bog orchid	0	1	0	0	0	0	0	1
Platanthera psycodes	purple fringed orchid	0	0	0	0	0	0	0	1
Poa paludigena	bog blue grass	0	0	0	0	0	0	0	1
Prenanthes racemosa	glaucous white lettuce	0	1	0	0	0	0	0	0
Prunus pensylvanica	pin cherry	0	0	0	0	1	0	0	1
Rhynchospora alba	white beak rush	0	1	0	0	0	0	0	0
Rhynchospora capitellata	brown beak rush	0	0	0	0	0	0	0	1
Ribes triste	swamp red currant	0	0	0	1	0	0	0	0
Rosa carolina	pasture rose	0	0	0	0	0	0	0	1
Rubus alleghaniensis	common blackberry	0	0	0	1	0	1	0	0
Rubus flagellaris	common dewberry	0	0	0	1	0	0	0	1
Sagittaria graminea	grass-leaved arrowhead	0	1	0	0	0	0	0	0
Salix pedicellaris	bog willow	0	0	0	0	0	0	0	1
Sambucus racemosa v. racemosa	red-berried elder	0	1	0	0	0	0	0	1
Schoenoplectus tabernaemontani	softstem bulrush	0	1	0	0	0	0	0	1
Scleria triglomerata	tall nutrush	0	0	0	0	0	0	0	1
Solanum nigrum	black nightshade	0	0	1	0	0	0	0	0
Solidago canadensis	Canada goldenrod	0	0	0	1	0	1	0	0
Spiraea tomentosa	hardhack	0	0	1	0	0	0	0	1
Spiranthes cernua	nodding ladies' tresses	0	0	0	0	0	0	0	1
Spirodela polyrhiza	great duckweed	0	0	0	1	0	0	0	0
Symphyotrichum laeve v. laeve	smooth blue aster	0	1	0	0	0	0	0	0
Tilia americana	basswood	0	0	0	0	0	0	0	1
Triglochin maritima	common bog arrow grass	0	1	0	0	0	0	1	1
Typha latifolia	common cattail	0	0	1	1	1	1	0	1
Vaccinium angustifolium	early low blueberry	0	0	0	0	1	0	0	0

Appendix SII:B-12 continued									
Vaccinium macrocarpon	large cranberry	0	1	0	0	0	0	0	1
Vaccinium pallidum	late low blueberry	1	0	0	0	0	0	0	0
Viola lanceolata	lance-leaved violet	0	0	0	0	0	0	0	1
Woodwardia virginica	Virginia chain fern	0	0	1	0	0	0	0	1

Appendix SII:B-13 – Crosswalk for Scientific Nomecature between the Integrated Taxonomic Information System (ITIS) and the Flora of Chicago. Two Common Names are Provided; Common Name #1 is the Common Name used in the Text.

Scientific Name (ITIS)	Scientific Name (Flora of Chicago)	Common Name #1	Common Name (#2)
Acer rubrum L.	Acer rubrum L.	red maple	red maple
Acer saccharinum L.	Acer saccharinum L.	silver maple	silver maple
Acer saccharum Marshall	Acer saccharum Marshall	sugar maple	sugar maple
Agrimonia gryposepala Wallr.	Agrimonia gryposepala Wallr.	tall agrimony	
Agrimonia parviflora Aiton	Agrimonia parviflora Aiton	swamp agrimony	harvestlice
Agrostis gigantea Roth	Agrostis alba L.	redtop	water bentgrass
Agrostis perennans (Walter) Tuck.	Agrostis perennans (Walter) Tuck.	thin grass	autumm bentgrass
Alisma subcordatum Raf.	Alisma subcordatum Raf.	common water plantain	American water plantain
Alnus incana ssp.rugosa (Du Roi) Clausen	Alnus rugosa (Du Roi) Spreng	speckled alder	speckled alder
Amaranthus retroflexus L.	Amaranthus retroflexus L.	rough amaranth	rough pigweed
Ambrosia artemisiifolia L.	Ambrosia artemisiifolia L.	common ragweed	annual ragweed
Amelanchier arborea (Michx.f.) Fern	Amelanchier arborea (Michx.f.) Fern	serviceberry	juneberry
Amphicarpaea bracteata (L.) Fern.	Amphicarpaea bracteata (L.) Fern.	upland hog peanut	American hogpeanut
Andromeda polifolia L. v. glaucophylla (Link) DC.	Andromeda glaucophylla (Link) DC.	bog rosemary	bog rosemary
Angelica atropurpurea L.	Angelica atropurpurea L.	great angelica	purplestem angelica
Apios americana Medic	Apios americana Medic	ground nut	potatobean
Apocynum cannabinum var hypericifolium Gray	Apocynum sibiricum Jacq.	dogbane	prairie Indian hemp
Aralia hispida Vent.	Aralia hispida Vent.	bristly sarsaparilla	bristly spikenard
Aralia nudicaulis L.	Aralia nudicaulis L.	wild sarsaparilla	small spikenard
Arisaema triphyllum (L.) Schott	Arisaema triphyllum (L.) Schott	jack-in-the-pulpit	indian jack in the pulpit
Asclepias incarnata L.	Asclepias incarnata L.	swamp milkweed	rose milkweed
Aster sagittifolius Willd.	Aster sagittifolius Willd.	arrow-leaved aster	arrow-leaved aster
Bartonia virginica (L.) BSP.	Bartonia virginica (L.) BSP.	screwstem	yellow screwstem
Berberis thunbergii DC.	Berberis thunbergii DC.	japanese barberry	Japanese barberry
Betula alleghaniensis Britton	Betula alleghaniensis Britton	yellow birch	yellow birch
Betula papyrifera Marshall	Betula papyrifera Marshall	paper birch	paper birch
Betula pumila L.	Betula pumila L.	dwarf birch	bog birch
Bidens cernua L.	Bidens cernua L.	nodding bur marigold	nodding beggarticks
Bidens connata Muhl.	Bidens connata Muhl.	purple-stemmed tickseed	purple-stem beggarticks
Bidens coronata (L.) Britton	Bidens coronata (L.) Britton	tall swamp marigold	crowned beggarticks
Bidens frondosa L.	Bidens frondosa L.	common beggar's ticks	bur marigold
Bidens tripartita L.	Bidens comosa (A. Gray) Wiegand	swamp tickseed	three-lobe beggarticks
Boehmeria cylindrica (L.) Sw.	Boehmeria cylindrica (L.) Sw.	false nettle	small-spike false nettle

Appendix SII:B-13 continued			
Botrychium dissectum Spreng.	Botrychium dissectum Spreng.	cut-leaved grape fern	cut-leaved grape fern
Bromus ciliatus L.	Bromus ciliatus L.	fringed brome	fringed brome
Calamagrostis canadensis (Michx.) P. Beauv.	Calamagrostis canadensis (Michx.) P. Beauv.	blue joint grass	bluejoint
Calamagrostis stricta ssp. Inexpansa (Gray) C.W. Greene	Calamagrostis inexpansa Gray	bog reed grass	narrow spike reedgrass
Calopogon tuberosus (L.) B.S.P.	Calopogon tuberosus (L.) B.S.P.	grass pink	tuberous grass pink
Caltha palustris L.	Caltha palustris L.	marsh marigold	yellow marsh marigold
Calystegia sepium ssp. sepium (L.) R. Br.	Convolvulus sepium L.	hedge bindweed	hedge false bindweed
Campanula aparinoides Pursh	Campanula aparinoides Pursh	marsh bellflower	bedstraw bellflower
Cardamine bulbosa (Muhl.) BSP.	Cardamine bulbosa (Muhl.) BSP.	bulbous cress	bulb bittercress
Cardamine pensylvanica Willd.	Cardamine pensylvanica Willd.	Pennsylvania bitter cress	quaker bittercress
Carex alata T. & G.	Carex alata T. & G.	winged oval sedge	broadwing sedge
Carex annectens E. P. Bicknell	Carex annectens E. P. Bicknell	yellow fox sedge	yellowfruit sedge
Carex aquatilis Wahlenb.	Carex aquatilis Wahlenb.	aquatic sedge	water sedge
Carex atherodes Spreng.	Carex atherodes Spreng.	hairyleaf lake sedge	awned sedge
Carex atlantica ssp. capillacea (Bailey) Reznicek	Carex howei L. H. Bailey	atlantic star sedge	howe sedge
Carex blanda Dewey	Carex blanda Dewey	common wood sedge	bland sedge
Carex bromoides Willd.	Carex bromoides Willd.	brome hummock sedge	bromelike sedge
Carex canescens L.	Carex canescens L.	gray bog sedge	silvery sedge
Carex comosa Boott	Carex comosa Boott	porcupine sedge	bristly sedge
Carex crinita Lam.	Carex crinita Lam.	fringed sedge	fringed sedge
Carex cristatella Britton	Carex cristatella Britton	crested oval sedge	crested sedge
Carex disperma Dewey	Carex disperma Dewey	twoseeded sedge	softleaf sedge
Carex echinata Murray	Carex echinata Murray	large-fruited star sedge	prickly sedge
Carex hystericina Willd.	Carex hystericina Willd.	porcupine sedge	bottlebrush sedge
Carex interior L. H. Bailey	Carex interior L. H. Bailey	prairie star sedge	inland sedge
Carex intumescens Rudge	Carex intumescens Rudge	shining bur sedge	greater bladder sedge
Carex lacustris Willd.	Carex lacustris Willd.	lake sedge	hairy sedge
Carex lasiocarpa Ehrh.	Carex lasiocarpa Ehrh.	hairy-fruited sedge	woollyfruit sedge
Carex leptalea Wahlenb.	Carex leptalea Wahlenb.	slender sedge	bristlestalked sedge
Carex limosa L.	Carex limosa L.	muck sedge	mud sedge
Carex lupulina Willd.	Carex lupulina Willd.	common hop sedge	hop sedge
Carex lurida Wahlenb.	Carex lurida Wahlenb.	bottlebrush sedge	shallow sedge
Carex pellita Willd.	Carex pellita Willd.	broadleaf woolly sedge	woolly sedge
Carex projecta Mack.	Carex projecta Mack.	loose-headed oval sedge	necklace sedge
Carex radiata (Wahlenb.) Small	Carex radiata (Wahlenb.) Small	star sedge	eastern star sedge

Appendix SII:B-13 continued			
Carex rosea Schkuhr	Carex rosea Schkuhr	curly-styled wood sedge	rosy sedge
Carex sartwellii Dewey	Carex sartwellii Dewey	running marsh sedge	Sartwell's sedge
Carex scoparia Willd.	Carex scoparia Willd.	lance-fruited oval sedge	broom sedge
Carex squarrosa L.	Carex squarrosa L.	narrowleaf cattail sedge	squarrose sedge
Carex seorsa Howe	Carex seorsa Howe	swamp star sedge	weak stellate sedge
Carex sterilis Willd.	Carex sterilis Willd.	fen star sedge	dioecious sedge
Carex stipata Willd.	Carex stipata Willd.	common fox sedge	owl fruit sedge
Carex stricta Lam.	Carex stricta Lam.	tussock sedge	upright sedge
Carex swanii (Fern.) Mack.	Carex swanii (Fern.) Mack.	downy green sedge	swan sedge
Carex tenera Dewey	Carex tenera Dewey	narrowleaf oval sedge	quill sedge
Carex tetanica Schkuhr	Carex tetanica Schkuhr	common stiff sedge	rigid sedge
Carex tribuloides Wahlenb.	Carex tribuloides Wahlenb.	awl-fruited oval sedge	blunt broom sedge
Carex trisperma Dewey	Carex trisperma Dewey	threeseeded bog sedge	threeseeded sedge
Carex utriculata Boott	Carex utriculata Boott	yellow lake sedge	beaked sedge
Carex vulpinoidea Michx.	Carex vulpinoidea Michx.	brown fox sedge	common fox sedge
Catalpa speciosa Warder	Catalpa speciosa Warder	hardy catalpa	northern catalpa
Celastrus orbiculatus Thunb.	Celastrus orbiculatus Thunb.	oriental bittersweet	Asian bittersweet
Celtis occidentalis L.	Celtis occidentalis L.	hackberry	common hackberry
Cephalanthus occidentalis L.	Cephalanthus occidentalis L.	buttonbush	common buttonbush
Chamaedaphne calyculata (L.) Moench	Chamaedaphne calyculata (L.) Moench	leatherleaf	leatherleaf
Chelone glabra L.	Chelone glabra L.	turtlehead	white turtlehead
Chrysosplenium americanum Schwein. ex Hook	Chrysosplenium americanum Schwein. ex Hook	golden saxifrage	American saxifrage
Cicuta bulbifera L.	Cicuta bulbifera L.	Bulblet water hemlock	bulb waterhemlock
Cinna arundinacea L.	Cinna arundinacea L.	common wood reed	stout wood reed-grass
Circaea lutetiana L.	Circaea lutetiana L. var. canadensis L.	enchanter's nightshade	enchanter's nightshade
Cirsium arvense (L.) Scop.	Cirsium arvense (L.) Scop.	Canada thistle	Californian thistle
Cirsium muticum Michx.	Cirsium muticum Michx.	swamp thistle	swamp thistle
Cladium mariscoides (Muhl.) Torr.	Cladium mariscoides (Muhl.) Torr.	twig rush	smooth sawgrass
Clematis virginiana L.	Clematis virginiana L.	virgin's bower	devil's darning needles
Comarum palustre L.	Potentilla palustris (L.) Scop.	marsh cinquefoil	purple marshlocks
Convallaria majalis L.	Convallaria majalis L.	lily-of-the-valley	European lilly of the valley
Convolvulus arvensis L.	Convolvulus arvensis L.	field bindweed	creeping jenny
Conyza canadensis	Erigeron canadensis	horseweed	
Coptis trifolia (L.) Salisb.	Coptis trifolia (L.) Salisb.	goldthread	threeleaf goldthread
Corallorhiza maculata Raf.	Corallorhiza maculata Raf.	spotted coral root	spotted coral root
Cornus canadensis L.	Cornus canadensis L.	bunchberry	bunchberry dogwood

Appendix SII:B-13 continued			
Cornus obliqua Raf.	Cornus obliqua Raf.	silky dogwood	silky dogwood
Cornus racemosa Lam.	Cornus racemosa Lam.	gray dogwood	gray dogwood
Cornus sericea ssp. sericea L.	Cornus stolonifera Michx.	red-osier dogwood	red-osier dogwood
Cryptotaenia canadensis (L.) DC.	Cryptotaenia canadensis (L.) DC.	honewort	Canadian honewort
Cuscuta gronovii Willd.	Cuscuta gronovii Willd.	common dodder	scaldweed
Cyperus bipartitus	Cyperus rivularis Kunth	brook nut sedge	slender flatsedge
Cyperus erythrorhizos Muhl.	Cyperus erythrorhizos Muhl.	red-rooted nut sedge	redroot flatsedge
Cyperus esculentus L.	Cyperus esculentus L.	field nut sedge	yellow nutsedge
Cyperus odoratus L.	Cyperus engelmanni Steud.	false rusty nut sedge	rusty flatsedge
Cyperus odoratus L.	Cyperus ferruginescens Boeck.	rusty nut sedge	fragrant flatsedge
Cyperus strigosus L.	Cyperus strigosus L.	long-scaled nut sedge	strawcolored flatsedge
Cypripedium acaule Aiton	Cypripedium acaule Aiton	moccasin Flower	lady's-slipper orchid
Cypripedium candidum Willd.	Cypripedium candidum Willd.	white lady's slipper	small white lady's-slipper
Cypripedium pubescens var. pubescens Willd.	Cypripedium calceolus L. var pubescens (Willd.) Correll	large yellow lady's slipper	greater yellow lady's slipper
Cypripedium reginae Walter	Cypripedium reginae Walter	showy lady's slipper	showy lady's slipper
Decodon verticillatus (L.) Elliott	Decodon verticillatus (L.) Elliott	swamp loosestrife	swamp loosestrife
Dichanthelium acuminatum (SW.) Gould&CA. Clark var. fasciculatum (Torr.) Freckmann	Panicum implicatum Britton	old-field panic grass	western panic grass
Dichanthelium clandestinum (L.) Gould	Panicum clandestinum L.	deer-tongue grass	deer-tongue grass
Dichanthelium spretum (Schult.) Freckman	Panicum spretum Schult.	sand panic grass	Eaton's rosette grass
Doellingeria umbellata var. umbellata (P. Mill.) Nees	Aster umbellatus Mill.	flat-top aster	parasol whitetop
Drosera intermedia Hayne	Drosera intermedia Hayne	narrow-leaved sundew	spoonleaf sundew
Drosera rotundifolia L.	Drosera rotundifolia L.	round-leaved sundew	round-leaved sundew
Dryopteris carthusiana (Vill.) H.P. Fuchs	Dryopteris spinulosa (O. F. Müll.) Watt	spinulose shield fern	spinulose wood fern
Dryopteris cristata (L.) A. Gray	Dryopteris cristata (L.) A. Gray	crested wood fern	crested wood fern
Dryopteris intermedia (Muhl. Ex Willd.)A.Gray	Dryopteris intermedia (Muhl. Ex Willd.)A.Gray	florist's wood fern	intermediate woodfern
Dulichium arundinaceum (l.) Britton	Dulichium arundinaceum (l.) Britton	three-way sedge	threeway sedge
Echinochloa crusgalli (L.) P. Beauv.	Echinochloa crusgalli (L.) P. Beauv.	barnyard grass	barnyard grass
Elaeagnus umbellata Thunb.	Elaeagnus umbellata Thunb.	autumn olive	oleaster
Eleocharis erythropoda Steud.	Eleocharis erythropoda Steud.	red-rooted spike rush	bald spike-rush
Eleocharis obtusa (Willd.) Schult.	Eleocharis obtusa (Willd.) Schult.	blunt spike rush	blunt spikesedge
Eleocharis palustris (L.) Roem. & Schult.	Eleocharis palustris (L.) Roem. & Schult.	great spike rush	common spikerush
Eleocharis rostellata Torr.	Eleocharis rostellata Torr.	wicket spike rush	beaked spike-rush
Epilobium coloratum Biehler	Epilobium coloratum Biehler	cinnamon willow	purple-leaf willowherb

Appendix SII:B-13 continued			
Epilobium leptophyllum Raf.	Epilobium leptophyllum Raf.	fen willow herb	bog willowherb
Epilobium strictum Muhl. ex Spreng.	Epilobium strictum Muhl. ex Spreng.	downy willow herb	downy willowherb
Epipactis helleborine (L.) Crantz	Epipactis helleborine (L.) Crantz	helleborine orchid	broadleaf helleborine
Equisetum arvense L.	Equisetum arvense L.	horsetail	field horsetail
Eragrostis pectinacea (Michx.) Ness ex Steud.	Eragrostis pectinacea (Michx.) Ness ex Steud.	small love grass	tufted lovegrass
Erechtites hieracifolia (L.) Raf.	Erechtites hieracifolia (L.) Raf.	fireweed	burnweed
Erigeron annuus (L.) Pers.	Erigeron annuus (L.) Pers.	annual fleabane	eastern daisy fleabane
Erigeron philadelphicus L.	Erigeron philadelphicus L.	marsh fleabane	Philadelphia daisy
Eriophorum virginicum L.	Eriophorum virginicum L.	rusty cotton grass	tawny cottongrass
Eupatorium maculatum L.	Eupatorium maculatum L.	spotted joe pye weed	spotted joe pye weed
Eupatorium perfoliatum L.	Eupatorium perfoliatum L.	common boneset	common boneset
Eupatorium purpureum L.	Eupatorium purpureum L.	purple joe pye weed	sweetscented joe pye weed
Eupatorium serotinum Michx.	Eupatorium serotinum Michx.	late boneset	fall boneset
Euthamia graminifolia var. nuttallii (Greene) W. Stone	Solidago graminifolia (L.) Salisb. var. nuttallii (Greene) Fern.	hairy grass-leaved goldenrod	flat-top goldentop
Euthamia gymnospermoides Greene	Solidago graminifolia var. media (Greene) S. K. Harris	common grass-leaved goldenrod	Texas goldentop
Fragaria virginiana Duchesne	Fragaria virginiana Duchesne	wild strawberry	thickleaved wild strawberry
Fraxinus americana L.	Fraxinus americana L.	white ash	white ash
Fraxinus nigra Marshall	Fraxinus nigra Marshall	black ash	black ash
Fraxinus pennsylvanica Marshall var. subintegerrima (Vahl) Fern.	Fraxinus pennsylvanica Marshall var. subintegerrima (Vahl) Fern.	green ash	green ash
Fraxinus pensylvanica Marshall	Fraxinus pensylvanica Marshall	red ash	red ash
Galium aparine L.	Galium aparine L.	annual bedstraw	bedstraw
Galium labradoricum (Wiegand) Wiegand	Galium labradoricum (Wiegand) Wiegand	bog bedstraw	northern bog bedstraw
Galium obtusum Bigelow	Galium obtusum Bigelow	wild madder	blunt-leaf bedstraw
Galium tinctorium L.	Galium tinctorium L.	siff bedstraw	dye bedstraw
Galium trifidum L.	Galium trifidum L.	small bedstraw	three-petal bedstraw
Galium triflorum Michx.	Galium triflorum Michx.	sweet-scented bedstraw	fragrant bedstraw
Gaultheria procumbens L.	Gaultheria procumbens L.	wintergreen	eastern teaberry
Gaylussacia baccata (Wangenh.) K. Koch	Gaylussacia baccata (Wangenh.) K. Koch	box huckleberry	black huckleberry
Gentianopsis crinita (Froel.) Ma	Gentiana crinita Froel.	fringed gentian	greater fringed gentian
Gentianopsis virgata (Raf.) Holub	Gentiana procera Holm	small fringed gentian	lesser fringed gentian
Geum canadense Jacq.	Geum canadense Jacq.	white avens	white avens
Geum laciniatum Murray	Geum laciniatum Murray	northern rough avens	rough avens
Glyceria borealis (Nash) Batch.	Glyceria borealis (Nash) Batch.	northern manna grass	small floating manna grass

Appendix SII:B-13 continued			
Glyceria canadensis (Michx.) Trin.	Glyceria canadensis (Michx.) Trin.	rattlesnake grass	rattlesnake mannagrass
Glyceria striata (Lam.) Hitchc.	Glyceria striata (Lam.) Hitchc.	fowl meadow grass	fowl manna grass
Helianthus grosseserratus M. Martens	Helianthus grosseserratus M. Martens	sawtooth sunflower	sawtooth sunflower
Hypericum kalmianum L.	Hypericum kalmianum L.	kalm's St. John's wort	kalm's St. John's wort
Hypericum majus (A. Gray) Britton	Hypericum majus (A. Gray) Britton	sand St. John's wort	large st. John's wort
Ilex verticillata (L.) A. Gray	Ilex verticillata (L.) A. Gray	winterberry	common winterberry
Impatiens capensis Meerb.	Impatiens capensis Meerb.	spotted touch-me-not	jewelweed
Iris virginica L.	Iris virginica L.	blue flag	Virginia iris
Juncus acuminatus Michx	Juncus acuminatus Michx	sharp-fruited rush	tapertip rush
Juncus balticus Willd.	Juncus balticus Willd.	lake shore rush	Baltic rush
Juncus brachycarpus (Engelm.) Buchenau	Juncus brachycarpus (Engelm.) Buchenau	short-headed rush	smallhead rush
Juncus canadensis J. Gay	Juncus canadensis J. Gay	Canadian rush	Canadian rush
Juncus dudleyi Wiegand	Juncus dudleyi Wiegand	dudley's rush	dudley's rush
Juncus effusus L.	Juncus effusus L.	common rush	lamp rush
Juncus tenuis Willd.	Juncus tenuis Willd.	path rush	poverty rush
Juniperus virginiana L. var crebra Fern. & Griscom	Juniperus virginiana L. var crebra Fern. & Griscom	red cedar	red cedar
Larix laricina (Du Roi) K. Koch	Larix laricina (Du Roi) K. Koch	tamarack	Alaskan larch
Lathyrus palustris L.	Lathyrus palustris L.	marsh vetchling	marsh pea
Leersia oryzoides (L.) Sw.	Leersia oryzoides (L.) Sw.	rice cut grass	rice cut grass
Leersia virginica Willd.	Leersia virginica Willd.	white grass	white grass
Lemna minor L.	Lemna minor L.	small duckweed	common duckweed
Liatris spicata (L.) Willd.	Liatris spicata (L.) Willd.	marsh blazing star	dense blazing star
Ligustrum vulgare L.	Ligustrum vulgare L.	common privet	European privet
Lilium michiganense Farw.	Lilium michiganense Farw.	Michigan lily	Michigan lily
Lindera benzoin (L.) Blume	Lindera benzoin (L.) Blume	spicebush	northern spicebush
Lindernia dubia (L.) Pennell	Lindernia dubia (L.) Pennell	false pimpernel	moistbank pimpernel
Linnaea borealis L. var americana (Forbes) Rehder	Linnaea borealis L. var americana (Forbes) Rehder	twinflower	American twinflower
Liparis loeselii (L.) Rich.	Liparis loeselii (L.) Rich.	green twayblade	yellow wide-lip orchid
Lobelia kalmii L.	Lobelia kalmii L.	bog lobelia	brook lobelia
Lobelia siphilitica L.	Lobelia siphilitica L.	great blue lobelia	great blue lobelia
Lonicera dioica L.	Lonicera dioica L.	red honeysuckle	limber honeysuckle
Lonicera japonica Thunb.	Lonicera japonica Thunb.	Japanese honeysuckle	Chinese honeysuckle
Ludwigia palustris (L.) Elliott	Ludwigia palustris (L.) Elliott	marsh purslane	marsh primrose-willow
Lycopus americanus Muhl.	Lycopus americanus Muhl.	common water horehound	American bugleweed
Lycopus rubellus Moench	Lycopus rubellus Moench	stalked water horehound	taperleaf bugleweed

Appendix SII:B-13 continued			
Lycopus uniflorus Michx.	Lycopus uniflorus Michx.	northern bugle weed	bugleweed
Lycopus virginicus L.	Lycopus virginicus L.	Virginia water horehound	Virginia bugleweed
Lysimachia ciliata L.	Lysimachia ciliata L.	fringed loosestrife	fringed yellow loosestrife
Lysimachia terrestris (L.) BSP.	Lysimachia terrestris (L.) BSP.	swamp candles	earth loosestrife
Lysimachia thyrsiflora L.	Lysimachia thyrsiflora L.	tufted loosestrife	tufted yellow-loosestrife
Lythrum salicaria L.	Lythrum salicaria L.	purple loosestrife	purple lythrum
Maianthemum canadense Desf.	Maianthemum canadense Desf.	Canada mayflower	false lily-of-the-valley
Maianthemum racemosum (L.) Link ssp. Racemosum	Smilacina racemosa (L.) Desf.	feathery false solomon's seal	feathery solamon's plume
Maianthemum stellatum (L.) Link	Smilacina stellata (L.) Desf.	starry false solomon's seal	false solomons seal
Menispermum canadense L.	Menispermum canadense L.	moonseed	Canadian moonseed
Mentha arvensis L.	Mentha arvensis L.	wild mint	field mint
Mimulus ringens L.	Mimulus ringens L.	monkey flower	Allegheny monkey-flower
Mitchella repens L.	Mitchella repens L.	partridge berry	partridge berry
Mitella diphylla L.	Mitella diphylla L.	bishop's cap	twoleaf miterwort
Monarda fistulosa L.	Monarda fistulosa L.	wild bergamot	mintleaf beebalm
Morus alba L.	Morus alba L.	white mulberry	mulberry
Muhlenbergia frondosa (Poir.) Fern	Muhlenbergia frondosa (Poir.) Fern	common satin grass	wire-stem muhly
Muhlenbergia glomerata (Willd.) Trin.	Muhlenbergia glomerata (Willd.) Trin.	marsh wild timothy	spiked muhly
Muhlenbergia mexicana (L.) Trin.	Muhlenbergia mexicana (L.) Trin.	leafy satin grass	Mexican muhly
Muhlenbergia racemosa (Michx.) Br., Sterns & Poggenb	Muhlenbergia racemosa (Michx.) Br., Sterns & Poggenb	upland wild timothy	marsh muhly
Muhlenbergia sylvatica (Torr.) Torr. ex A. Gray	Muhlenbergia sylvatica (Torr.) Torr. ex A. Gray	woodland satin grass	woodland muhly
Myosotis laxa Lehm.	Myosotis laxa Lehm.	small forget-me-not	bay forget-me-not .
Nasturtium officinale W.T. Aiton.	Nasturtium officinale W.T. Aiton.	water cress	
Nemopanthus mucronatus (L.) Trel.	Nemopanthus mucronatus (L.) Trel.	mountain holly	catberry
Nuphar lutea ssp. Advena (Ait.) Kartesz & Gandhi	Nuphar advena (Aiton) W. T. Aiton	yellow pond lily	yellow pond lily
Nyssa sylvatica Marshall	Nyssa sylvatica Marshall	black gum, sour gum	black tupelo
Oligeneuron ohioense (Frank ex Riddell) G.N. Jones	Solidago ohiensis Riddell	Ohio goldenrod	
Oligeneuron riddellii (Frank ex Riddell) Rydb.	Solidago riddellii Frank	Riddell's goldenrod	
Onoclea sensibilis L.	Onoclea sensibilis L.	sensitive fern	sensitive fern
Orthilia secunda (L.) House	Pyrola secunda L.	one-sided shinleaf	sidebells wintergreen
Osmorhiza claytonii (Michx.) C.B. Clarke	Osmorhiza claytonii (Michx.) C.B. Clarke	hairy sweet cicely	clayton's sweetroot
Osmunda cinnamomea L.	Osmunda cinnamomea L.	cinnamon fern	cinnamon fern

Appendix SII:B-13 continued			
Osmunda regalis L.	Osmunda regalis L.	royal fern	royal fern
Oxypolis rigidior (L.) Raf.	Oxypolis rigidior (L.) Raf.	cowbane	stiff cowbane
Packera aurea (L.) A. & D. Löve	Senecio aureus L.	golden ragwort	golden ragwort
Panicum dichotomiflorum Michx.	Panicum dichotomiflorum Michx.	knee grass	fall panic
Parnassia glauca Raf.	Parnassia glauca Raf.	grass of parnassus	fen grass of parnassus
Parthenocissus quinquefolia (L.) Planch.	Parthenocissus quinquefolia (L.) Planch.	Virginia creeper	American ivy
Pedicularis lanceolata Michx.	Pedicularis lanceolata Michx.	fen betony	swamp lousewort
Peltandra virginica (L.) Schott & Endl.	Peltandra virginica (L.) Schott & Endl.	arrow arum	green arrow arum
Penthorum sedoides L.	Penthorum sedoides L.	ditch stonecrop	Virginia penthorum
Phalaris arundinacea L.	Phalaris arundinacea L.	reed canary grass	reed canary grass
Photinia floribunda (Lindl.) Robertson & Phipps	Aronia prunifolia (Michx.) Rehder	chokeberry	hybrid chokeberry
Phragmites australis (Cav.) Steud.	Phragmites australis (Cav.) Steud.	common reed	common reed
Physocarpus opulifolius (L.) Maxim.	Physocarpus opulifolius (L.) Maxim.	ninebark	Atlantic ninebark
Pilea fontana (Lunell) Rydb.	Pilea fontana (Lunell) Rydb.	bog clearweed	lesser clearweed
Pilea pumila (L.) A.Gray	Pilea pumila (L.) A.Gray	clearweed	canadian clearweed
Pinus banksiana Lamb.	Pinus banksiana Lamb.	jack pine	
Pinus strobus L.	Pinus strobus L.	white pine	Eastern white pine
Plantago major L.	Plantago major L.	common plantain	broadleaf plantain
Plantago rugelii Decne.	Plantago rugelii Decne.	red-stalked plantain	black-seed plantain
Platanthera blephariglottis (Willd.) Lindl.	Habenaria blephariglottis (Willd.) Hook.	white fringed orchid	white fringed orchid
Platanthera ciliaris (L.) Lindl.	Habenaria ciliaris (L.) R. Br.	orange fringed orchid	yellow fringed orchid
Platanthera clavellata (Michx.) Luer	Habenaria clavellata (Michx.) Spreng.	club-spur orchid	green woodland orchid
Platanthera hyperborea var. hyperborea (L.) Lindl.	Habenaria hyperborea (L.) R. Br. var huronensis (Nutt.) Farw.	northern bog orchid	northern green orchid
Platanthera psycodes (L.) Lindl.	Habenaria psycodes (L.) Spreng.	purple fringed orchid	lesser purple fringed orchid
Poa paludigena Fernald&Wiegand	Poa paludigena Fernald&Wiegand	bog blue grass	marsh spear grass
Poa pratensis L.	Poa pratensis L.	Kentucky blue grass	Kentucky blue grass
Podophyllum peltatum L.	Podophyllum peltatum L.	may apple	American mandrake
Polygonum amphibium L.	Polygonum amphibium L.	water knotweed	water smartweed
Polygonum amphibium L. var emersum Michx.	Polygonum coccineum*	water heartsease	longroot smartweed
Polygonum arifolium L.	Polygonum arifolium L.	halberd-leaved tear-thumb	halberd-leaved tear-thumb
Polygonum punctatum Elliott	Polygonum punctatum Elliott	smartweed	dotted smartweed
Polygonum sagittatum L.	Polygonum sagittatum L.	arrow-leaved tear-thumb	arrowleaf knotweed
Polygonum scandens L.	Polygonum scandens L.	climbing false buckwheat	climbing knotweed
Polygonum virginianum L.	Polygonum virginianum L.	woodland knotweed	jumpseed
Populus deltoides Marshall	Populus deltoides Marshall	eastern cottonwood	common cottonwood

Appendix SII:B-13 continued			
Populus tremuloides Michx.	Populus tremuloides Michx.	quaking aspen	quaking aspen
Potentilla norvegica L.	Potentilla norvegica L.	rough cinquefoil	Norwegian cinquefoil
Potentilla simplex Michx.	Potentilla simplex Michx.	common cinquefoil	oldfield cinquefoil
Prenanthes alba L.	Prenanthes alba L.	white lettuce	white rattlesnake-root
Prenanthes racemosa Michx.	Prenanthes racemosa Michx.	glaucous white lettuce	purple rattlesnakeroot
Prunella vulgaris ssp. Lanceolata (W. Bart.) Hultén	Prunella vulgaris L. var. lanceolata (Barton) Fern.	self-heal	lance selfheal
Prunus pensylvanica L.F.	Prunus pensylvanica L.F.	pin cherry	pin cherry
Prunus serotina Ehrh.	Prunus serotina Ehrh.	wild black cherry	black cherry
Prunus virginiana L.	Prunus virginiana L.	choke cherry	common chokecherry
Pycnanthemum virginianum (L.) T. Durand & B. D. Jacks.	Pycnanthemum virginianum (L.) T. Durand & B. D. Jacks.	common mountain mint	Virginia mountain-mint
Quercus alba L.	Quercus alba L.	white oak	white oak
Quercus bicolor Willd.	Quercus bicolor Willd.	swamp white oak	swamp white oak
Quercus palustris Münchh.	Quercus palustris Münchh.	pin oak	pin oak
Quercus rubra L.	Quercus rubra L.	red oak	northern red oak
Quercus velutina Lam.	Quercus velutina Lam.	black oak	black oak
Ranunculus abortivus L.	Ranunculus abortivus L.	small-flowered buttercup	early woodbuttercup
Ranunculus hispidus var. nitidus (Chapman) T. Duncan	Ranunculus septentrionalis Poir.	swamp buttercup	bristly buttercup
Ranunculus pensylvanicus L. f.	Ranunculus pensylvanicus L. f.	bristly buttercup	Pennsylvania buttercup
Ranunculus recurvatus Poir.	Ranunculus recurvatus Poir.	hooked buttercup	blisterwort
Ranunculus sceleratus L.	Ranunculus sceleratus L.	cursed buttercup	celeryleaf buttercup
Rhamnus alnifolia L' Hér.	Rhamnus alnifolia L' Hér.	alder buckthorn	alder-leaf buckthorn
Rhynchospora alba (L.) Vahl	Rhynchospora alba (L.) Vahl	white beak rush	white beak rush
Rhynchospora capitellata (Michx.) Vahl	Rhynchospora capitellata (Michx.) Vahl	brown beak rush	browish beaksedge
Rhynchospora scirpoides (Torr.) A.Gray	Psilocarya scirpoides Torr.	long-beaked bald rush	longbeak beaksedge
Ribes americanum Mill.	Ribes americanum Mill.	wild black currant	American black currant
Ribes cynosbati L.	Ribes cynosbati L.	prickly wild gooseberry	eastern prickly gooseberry
Ribes hirtellum Michx.	Ribes hirtellum Michx.	northern gooseberry	hairy stem gooseberry
Ribes triste Pall.	Ribes triste Pall.	swamp red currant	red currant
Robinia pseudoacacia L.	Robinia pseudoacacia L.	black locust	false acacia
Rosa carolina L.	Rosa carolina L.	pasture rose	Carolina rose
Rosa multiflora Thunb.	Rosa multiflora Thunb.	multiflora rose	multiflora rose
Rosa palustris Marshall	Rosa palustris Marshall	swamp rose	swamp rose
Rubus allegheniensis Porter	Rubus allegheniensis Porter	common blackberry	Allegheny blackberry

Appendix SII:B-13 continued			
Rubus flagellaris Willd.	Rubus flagellaris Willd.	common dewberry	northern dewberry
Rubus hispidus L.	Rubus hispidus L.	swamp dewberry	bristly dewberry
Rubus idaeus L.	Rubus idaeus L.	garden raspberry	American red raspberry
Rubus idaeus L. var. strigosus (Michx) Maxim.	Rubus idaeus L. var. strigosus (Michx) Maxim.	red raspberry	red raspberry
Rubus occidentalis L.	Rubus occidentalis L.	black raspberry	black raspberry
Rubus pensylvanicus Poir.	Rubus pensylvanicus Poir.	yankee blackberry	yankee blackberry
Rubus pubescens Raf.	Rubus pubescens Raf.	dwarf raspberry	dwarf red blackberry
Rumex crispus L.	Rumex crispus L.	curly dock	narrow leafdock
Rumex obtusifolius L.	Rumex obtusifolius L.	bitter dock	bluntleaf dock
Rumex orbiculatus A. Gray	Rumex orbiculatus A. Gray	great water dock	great water dock
Sagittaria graminea Michx.	Sagittaria graminea Michx.	grass-leaved arrowhead	grassy arrowhead
Sagittaria latifolia Willd.	Sagittaria latifolia Willd.	common arrowhead	broadleaf arrowhead
Salix alba L.	Salix alba L.	white willow	golden willow
Salix amygdaloides Andersson	Salix amygdaloides Andersson	peach-leaved willow	peach-leaved willow
Salix bebbiana Sarg.	Salix bebbiana Sarg.	beaked willow	bebb willow
Salix candida Flüggé	Salix candida Flüggé	hoary willow	sage willow
Salix discolor Muhl.	Salix discolor Muhl.	pussy willow	pussy willow
Salix eriocephala Michx.	Salix eriocephala Michx.	heart-leaved willow	Missouri River willow
Salix fragilis L.	Salix fragilis L.	crack willow	crack willow
Salix interior Rowlee	Salix interior Rowlee	sandbar willow	sandbar willow
Salix myricoides var. myricoides Muhl.	Salix glaucophylloides Fern.	blue-leaved willow	bayberry willow
Salix nigra Marshall	Salix nigra Marshall	black willow	black willow
Salix pedicellaris Pursh	Salix pedicellaris Pursh	bog willow	bog willow
Salix petiolaris Sm.	Salix petiolaris Sm.	meadow willow	slender willow
Salix rubens Schrank	Salix rubens Schrank	hybrid crack willow	hybrid crack willow
Salix sericea Marshall	Salix sericea Marshall	silky willow	silky willow
Salix X conifera Wangenh. (pro sp.)	Salix discolor var Latifolia Anderss.	pussy willow	conifer willow
Sambucus nigra ssp. canadensis (L.) R. Bolli	Sambucus canadensis L.	elderberry	blue elder
Sambucus racemosa L. var racemosa	Sambucus pubens Michx..	red-berried elder	red elderberry
Sarracenia purpurea L.	Sarracenia purpurea L.	pitcher plant	purple pitcherplant
Sassafras albidum (Nutt.) Nees	Sassafras albidum (Nutt.) Nees	sassafras	sassafras
Saxifraga pensylvanica L.	Saxifraga pensylvanica L.	swamp saxifrage	eastern swamp saxifrage
Schoenoplectus acutus var. acutus (Muhl. ex Bigelow) A. & D. Löve	Scirpus acutus Bigelow	hard-stemmed bulrush	hard-stemmed bulrush
Schoenoplectus fluviatilis (Torr.) M.T. Strong	Scirpus fluviatilis (Torr.) A. Gray	river bulrush	river bulrush
Schoenoplectus pungens v. pungens (Vahl) Palla	Scirpus pungens Vahl	chairmaker's rush	common threesquare

Appendix SII:B-13 continued			
Schoenoplectus tabernaemontani (C.C.Gmel) Palla	Scirpus validus Vahl. Var.creber Fernald	great bulrush	softstem bulrush
Scirpus atrovirens Willd.	Scirpus atrovirens Willd.	dark green rush	green bulrush
Scirpus cyperinus (L.) Kunth	Scirpus cyperinus (L.) Kunth	wool grass	bulrush
Scleria triglomerata Michx.	Scleria triglomerata Michx.	tall nut rush	whip nutrush
Scutellaria galericulata L.	Scutellaria epilobiifolia A. Ham.	marsh skullcap	hooded skullcap
Scutellaria lateriflora L.	Scutellaria lateriflora L.	mad-dog skullcap	blue skullcap
Setaria pumila	Setaria glauca (L.) P.Beauv.	yellow foxtail	yellow bristlegrass
Sium suave Walter	Sium suave Walter	tall water parsnip	common waterparsnip
Smilax rotundifolia L.	Smilax rotundifolia L.	green brier	roundleaf greenbrier
Smilax tamnoides L.	Smilax tamnoides L. var. Hispida (Torr.) Fern.	bristly green brier	bristly green brier
Solanum nigrum L.	Solanum nigrum L.	black nightshade	American black nghtshade
Solanum dulcamara L.	Solanum dulcamara L.	bittersweet nightshade	bitter nightshade
Solidago caesia L.	Solidago caesia L.	blue-stemmed goldenrod	wreath goldenrod
Solidago canadensis L.	Solidago canadensis L.	Canada goldenrod	common goldenrod
Solidago canadensis var. scabra Torr. & Gray	Solidago altissima L.	tall goldenrod	Canada goldenrod
Solidago gigantea Aiton	Solidago gigantea Aiton	late goldenrod	giant goldenrod
Solidago patula Muhl.	Solidago patula Muhl.	swamp goldenrod	roundleaf goldenrod
Solidago rugosa Aiton	Solidago rugosa Aiton	rough goldenrod	wrinkleleaf goldenrod
Solidago uliginosa Nutt.	Solidago uliginosa Nutt.	bog goldenrod	bog goldenrod
Sonchus arvensis ssp. uliginosus (Bieb.) Nyman	Sonchus uliginosus M. Bieb.	common sow thistle	field-sow thistle
Sparganium eurycarpum Engelm.	Sparganium eurycarpum Engelm.	common bur reed	broad-fruit bur-reed
Sphenopholis intermedia Rydb.	Sphenopholis intermedia Rydb.	slender wedge grass	slender wedgescale
Spiraea alba Du Roi	Spiraea alba Du Roi	meadowsweet	spirea
Spiraea tomentosa L.	Spiraea tomentosa L.	hardhack	steeplebush
Spiranthes cernua (L.) Rich	Spiranthes cernua (L.) Rich	nodding ladies' tresses	
Spirodella polyrhiza L.	Spirodella polyrhiza L.	great duckweed	common duckmeat
Stachys palustris L.	Stachys palustris L.	woundwort	marsh hedgenettle
Stachys tenuifolia Willd.	Stachys tenuifolia Willd. v. hispida (Pursh) Fern.	marsh hedge nettle	slender betony
Symphyotrichum boreale (Torr. & Gray) A. & D. Löve	Aster borealis Prov.	rush aster	northern bog aster
Symphyotrichum laeve (L.) A.& D. Love var. leave	Aster laevis (L.)	smooth blue aster	smooth blue aster
Symphyotrichum lanceolatum var. lanceolatum (Willd.) Nesom	Aster simplex Willd.	panicled aster	white panicle aster
Symphyotrichum lateriflorum var. lateriflorum (L.) A. & D. Löve	Aster lateriflorus (L.) Britton	side-flowering aster	calico aster

Appendix SII:B-13 continued			
Symphyotrichum praealtum var. praealtum (Poir.) Nesom	Aster praealtus Poir.	willow aster	willowleaf aster
Symphyotrichum puniceum var. puniceum (L.) A. & D. Löve	Aster puniceus L.	bristly aster	purplestem aster
Symplocarpus foetidus (L.) Nutt.	Symplocarpus foetidus (L.) Nutt.	skunk cabbage	skunk cabbage
Taraxacum officinale Weber	Taraxacum officinale Weber	common dandelion	blowball
Taxodium distichum (L.) L. C. Rich.	Taxodium distichum (L.) L. C. Rich.	baldcypress	baldcypress
Thalictrum dasycarpum Fisch. & Avé-Lall.	Thalictrum dasycarpum Fisch. & Avé-Lall.	purple meadow rue	purple meadow rue
Thelypteris noveboracensis (L.) Nieuwl.	Dryopteris noveboracensis (L.) A. Gray	New York fern	New York fern
Thelypteris palustris var. pubescens (Lawson) Fern.	Dryopteris thelypteris (L.) A. Gray	marsh shield fern	eastern marsh fern
Thuja occidentalis L.	Thuja occidentalis L.	eastern white cedar	arborvitae
Tilia americana L.	Tilia americana L.	basswood	American linden
Toxicodendron radicans ssp. radicans (L.) Kuntze	Rhus radicans L.	poison ivy	poison ivy
Toxicodendron vernix (L.) Kuntze	Rhus vernix L.	poison sumac	poison sumac
Triadenum virginicum (L.) Raf.	Hypericum virginicum L.	marsh St. John's wort	Virginia marsh St. John's wort
Trientalis borealis Raf.	Trientalis borealis Raf.	starflower	Starflower
Triglochin maritima L.	Triglochin maritima L.	common bog arrow grass	seaside arrowgrass
Typha angustifolia L.	Typha angustifolia L.	narrow-leaved cattail	
Typha latifolia L.	Typha latifolia L.	common cattail	broadleaf cattail
Typha X glauca (hybrid) Godr.	Typha X glauca (hybrid) Godr.	hybrid Cattail	white cattail
Ulmus americana L.	Ulmus americana L.	American elm	American elm
Ulmus rubra Muhl.	Ulmus rubra Muhl.	slippery elm	slippery elm
Urtica dioica ssp. gracilis (Ait.) Seland	Urtica procera Willd.	tall nettle	California nettle
Vaccinium angustifolium Aiton	Vaccinium angustifolium Aiton	early low blueberry	lowbush blueberry
Vaccinium corymbosum L.	Vaccinium corymbosum L.	highbush blueberry	highbush blueberry
Vaccinium macrocarpon Aiton	Vaccinium macrocarpon Aiton	large cranberry	cranberry
Vaccinium pallidum Aiton	Vaccinium pallidum Aiton	late low blueberry	blue ridge blueberry
Verbena hastata L.	Verbena hastata L.	blue vervain	blue verbena
Vernonia fasciculata Michx.	Vernonia fasciculata Michx.	common ironweed	prairie ironweed
Veronica peregrina L.	Veronica peregrina L.	purslane speedwell	neckweed
Viburnum lentago L.	Viburnum lentago L.	nannyberry	nannyberry
Viburnum prunifolium L.	Viburnum prunifolium L.	black haw	black haw
Vinca minor L.	Vinca minor L.	common periwinkle	lesser perwinkle
Viola blanda var. palustriformis Gray	Viola incognita Brainerd	hairy white violet	sweet white violet

Appendix SII:B-13 continued			
Viola cucullata Aiton	Viola cucullata Aiton	hooded violet	marsh blue violet
Viola lanceolata L.	Viola lanceolata L.	lance-leaved violet	bog white violet
Viola macloskeyi ssp. pallens (Banks ex Ging) M.S. Baker	Viola pallens (Banks) Brainerd	smooth white violet	smooth white violet
Viola sororia Willd.	Viola sororia Willd.	common blue violet	hooded blue violet
Vitis labrusca L.	Vitis labrusca L.	fox grape	fox grape
Vitis riparia Michx.	Vitis riparia Michx.	riverbank grape	riverbank grape
Woodwardia virginica (L.) Su.	Woodwardia virginica (L.) Su.	Virginia chain fern	
Zizania aquatica L.	Zizania aquatica L.	wild rice	annual wildrice

APPENDIXES SII:C SERIES

Appendix SII:C-1 Species detected in the seedbank of Cowles Bog Wetland Complex.

Appendix SII:C-2 Species detected in the seedbank East of Mineral Springs road.

Appendix SII:C-3 Species detected in the seedbank of the defined plant assemblages present in Cowles Bog Wetland Complex and East of Mineral Springs road.

Appendix SII:C-1: Species detected in the seedbank of Cowles Bog Wetland Complex. Average seed quantity (m^2), frequency (percent) and importance (relative quantity plus relative frequency) were derived from 64 sample points.

Scientific Name	Quantity	Frequency	Importance
Alisma subcordatum	1	4.6	0.5
Amaranthus retroflexus	0	3.1	0.2
Ambrosia artemisiifolia	0	1.5	0.4
Asclepias incarnata	1	1.5	0.2
Bidens connata	4	12.5	1.6
Bidens coronata	1	3.1	0.4
Calamagrostis canadensis	1	6.2	0.7
Campanula aparinoides	0	1.5	0.2
Cardamine pensylvanica	27	37.5	5.8
Carex alata	0	1.5	0.2
Carex aquatilis	3	7.8	1.0
Carex canescens	0	1.5	0.2
Carex comosa	6	21.8	2.7
Carex cristatella	0	1.5	0.2
Carex spp	0	3.1	0.4
Carex stipata	2	12.5	1.5
Carex stricta	0	4.6	0.5
Cephalanthus occidentalis	1	4.6	0.5
Cirsium arvense	0	1.5	0.2
Conyza canadensis	0	3.1	0.4
Cornus obliqua	0	3.1	0.4
Cuscuta gronovii	0	3.1	0.4
Cyperus erythrorhizos	1	4.6	0.6
Cyperus esculentus	1	1.5	0.2
Cyperus odoratus	2	6.2	0.8
Cyperus bipartitus	0	1.5	0.2
Cyperus strigosus	3	4.6	0.7
Doellingeria umbellata	1	1.5	0.2
Echinochloa crusgalli	0	3.1	0.4
Eleocharis palustris	1	4.6	0.6
Eleocharis rostellata	1	6.2	0.7
Epilobium coloratum	1	7.8	0.9
Eragrostis pectinacea	0	1.5	0.2
Erechtites hieracifolia	0	1.5	0.2
Erigeron annuus	0	1.5	0.2
Eupatorium maculatum	5	23.4	2.8
Eupatorium perfoliatum	11	34.3	4.4
Eupatorium serotinum	0	1.5	0.2
Euthamia graminifolia	10	28.1	3.6
Galium tinctorium	1	6.2	0.8
Galium trifidum	0	3.1	0.4
Glyceria striata	26	40.6	6.0
Hypericum majus	0	4.6	0.5
Iris virginica	0	1.5	0.2
Juncus acuminatus	2	7.8	1.0
Juncus canadensis	1	6.2	0.7
Juncus dudleyi	6	12.5	1.8
Juncus effusus	79	31.2	8.6
Juncus tenuis	12	25.0	3.5

Appendix SII:C-1 continued

Scientific Name	Quantity	Frequency	Importance
Leersia oryzoides	36	46.8	7.4
Lindernia dubia	2	9.3	1.1
Lobelia siphilitica	0	1.5	0.2
Ludwigia palustris	9	10.9	1.8
Lycopus americanus	3	0.2	0.9
Lycopus rubellus/uniflorus	2	10.9	1.3
Mentha arvensis	11	10.9	1.9
Mimulus ringens	18	14.0	2.7
Muhlenbergia mexicana	0	1.5	0.2
Myosotis laxa	2	9.3	1.1
Panicum dichotomiflorum	2	9.3	1.1
Panicum spp	0	4.6	0.5
Penthorum sedoides	0	3.1	0.4
Phragmites australis	1	6.2	0.7
Pilea fontana	19	42.1	5.7
Polygonum punctatum	8	15.6	2.2
Polygonum sagittatum	2	10.9	1.3
Ranunculus recurvatus	0	1.5	0.2
Ranunculus sceleratus	2	9.3	1.1
Rhynchospora scirpoides	0	1.5	0.2
Rumex altissimus	0	1.5	0.2
Sagittaria latifolia	0	1.5	0.2
Schoenoplectus acutus	8	12.5	1.8
Scirpus cyperinus	118	87.5	17.2
Scutellaria galericulata	1	1.5	0.2
Scutellaria lateriflora	3	10.9	1.4
Setaria pumila	1	9.3	1.1
Solanum dulcamara	2	7.8	0.9
Solidago gigantea	2	10.9	1.3
Solidago patula	0	3.1	0.4
Symphyotrichum lanceolatum	7	25.0	3.1
Symphyotrichum lateriflorum	1	4.6	0.5
Toxicodendron vernix	0	1.5	0.2
Triadenum virginicum	0	1.5	0.2
Typha spp	994	100.0	77.4
Urtica dioica ssp. gracilis	0	1.5	0.2
Verbena hastata	13	21.8	3.2
Veronica peregrina	0	1.6	0.2
TOTAL SEED	**1487**		

Appendix SII:C-2: Species Detected in the Wetland Seedbank East of Mineral Springs Road. Average seed quantity (m^2), frequency (percent) and importance (relative quantity plus relative frequency) were derived from 10 sample points.

Scientific Name	Quantity	Frequency	Importance
Alisma subcordatum	3	30.0	2.7
Asclepias incarnata	2	20.0	1.8
Calamagrostis canadensis	5	20.0	2.0
Cardamine pensylvanica	23	60.0	6.7
Carex lacustris	3	20.0	1.9
Carex spp.	2	10.0	1.0
Carex stipata	1	10.0	0.9
Carex stricta	13	30.0	3.4
Carex tribuloides	2	10.0	1.0
Cyperus strigosus	1	10.0	0.9
Echinochloa crusgalli	1	10.0	0.9
Epilobium coloratum	2	20.0	1.8
Erechtites hieracifolia	1	10.0	0.9
Eupatorium maculatum	4	30.0	2.8
Eupatorium perfoliatum	4	20.0	2.0
Euthamia graminifolia	10	20.0	2.4
Galium tinctorium	11	40.0	4.1
Glyceria striata	2	20.0	1.8
Juncus acuminatus	2	10.0	1.0
Juncus canadensis	1	10.0	0.9
Juncus effusus	275	50.0	25.7
Juncus tenuis	1	10.0	0.9
Leersia oryzoides	16	50.0	5.3
Ludwigia repens	129	50.0	14.2
Lycopus americanus	4	10.0	1.1
Mentha arvensis	30	50.0	6.4
Mimulus ringens	84	50.0	10.7
Panicum dichotomiflorum	1	10.0	0.9
Panicum spp	3	10.0	1.1
Penthorum sedoides	1	10.0	0.9
Pilea fontana	3	10.0	1.1
Polygonum punctatum	64	50.0	9.1
Polygonum sagittatum	10	50.0	4.8
Ranunculus sceleratus	1	10.0	0.9
Scirpus cyperinus	226	100.0	25.9
Scutellaria galericulata	1	10.0	0.9
Setaria pumila	4	30.0	2.8
Solanum dulcamara	1	10.0	0.9
Solidago gigantea	2	20.0	1.8
Solidago patula	2	10.0	1.0
Symphyotrichum lanceolatum	25	40.0	5.3
Symphyotrichum puniceum	3	20.0	1.9
Typha spp	265	100.0	29.0
Verbena hastata	22	60.0	6.6
TOTAL SEED			

Appendix SII:C-3: Species Detected in Seedbanks of Defined Plant Assemblages Present in Cowles Bog Wetland Complex and Wetland East of Mineral Springs Road. Average seed quantity (m^2), frequency (percent) and importance (relative quantity plus relative frequency) were derived from the quantity of sample points indicated.

Carex Lacustris east of Mineral Springs Road (sample points = 5)

Scientific Name	Quantity	Frequency	Importance
Alisma subcordatum	6	60.0	4.2
Asclepias incarnata	2	20.0	1.4
Calamagrostis canadensis	11	40.0	3.1
Cardamine pensylvanica	45	100.0	8.6
Carex lacustris	6	40.0	2.9
Carex spp	4	20.0	1.5
Cyperus strigosus	2	20.0	1.4
Epilobium coloratum	2	20.0	1.4
Erechtites hieracifolia	2	20.0	1.4
Eupatorium perfoliatum	8	40.0	3.0
Galium tinctorium	21	80.0	6.2
Juncus acuminatus	4	20.0	1.5
Juncus canadensis	2	20.0	1.4
Juncus effusus	550	100.0	32.0
Juncus tenuis	2	20.0	1.4
Leersia oryzoides	21	40.0	3.6
Ludwigia palustris	252	80.0	16.9
Mentha arvensis	59	100.0	9.3
Mimulus ringens	168	100.0	14.3
Panicum dichotomiflorum	2	20.0	1.4
Penthorum sedoides	2	20.0	1.4
Polygonum punctatum	129	100.0	12.5
Polygonum sagittatum	8	20.0	1.7
Scirpus cyperinus	413	100.0	25.7
Scutellaria galericulata	2	20.0	1.4
Setaria pumila	6	40.0	2.9
Solanum dulcamara	2	20.0	1.4
Solidago gigantea	2	20.0	1.4
Symphyotrichum puniceum	2	20.0	1.4
Typha spp	382	100.0	24.3
Verbena hastata	38	80.0	7.0
Total Seed	**2159**		

Carex stricta east of Mineral Springs Road (sample points = 5)

Asclepias incarnata	2	20.0	2.7
Cardamine pensylvanica	2	20.0	2.7
Carex stipata	2	20.0	2.7
Carex stricta	25	60.0	13.1
Carex tribuloides	4	20.0	3.3
Echinochloa crusgalli	2	20.0	2.7
Epilobium coloratum	2	20.0	2.7
Eupatorium maculatum	8	60.0	8.6
Euthamia graminifolia	19	40.0	9.3
Glyceria striata	2	20.0	2.7
Leersia oryzoides	11	60.0	9.2
Ludwigia palustris	6	20.0	3.8

Appendix SII:C-3 continued

Scientific Name	Quantity	Frequency	Importance
Lycopus americanus	8	20.0	4.4
Panicum spp	6	20.0	3.8
Pilea fontana	6	20.0	3.8
Polygonum sagittatum	11	80.0	11.3
Ranunculus sceleratus	2	20.0	2.7
Scirpus cyperinus	38	100.0	20.8
Setaria pumila	2	20.0	2.7
Solidago gigantea	2	20.0	2.7
Solidago patula	4	20.0	3.3
Symphyotrichum lanceolatum	51	80.0	22.0
Symphyotrichum puniceum	4	20.0	3.3
Typha spp	148	100.0	50.0
Verbena hastata	6	40.0	5.9
Total Seed	**377**		
Raised Fen of Cowles Bog Wetland Complex (sample points = 8)			
Asclepias incarnata	4	12.5	2.1
Bidens connata	3	12.5	1.9
Cardamine pensylvanica	16	37.5	6.8
Carex comosa	12	37.5	6.2
Cuscuta gronovii	3	25.0	3.4
Eleocharis rostellata	1	12.5	1.7
Eupatorium maculatum	16	37.5	6.8
Eupatorium perfoliatum	16	50.0	8.3
Glyceria striata	49	75.0	15.9
Juncus tenuis	12	12.5	3.2
Leersia oryzoides	25	37.5	8.1
Lobelia siphilitica	1	12.5	1.7
Lycopus americanus	13	12.5	3.4
Lycopus rubellus/uniflorus	1	12.5	1.7
Myosotis laxa	4	37.5	5.1
Phragmites australis	3	12.5	1.9
Pilea fontana	23	75.0	12.2
Psilocarya scirpoides	1	12.5	1.7
Ranunculus recurvatus	1	12.5	1.7
Scirpus acutus	3	12.5	1.9
Scirpus cyperinus	54	75.0	16.7
Scutellaria galericulata	8	25.0	4.1
Solanum dulcamara	4	25.0	3.6
Solidago gigantea	7	12.5	2.4
Symphyotrichum lanceolatum	4	25.0	3.6
Typha spp.	432	100.0	72.4
Verbena hastata	1	12.5	1.7
Total Seed	**717**		
North Graminoid Fen of Cowles Bog Wetland Complex (sample points = 5)			
Bidens coronata	2	20.0	3.9
Cardamine pensylvanica	6	20.0	4.2
Carex comosa	30	60.0	13.5
Eleocharis rostellata	4	20.0	4.0

Appendix SII:C-3 continued

Scientific Name	Quantity	Frequency	Importance
Eupatorium maculatum	2	20.0	3.9
Glyceria striata	2	20.0	3.9
Juncus canadensis	2	20.0	3.9
Juncus tenuis	19	60.0	12.6
Leersia oryzoides	21	20.0	5.4
Lycopus rubellus/uniflorus	6	20.0	4.2
Pilea fontana	4	20.0	4.0
Schoenoplectus acutus	34	40.0	10.1
Scirpus cyperinus	66	60.0	16.4
Solidago gigantea	2	20.0	3.9
Symphyotrichum lateriflorum	2	20.0	3.9
Typha spp	1047	100.0	102.2
Total	**1251**		
Remnant Sedge Meadow of Cowles Bog Wetland Complex (sample points = 9)			
Alisma subcordatum	1	11.1	0.9
Calamagrostis canadensis	1	11.1	0.9
Cardamine pensylvanica	5	22.2	2.0
Carex aquatilis	2	11.1	1.0
Carex spp	1	11.1	0.9
Carex stipata	4	22.2	1.9
Carex stricta	1	11.1	0.9
Cyperus strigosus	12	22.2	2.5
Eleocharis palustris	1	11.1	0.9
Erigeron canadensis	1	11.1	0.9
Eupatorium maculatum	1	11.1	0.9
Eupatorium perfoliatum	12	44.4	4.2
Glyceria striata	7	33.3	3.0
Hypericum majus	2	22.2	1.8
Iris virginica	1	11.1	0.9
Juncus acuminatus	4	11.1	1.1
Juncus canadensis	2	22.2	1.8
Juncus dudleyi	28	66.7	7.1
Juncus effusus	415	100.0	37.6
Juncus tenuis	45	55.6	7.4
Leersia oryzoides	18	44.4	4.6
Lindernia dubia	1	11.1	0.9
Ludwigia palustris	12	22.2	2.5
Lycopus americanus	5	11.1	1.2
Lycopus rubellus/uniflorus	4	33.3	2.8
Muhlenbergia mexicana	1	11.1	0.9
Panicum dichotomiflorum	1	11.1	0.9
Pilea fontana	9	44.4	4.0
Polygonum punctatum	1	11.1	0.9
Polygonum sagittatum	11	55.6	4.9
Ranunculus sceleratus	2	22.2	1.8
Scirpus cyperinus	179	100.0	20.5
Scutellaria galericulata	4	22.2	1.9
Solidago gigantea	1	11.1	0.9
Solidago graminifolia	42	100.0	10.6
Solidago patula	2	22.2	1.8

Appendix SII:C-3 continued			
Scientific Name	**Quantity**	**Frequency**	**Importance**
Symphyotrichum lanceolatum	26	66.7	6.9
Symphyotrichum lateriflorum	4	22.2	1.9
Typha spp	440	100.0	39.5
Verbena hastata	66	88.9	11.5
Total	**1375**		
Forested Swamp of Cowles Bog Wetland Complex (sample points = 6)			
Bidens connata	23	66.7	8.1
Bidens coronata	4	16.7	1.8
Cardamine pensylvanica	127	83.3	19.1
Carex canescens	2	16.7	1.7
Carex stipata	9	50.0	5.3
Cyperus erythrorhizos	2	16.7	1.7
Eupatorium maculatum	2	16.7	1.7
Eupatorium perfoliatum	14	50.0	5.8
Glyceria striata	110	100.0	19.0
Juncus acuminatus	7	33.3	3.7
Juncus canadensis	4	16.7	1.8
Leersia oryzoides	60	66.7	11.5
Lycopus americanus	7	16.7	2.2
Mentha arvensis	9	16.7	2.3
Mimulus ringens	150	50.0	18.1
Myosotis laxa	11	33.3	4.0
Panicum dichotomiflorum	4	16.7	1.8
Panicum spp	2	16.7	1.7
Pilea fontana	37	83.3	10.9
Scirpus cyperinus	182	100.0	25.6
Scutellaria galericulata	16	50.0	6.0
Setaria pumila	2	16.7	1.7
Solidago graminifolia	9	50.0	5.3
Typha spp	311	100.0	37.3
Urtica dioica spp. gracilis	4	16.7	1.8
Total	**1104**		
Cattail dominated zones (sample points =34)			
Alisma subcordatum	1	5.9	0.7
Amaranthus retroflexus	0	2.9	0.3
Ambrosia artemisiifolia	1	5.9	0.7
Bidens connata	1	5.9	0.7
Calamagrostis canadensis	2	8.8	1.1
Campanula aparinoides	0	2.9	0.3
Cardamine pensylvanica	10	32.4	4.1
Cephalanthus occidentalis	1	8.8	1.0
Cirsium arvense	1	2.9	0.4
Cornus obliqua	1	5.9	0.7
Carex alata	0	2.9	0.3
Carex aquatilis	5	11.8	1.6
Carex comosa	4	20.6	2.5
Carex cristatella	0	2.9	0.3
Carex spp	0	2.9	0.3

Appendix SII:C-3 continued

Scientific Name	Quantity	Frequency	Importance
Carex stipata	1	5.9	0.7
Carex stricta	1	5.9	0.7
Conyza canadensis	0	2.9	0.3
Cyperus erythrorhizos	2	5.9	0.8
Cyperus esculentus	2	2.9	0.4
Cyperus odoratus	3	11.8	1.5
Cyperus bipartitus	0	2.9	0.3
Cyperus strigosus	3	2.9	0.5
Doellingeria umbellata	1	2.9	0.4
Echinochloa crusgalli	1	5.9	0.7
Eleocharis palustris	2	5.9	0.8
Eleocharis rostellata	1	5.9	0.7
Epilobium coloratum	2	14.7	1.7
Eragrostis pectinacea	0	2.9	0.3
Erechtites hieracifolia	0	2.9	0.3
Erigeron annuus	1	2.9	0.4
Eupatorium maculatum	4	20.6	2.5
Eupatorium perfoliatum	10	29.4	3.8
Eupatorium serotinum	0	2.9	0.3
Euthamia graminifolia	6	17.6	2.3
Galium tinctorium	3	11.8	1.5
Galium trifidum	1	5.9	0.7
Glyceria striata	13	23.5	3.3
Hypericum majus	0	2.9	0.3
Juncus acuminatus	2	5.9	0.8
Juncus dudleyi	5	5.9	0.9
Juncus effusus	39	32.4	5.7
Juncus tenuis	6	20.6	2.6
Leersia oryzoides	39	47.1	7.3
Lindernia dubia	4	14.7	1.8
Ludwigia palustris	14	14.7	2.4
Lycopus americanus	2	5.9	0.8
Lycopus rubellus/uniflorus	1	2.9	0.4
Mentha arvensis	18	17.6	2.9
Mimulus ringens	7	17.6	2.4
Myosotis laxa	2	2.9	0.4
Panicum dichotomiflorum	3	11.8	1.5
Panicum spp.	1	5.9	0.7
Penthorum sedoides	1	5.9	0.7
Phragmites australis	2	8.8	1.1
Pilea fontana	18	26.5	3.9
Polygonum punctatum	15	26.5	3.7
Polygonum sagittatum	1	5.9	0.7
Ranunculus sceleratus	2	11.8	1.4
Rumex altissimus	0	2.9	0.3
Sagittaria latifolia	0	2.9	0.3
Schoenoplectus acutus	7	11.8	1.7
Scirpus cyperinus	115	88.2	16.0
Scutellaria galericulata	2	2.9	0.4
Setaria pumila	2	14.7	1.7
Solanum dulcamara	2	8.8	1.1

Appendix SII:C-3 continued			
Scientific Name	**Quantity**	**Frequency**	**Importance**
Solidago gigantea	2	11.8	1.4
Symphyotrichum lanceolatum	5	23.5	2.9
Toxicodendron vernix	0	2.9	0.3
Triadenum virginicum	1	2.9	0.4
Typha spp.	1435	100.0	88.8
Verbena hastata	7	14.7	2.0
Veronica peregrina	0	2.9	0.3
Total	**1845**		
Cattail dominated wetland; ten to twenty years of age (sample points = 8)			
Alisma subcordatum	1	12.5	1.2
Amaranthus retroflexus	1	12.5	1.2
Bidens connata	1	12.5	1.2
Calamagrostis canadensis	4	12.5	1.3
Campanula aparinoides	1	12.5	1.2
Cardamine pennsylvanica	21	75.0	7.7
Carex aquatilis	19	12.5	4.2
Carex cristatella	5	12.5	1.4
Carex comosa	1	12.5	1.2
Carex stipata	1	12.5	1.2
Carex stricta	1	12.5	1.2
Cephalanthus occidentalis	3	37.5	1.2
Cornus obliqua	1	12.5	1.2
Cyperus erythrorhizos	4	12.5	1.3
Cyperus odoratus	1	12.5	1.2
Cyperus bipartitus	1	12.5	1.2
Eleocharis palustris	1	12.5	1.2
Epilobium coloratum	4	25.0	2.4
Eupatorium maculatum	4	25.0	2.4
Eupatorium perfoliatum	4	37.5	3.5
Euthamia graminifolia	3	12.5	1.2
Galium tinctorium	3	25.0	2.4
Galium trifidum	1	12.5	1.2
Glyceria striata	15	37.5	4.0
Juncus dudleyi	19	12.5	1.9
Juncus effusus	99	50.0	8.8
Juncus tenuis	12	12.5	1.6
Leersia oryzoides	56	75.0	9.1
Lindernia dubia	4	12.5	1.3
Ludwigia palustris	20	12.5	2.0
Lycopus americanus	5	12.5	1.4
Mentha arvensis	44	37.5	5.3
Mimulus ringens	11	12.5	1.6
Pilea fontana	19	25.0	3.0
Polygonum punctatum	9	37.5	3.8
Polygonum sagittatum	1	12.5	1.2
Sagittaria latifolia	1	12.5	1.2
Scirpus cyperinus	278	100.0	21.0
Setaria pumila	1	12.5	1.2
Solanum dulcamara	4	12.5	1.3
Symphyotrichum lanceolatum	7	37.5	3.7

Appendix SII:C-3 continued			
Scientific Name	**Quantity**	**Frequency**	**Importance**
Triadenum virginicum	3	12.5	1.2
Typha spp.	1618	100.0	78.7
Verbena hastata	5	25.0	2.5
Veronica peregrina	1	12.5	1.2
TOTAL	**2320**		
Cattail dominated wetland; twenty to forty years of age (sample points = 19)			
Alisma subcordatum	1	5.3	0.6
Ambrosia artemisiifolia	1	5.3	0.6
Bidens connata	1	5.3	0.6
Calamagrostis canadensis	2	10.5	1.3
Cardamine pennsylvanica	8	26.3	3.5
Carex alata	1	21.1	0.6
Carex aquatilis	1	5.3	0.6
Carex comosa	4	5.3	2.6
Carex spp	1	10.5	0.6
Carex stricta	1	5.3	0.6
Cephalanthus occidentalis	1	5.3	1.3
Cornus obliqua	1	5.3	0.6
Cyperus erythrorhizos	2	5.3	0.7
Cyperus esculentus	3	5.3	0.8
Cyperus odoratus	5	10.5	1.5
Cyperus strigosus	6	5.3	1.0
Echinochloa crusgalli	1	5.3	0.6
Eleocharis palustris	3	5.3	0.8
Eleocharis rostellata	1	10.5	1.3
Epilobium coloratum	2	15.8	1.9
Erigeron annuus	1	5.3	0.7
Eupatorium maculatum	6	26.3	3.4
Eupatorium perfoliatum	12	21.1	3.1
Euthamia graminifolia	9	26.3	3.6
Galium tinctorium	1	5.3	0.7
Galium trifidum	1	5.3	0.6
Glyceria striata	5	21.1	2.7
Hypericum majus	1	5.3	0.6
Juncus acuminatus	4	10.5	1.4
Juncus dudleyi	1	5.3	0.6
Juncus effusus	23	26.3	4.3
Juncus tenuis	3	21.1	2.6
Leersia oryzoides	38	47.4	7.6
Lindernia dubia	5	21.1	2.7
Ludwigia palustris	16	15.8	2.7
Lycopus americanus	2	5.3	0.7
Mentha arvensis	15	15.8	2.6
Mimulus ringens	2	15.8	1.9
Panicum dichotomiflorum	3	10.5	1.4
Penthorum sedoides	2	10.5	1.3
Phragmites australis	1	5.3	0.7
Pilea fontana	18	26.3	4.1
Polygonum punctatum	18	15.8	2.8
Polygonum sagittatum	1	5.3	0.6

Appendix SII:C-3 continued			
Scientific Name	**Quantity**	**Frequency**	**Importance**
Ranunculus sceleratus	4	15.8	2.0
Rumex altissimus	1	5.3	0.6
Schoenoplectus acutus	13	94.7	3.2
Scirpus cyperinus	67	21.1	14.7
Setaria pumila	2	10.5	1.3
Solanum dulcamara	1	5.3	0.6
Solidago gigantea	3	21.1	2.6
Symphyotrichum lanceolatum	7	26.3	3.4
Toxicodendron vernix	1	5.3	0.6
Typha spp.	1410	100.0	92.3
Verbena hastata	11	15.8	2.5
TOTAL	**1746**		
Cattail dominated wetland; seventy to eighty years of age (sample points = 5)			
Ambrosia artemisiifolia	2	20.0	3.7
Cirsium arvense	4	20.0	3.9
Conyza canadensis	2	20.0	3.7
Cyperus odoratus	2	20.0	3.7
Echinochloa crusgalli	2	20.0	3.7
Eupatorium perfoliatum	2	20.0	3.7
Eupatorium serotinum	2	20.0	3.7
Juncus effusus	17	40.0	8.7
Juncus tenuis	2	20.0	3.7
Ludwigia palustris	2	20.0	3.7
Mimulus ringens	2	20.0	3.7
Panicum dichotomiflorum	8	20.0	4.3
Panicum spp	4	40.0	7.3
Phragmites australis	6	40.0	7.6
Polygonum punctatum	4	20.0	3.9
Ranunculus sceleratus	2	20.0	3.7
Scirpus cyperinus	6	40.0	7.6
Setaria pumila	4	40.0	7.3
Solanum dulcamara	6	20.0	4.1
Typha spp.	876	100.0	108.6
TOTAL	**958**		