RESTORATION AND VEGETATION RESPONSE IN KIRK FEN, A PRAIRIE FEN IN ANN ARBOR MICHIGAN

By

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ABSTRACT

Kirk Fen is a 0.73-hectare remnant prairie fen located at the University of Michigan Matthaei Botanical Gardens property in Ann Arbor, Michigan in Washtenaw County. It is known to have high floristic quality and two floral species threatened and imperiled in Michigan: the small white lady slipper (*Cypripedium candidum*) and common valerian (*Valeriana ciliata*). The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), a reptile of special concern, is a resident there as well. However, Kirk Fen occupies only twelve percent of its historical boundaries and is becoming a low diversity shrub-carr habitat dominated by invasive woody species, particularly glossy buckthorn (*Rhamnus frangula*). Intervention is necessary to prevent further deterioration (Ruhfel 2005).

Functioning prairie fens serve a critical role in our watersheds and are globally and locally rare. They are unique ecosystems throughout their range in the upper Midwestern North America and are threatened both from agriculture and urban development. This practicum is focused on two basic questions relating to fen restoration . What is the response of vegetation to the removal of invasive species? How should “success” be measured in fen restoration efforts?

Clearing of woody invasive species in Kirk Fen was done in the years 2006 to 2009. Floral response was captured in 2008 and 2009 with comprehensive floral inventories, a pilot plant species dominance survey, and a pilot *Cypripedium candidum* survey. An inventory and species cover survey using five line-intercept transects was conducted in 2009. Photo points were established and base-line photo-point documentation was conducted from 2008 to 2009. Reports were made based on the inventories, surveys, and line-intercept transects.

Using the Floristic Quality Assessment for Michigan flora (Herman et al. 2001) to compare the inventories of 2008 and 2009 to those reported in 2005, it was found that the original remnants had slightly less Mean C and lower species diversity. However, Mean Wetness (Mean W) increased, fewer native and adventive woody species were present, and greater native forbs and graminoid species were found. Low-, mid-, and high-C distribution remained relatively the same. Some important species did not recover during the two years of the inventories.

Using the FQA and pilot surveys, the greater restored Kirk Fen site has shown dramatic recovery after clearing of woody invasive species. While common fen species numbers recovered during the study, the numbers of rare species historically found in the fen declined. These results raise questions about the impact of management activities on rare vs. common species in fen restoration projects.

The study concludes with recommendations for future fire management, continued invasive species removal, deer exclusion, mitigation and improvements to the Kirk Brook catchment outside the fen, and creation of limited public access and educational activities related to the restoration of the fen.

DEDICATION

This practicum is dedicated to Leon

ACKNOWLEDGEMENTS

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Erskine, dedicated volunteer who assisted with the 2008 inventories with enthusiasm and encouragement; to Adam Ferris-Smith for his help with the last formatting; my cousin Chuck for his professional input and encouragement; Dorothea Coleman for her formatting, edits and for bringing me pieces of historical information related to Kirk Fen when she was organizing the Botanical Gardens files; to Joanne Koptur for final editing; to MBGNA staff and volunteers who encouraged me during the process of writing this opus; everyone who volunteered and helped with this project; and my brother Chris Crancer who waited patiently for another visit.

EXECUTIVE SUMMARY

Kirk Fen is a .73-hectare remnant prairie fen located at the University of Michigan Matthaei Botanical Gardens property in Ann Arbor, Michigan in Washtenaw County. The site is directly northwest of the confluence of Kirk Brook and Fleming Creek. Kirk Fen is known to have high floristic quality and two floral species threatened and imperiled in Michigan: the white lady slipper (*Cypripedium candidum*) and common valerian (*Valeriana cilata*). The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), a reptile of special concern, is a resident there as well. However, only twelve percent of the historically open areas of Kirk Fen remain, and the entire site is on a trajectory to becoming a low diversity shrub-carr habitat dominated by invasive woody species, particularly glossy buckthorn (*Rhamnus frangula*) (Ruhfel 2005).

Because functioning prairie fens serve a critical role in our watersheds and are globally and locally rare and unique ecosystems, the restoration of Kirk Fen to its historical boundaries is important. And because prairie fen restoration documentation and follow up studies are limited in the literature, addressing these needs through peer-respected methods is critical for the future survival of these rare habitats.

The central theme of this study is to investigate the response by historic fen vegetation to the removal of invasive species and to determine how to measure project success.

The objectives for this practicum were to 1) plan and implement woody invasive removal, while minimizing the impact on the peat soils of the site, 2)

document restoration efforts, 3) measure floral and site response after restoration efforts, and 4) create a monitoring program that will articulate floral objectives and goals for measuring success. Through these efforts, the study will contribute to a wider understanding of prairie fen restoration in the Midwest.

Clearing of woody invasive species was done in the years 2006 to 2009. Much of the site within the 1949 boundaries were cleared. Floral response was captured in 2008 and 2009 with comprehensive floral inventories, a pilot dominance survey, and a pilot *Cypripedium candidum* survey. Inventory and species cover was also captured by with five line-intercept transects in 2009. Photo points were set up and base-line photo-point documentation conducted in 2008 to 2009. Reports were given based on the inventories, surveys and line-intercept transects.

Using the Floristic Assessment program created for the state of Michigan (Herman et al 2001) the original remnants in 2008 and 2009 as compared to 2005 were found to have 0.02 decrease in Mean Coefficient of Conservatism (Mean C), however, this is expected after restoration activities such as woody species removal (Wilhelm et al 2005). Additionally the remnants showed a Mean C of 4.5 demonstrating high natural area potential, irreplaceable by mitigation. With proper stewardship, the Mean C is expected to remain constant over time. Furthermore, mean Wetness (Mean W) increased from -1.8 to -2.7 raising the wetland category of the intact area from facultative wet minus (FACW-) to facultative wet (FACW) indicating an increase in wetland flora. Low-, mid- and high-C distribution remained relatively unchanged; however, some important high-C species were absent. Among them were *Valeriana ciliata* (inventoried in 2008 but not on the 2009) and *Cypripedium candidum* (not documented in either the 2008 or 2009 inventories but seen in earlier inventories done in the spring and summer of 2006 and 2007). Although species diversity was lower after restoration efforts, the percent of native species increased and there were fewer native and adventive woody species and greater native forbs and graminoid species. As in the earlier inventories from 2005, sedge meadow species of prairie fen complex dominated, woody fen species were significant and the number of inundated fen species was low. There were, however, fewer total prairie fen species in 2009 which directly related to the absence of calcareous species originally seen in 2005. The count of plant species typically associated with *Cypripedium candidum* were the same as in 2005.

Over all, the inventories and surveys indicate definite progress towards achieving a similar species composition and floristic quality as the intact 2005 areas just three years from the start of the project.

Spatial analysis of the 2009 inventories showed all but four of the areas at or above the Mean C threshold of 3.5. A general pattern was that those areas sharing the same topological gradient and occupying the middle areas of the 1949 boundaries, have the highest values of FQI, Mean C, Mean W, percent native species, percent graminoid species, prairie fen species and indicators, and the greatest number of *Cypripedium candidum* associates. However, woody adventive species did not necessarily show an inverse relationship to the high quality indicators. Percent adventive woody species ranged from 3.8% to 20% throughout the 2009 inventoriesm, indicating more removal work is needed.

The *Cypripedium candidum* pilot surveys of 2008 and 2009 showed greater ground water presence, greater sun exposure and less shrub threat in 2009. Forb competition in the intact areas was less in 2009 but increased in the cut phase 1 areas. While there were slightly fewer *Cypripedium candidum* associates in 2009, their spatial distribution was more widespread.

For future monitoring of floral and site response, proximate and distal thresholds were articulated to measure project success and two schedules were offered, one using comprehensive inventories, dominance survey and *Cypripedium candidum* survey and another including line-intercept transects. Continued photo-monitoring is suggested.

The short, two year time frame of this study raises questions about the longer-term impact of management activities on floral response: specifically the long-term recovery of rare vs. common species in fens. It is unknown, for instance, if trampling related to management work impacted several of the rare fen species, or if the opening up of the site may have made these species more vulnerable to deer predation, which is high across the site. It may be that the asynchronous response of species is to be expected and, in time, more conservative species will regenerate once soil dynamics return to historical equilibrium. Or, perhaps the hydrology of the site has been compromised from nearby development and what we are seeing is an ecosystem change.

The study also addresses future management needs: continued woody removal to the rest of the 1949 boundaries and specific areas beyond, development of a fire management program, the creation of a contiguous fire-dependant landscape with exciting prairie and oak savanna, continued invasive forb management, and deer exclusion. In addition, degradation of Kirk Brook along the edge of the fen may be reducing ground water flows through the fen. The development of a catchment mitigation and protection plan and the installation of ground water monitoring wells would begin to address these problems. Finally, the Kirk Fen restoration project is an excellent area for public access and opportunity for eco-restoration education.

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I. INTRODUCTION

This practicum is focused on the restoration of Kirk Fen, one of the unique natural habitats found at the University of Michigan's Matthaei Botanical Gardens and Nichols Arboretum, (hereafter referred to as MBGNA), an analysis of the impacts of restoration activities carried out from 2006-2010, and a suggestion of future restoration and monitoring activities. This chapter addresses the reasoning of the practicum and includes a brief site description. Sections include: 1) Justification, 2) Background, 3) Objectives and Approach, and 4) Study Area.

JUSTIFICATION

The justification for this practicum is based on a) the important functions of wetlands in our watersheds; b) the rarity and uniqueness of fens and especially prairie fens, c) prairie fens as diverse ecosystems each with its own mix of rare, threatened, and unique flora and fauna; d) prairie fens in threat and the need for protection and restoration; e) Kirk Fen as a high quality remnant prairie fen with rare and threatened species that is in need of both study and restoration; f) furthering the establishment of a fire-dependent continuum with the existing prairie and remnant oak savanna; g) the need to document restoration activities, the responses of the flora, and to establish object based monitoring in order to measure restoration success; and h) this practicum's alignment with the University of Michigan Botanical Gardens and Arboretum's Mission Statement and stakeholder interest in Kirk Fen.

IMPORTANT FUNCTIONS OF WETLANDS IN OUR WATERSHEDS

Intact and functioning wetlands serve a critical role in our watersheds by preserving stream water quality and temperature (Amon et al. 2002, Bedford and Godwin 2003). Particularly, the proximity of prairie fens to watershed headwaters serves to modify the level of phosphorous and nitrogen in streams (Bedford and Godwin 2003), provide clean water for streams and lakes, store and slowly release storm and floodwaters, and serve as habitat for a broad diversity of plants and animals (Kost and Hyde 2009). Other wetland functions include ground water recharge and discharge, floodwater alteration and mitigation, sediment stabilization, sediment and toxicant retention, and bio-production export (Campbell 1999).

PRAIRIE FENS AS DIVERSE ECOSYSTEMS

Fens in general are restricted to interlobate glaciated areas and are the result of specific hydrogeological factors of surface topography, slope, stratigraphic and hydraulic soil properties, surficial geologic deposits and bedrock within the watershed and underlying the fen, the mineralogy of its soils, the area of the wetland relative to area of the immediate watershed and flow-path length of ground water before it reaches the wetland (Bedford and Godwin 2003; Spieles, et al. 2010). Fens are typically peat-accumulating systems that are influenced by ground water (Joosten and Clarke 2002 cited in Middleton et al. 2006). They are located where mineral-rich ground water flows to the plant root zone (Bedford and Godwin 2003), the ground water level is relatively constant (Amon et a 2002) and dominates the water budget (Bedford and Godwin 2003). Calcareous fens (rich fens) have soils enriched with calcium bicarbonate ground water (Bedford and Godwin 2003). Soils are also typically low in phosphorous and nitrogen (Bedford and Godwin 2003).

Prairie fens are a unique type of calcareous fens that evolved in a continuum with upland fire-driven ecosystems (Bowles et al. 2005, Kost and Hyde 2009, MSU website 2010, Spieles et al. 2010) and features prairie forbs within a matrix of prairie grasses and sedges, which are the dominant plants in the ecosystem (Bowles et al. 2005; Kost and Hyde 2009). Fen rarity is also due to their destruction by anthropogenic disturbance from agriculture and urban development (Kost and Hyde 2009; Spieles et al. 2010, MSU web site 2010). Fens of all types now occupy less than 1% of the earth's surface. In the midwestern United States, calcareous fens comprise a very small percentage of area (0.02% to 0.01%) **(**Miner and Ketterling 2003**)**. Prairie fens, a subset of rich calcareous fens, occupy even less acreage and are less common in the Midwest than are calcareous fens and are considered to be globally and locally rare and unique ecosystems (Amon et al. 2002; Kost and Hyde 2009; Spieles et al. 2010). Today, there are 150 prairie fens reported in Michigan, of various degrees of preservation and degradation, all found in the lower third of the Lower Peninsula. Kirk Fen is one 81 reported in southeast Michigan and one of 15 reported in Washtenaw County.

Intact prairie fens are not only rare, they are among the most biologically diverse wetland habitats of North America and often are refugia for rare and endangered flora and fauna (Nekola 1999; Amon et al. 2002; Bedford and Godwin 2003; Miner and Ketterling 2003; Spieles et al. 2010). Michigan prairie fens are habitat to sixteen rare species of flora and ten fauna species (Spieles et al. 2010). The unique flora found in prairie fens is the result of plant adaptation to the particular and distinctive hydrogeological properties (Amon et al. 2002, Bedford and Godwin 2003, Picking and Veneman 2004, Spieles et al. 2010) and their unique post-glacial history of immigration and extinction (Nekola 1999).

PRAIRIE FENS THREATENED

Prairie fens are under threat of land-use pressure and degradation such as fragmentation, changes in hydrology, nutrient loading, fire suppression, and colonization of non-native invasive species (Bedford et al. 2003; Kost and Hyde 2009). Individual species found in prairie fens can be vulnerable to local extinction because of the fragmented landscape in which they are embedded (Nedola 1999, Bowles 2005, MSU web site 2010). Altered hydrology of the water table or water movement can result from urban development and have a direct effect on flora (Bowles et al. 2005; Kost and Hyde 2009; Spieles et al. 2010; MSU website 2010). Colonization by non-native invasive woody species is frequently attributed to fire suppression as well as to nutrient loading (Bedford and Godwin 2003; Kost and Hyde 2009; Bowles et al. 2005; MSU website 2010). Additionally, fens often develop in headwater areas and, being distant from navigable-in-fact waters, are considered “isolated” for jurisdictional purposes (Bedford and Godwin 2003). Because prairie fens are so rare and have unique flora and fauna, high levels of protection and study are warranted (Bedford and Goldwin 2003; Bowles et al. 2005, Miner and Ketterling 2003).

KIRK FEN

Since the earliest inventories of the Matthaei Botanical Gardens property in the 1950s and 1960s, the complex of wetlands in the Kirk Fen area was noted as a special area. On a 1960s era map of the property, for instance, the complex of wetlands was noted as Kirk Bog, Cummings Marsh and Sinclair Bog. In Brad Ruhfel's thesis work in 2005 (Ruhfel 2005), he more properly identified Kirk Fen as a remnant prairie fen by way of remnant flora, regional landscape conditions, and soil conditions. Comprehensive floral inventories indicate Kirk Fen is a high quality wetland remnant of native character and a profoundly important wetland from both an environmental and a regional natural area perspective. In Ruhfel's comparison of remnant fen ecosystems in Washtenaw County, Kirk Fen was rated as the second highest in quality. Furthermore, Kirk Fen was reported to have remnant populations of two floral species threatened and imperiled in Michigan: the small white lady slipper (*Cypripedium candidum*) and common valerian (*Valeriana ciliata*). The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), a reptile of special concern, is a resident there as well. However, prior to the work initiated by this study, Kirk Fen was on a trajectory to become a low diversity shrub-carr habitat dominated by invasive woody species, particularly glossy buckthorn (*Rhamnus frangula*). Ruhfel suggested that intervention would be necessary to prevent further deterioration (Ruhfel 2005).

ESTABLISHING A FIRE-DEPENDENT CONTINUUM WITH THE EXISTING PRAIRIE AND REMNANT OAK SAVANNA

The restoration and stewardship of Kirk Fen will aid in the establishment of a gradient of diverse fire-dependent landscapes with the nearby existing prairie and an oak savanna remnant to the southeast of Kirk Fen on the grounds of the Botanical Gardens. Historically, prairie fens evolved in conjunction with upland fire-dependent ecosystems (Bowles et al. 2005, Kost and Hyde 2009, MSU website 2010; Spieles et al. 2010). Since prairie fens and prairies have many grasses and forbs in common (Spieles et al. 2010), such a continuum will aid in genetic movement and flow between these ecosystems. Additionally, female eastern massasauga rattlesnakes typically seek upland oak savanna and prairie edges for rearing their young: a continuum of quality landscape will benefit this herpetofauna (Lee and Legge 2000).

NEED TO DOCUMENT RESTORATION ACTIVITIES AND RESULTS, AND ESTABLISH OBJECT-BASED MONITORING IN ORDER TO MEASURE RESTORATION SUCCESS

Prairie fen restoration documentation and follow up studies are limited in the literature. Each is specific to a region or concerned with other types of fens. There is a need for more documentation of restoration efforts and floral response (Jordan et al. 1987, Harker and Harker 1993, Amon et al. 2002, Spieles et al. 2010) and for object-based monitoring in place to measure success (Palmer 1986; Owen and Rosentreter 1992; Falk et al. 1996; Elzinga et al. 1998, Apfelbaum and Haney 2010). Therefore, this study and the development of an object-based monitoring program in Kirk Fen provide an opportunity to further the knowledge base regarding restoration of prairie fens in the Midwest.

THIS PRACTICUM AND THE MISSION OF MBGNA

This practicum aligns with University of Michigan Matthaei Botanical Gardens and Nichols Arboretum's strong commitment and explicit mission of natural conservation and restoration of the many ecosystems found in the various properties under its stewardship. The restoration of Kirk Fen and the documentation of floral response are important to additional stakeholders including the 1800 members of the Friends of MBGNA, university students and faculty, MBGNA's ecological stewardship volunteers, many mission-related organizations, Botanical Gardens neighbors and surrounding community, and the Fleming Creek Watershed and Huron River Watershed Councils.

BACKGROUND

This section reports on previous floral studies in Kirk Fen in chronological order.

The earliest studies related to Kirk Fen were several floral surveys. The first floristic survey at the Botanical Gardens was conducted and reported by Wilson in 1958. In this first survey, Kirk Fen was recorded as "*Potentilla fruticosa* Bog, Area 1" and included 146 species, many of them prairie fen indicators and having high coefficients of conservatism by today's standards. In 1967 a floral inventory was conducted by Schmid (1967) in which Kirk Fen was referred to as Cummings Marsh. In 1971, Marilyn Bland updated a previous compilation of species by Sylvia Taylor (1967) in which the Kirk Fen area was referred to as a seepage bog. In 1972 a floral phenology report of the Botanical Gardens was published (McWilliams and Ludwig 1972); again the Kirk Fen area was referred to as a seepage bog. In both the Bland (1971) and the Mcwilliams and Ludwig (1972) floral surveys, the small white lady slipper (*Cypripedium candidum*) was documented in a seepage bog and weedy habitat. However, in both these surveys, it was unclear if the small white lady slipper was sighted in the south seepage bog (Radrick Fen) or that to the north seepage bog (Kirk Fen). The first definite recorded sighting of the small white lady slipper in Kirk Fen was made in 1995 by botanist Ellen Elliot Weatherbee (Ruhfel 2005). Interest in the small white lady slipper and state threatened and species of high coefficients and conservatism reported by Weatherbee is what drew the attention of MBGNA administration to Kirk Fen and inspired University of Michigan School of Natural Resources and Environment student Brad Ruhfel to choose this area for his thesis.

Included in Ruhfel's thesis was a new comprehensive floral inventory of the remnant portion of Kirk Fen. In his study, the Michigan Floristic Quality Assessment (FQA) tool was used to ascertain a floristic quality index (FQI) of 45 and a Mean Coefficient of Conservatism (Mean C) of 4.7 for Kirk Fen. These FQI and Mean C ratings exceed the threshold indicating a remnant with natural area potential (Wilhelm and Masters 1995) and indicate that the fen is a "critical" wetland remnant of native character. They also signify a profound environmentally important wetland from a regional natural area perspective

(DuPage Co. Stormwater Management, as reported by Herman et al. 2005, Wilhelm and Masters 1995 and Wilhelm 1992). These indices placed this remnant area in a high ranking for Michigan fens and as the second highest for a wetland in the surrounding region (Ruhfel 2005). Additionally, his survey revealed remnant populations of two threatened and imperiled flora, the small white lady slipper (*Cypripedium candidum*) and common valerian (*Valeriana ciliata*), as well as several plant species that are prairie fen indicators and many other plant species that are typically found in prairie fens. Furthermore, through aerial photo comparison from 1949 to 2003, Kirk Fen was shown to have lost eighty-two percent of its open fen area to invasive woody species, particularly glossy buckthorn (*Rhamnus frangula*). Ruhfel documented that Kirk Fen was on a trajectory toward a low diversity shrub-carr habitat and proposed active restoration to interrupt that trajectory and to return it to its historic status as a prairie fen ecosystem. Restoration guidelines included the removal of tree and shrub populations from within the 1949 boundaries in order to restore the damaged areas. Through the removal of trees and shrubs and subsequent raised water table, it was hoped the that all habitat in the historical boundaries of Kirk Fen would return to being a high quality sustainable prairie fen with autogenic processes and a functioning wetland ecosystem within the greater landscape of the Fleming Creek Watershed.

OBJECTIVES AND APPROACH

This practicum's specific objectives are to 1) implement woody invasive removal in Kirk Fen; 2) document restoration efforts; 3) report on floral and site response after restoration efforts; and 4) create a monitoring program that will articulate proximate and distal site and floral objectives and goals for measuring success and contribute to a wider understanding of prairie fen restoration in the Midwest.

Background objectives common to all restoration projects at Matthaei Botanical Gardens and Nichols Arboretum include being ecologically mindful when administering restoration practices, incorporating students and volunteers wherever and whenever possible in the practices of site specific restoration activities as well as exploring site specific monitoring techniques, and being mindful of the limited monetary and personnel resources available when designing a monitoring program that benefits MBGNA directly but also expands the understanding of the practice and art of native areas restoration. In addition, MBGNA promotes invasive species removal practices that avoid both ecosystem contamination with herbicides and soil degradation from foot traffic and that safely utilize volunteers and students to assist with the work.

STUDY AREA

Kirk Fen is a 0.73-hectare site located at the University of Michigan Matthaei Botanical Gardens in Washtenaw County (figure 1.1). It is located in the southwest quarter of section 18 within Superior Township (T. 2 S., R. 7 E.). The site is near the intersection of a glacial end moraine with medium textured till and an outwash plain consisting of sand, gravel, and post-glacial alluvium (Ruhfel 2005).

The site is directly northwest of the confluence of Kirk Brook and Fleming Creek and is located at the lowest most portion of the Kirk Brook watershed. Low-density housing with septic systems is located at the north boundary of the Botanical Gardens at the upper topological gradient 109 feet from the 1949 Kirk Fen boundary. High-density housing with open drain storm water catchments is to the west, situated on upper topological gradients and separated from the site by a two-lane paved road (Dixboro Rd.), approximately 375 feet from the 1949 Kirk Fen boundaries.

Soils are part of the poorly drained Houghton Series. Kirk Fen's soils are typically a mix of mineral soil and sapric peat with some fibric soils at the surface and below. The site has a gentle southwest aspect, sloping from 245 meters to 242 meters above sea level, before an abrupt drop into Kirk Brook.

Within the 1949 boundaries are two intact areas surrounded by a low, dense-canopy shrub layer principally of *Rhamnus frangula* and other non-native and native woody species. At the soil surface the roots of the shrubs are exposed from what is likely the result of soil decomposition/peat oxidation due to the loss of water at the soil level from extensive evapotranspiration by the woody plant species. The forb layer of the more degraded areas is principally that of skunk cabbage (*Symplocarpus foetidus*), golden ragwort (*Senecio aureus*), and other wet mesic and wet species of low coefficients of conservatism values. To the northeast of the intact sites is an open area with a high water table that corresponds to the northeast neck of the 1949 fen boundary. An open area adjacent to Fleming Creek lies to the southeast of the intact sites.

This area has a growing season of 158 days and receives annual precipitation of 88.9 centimeters.

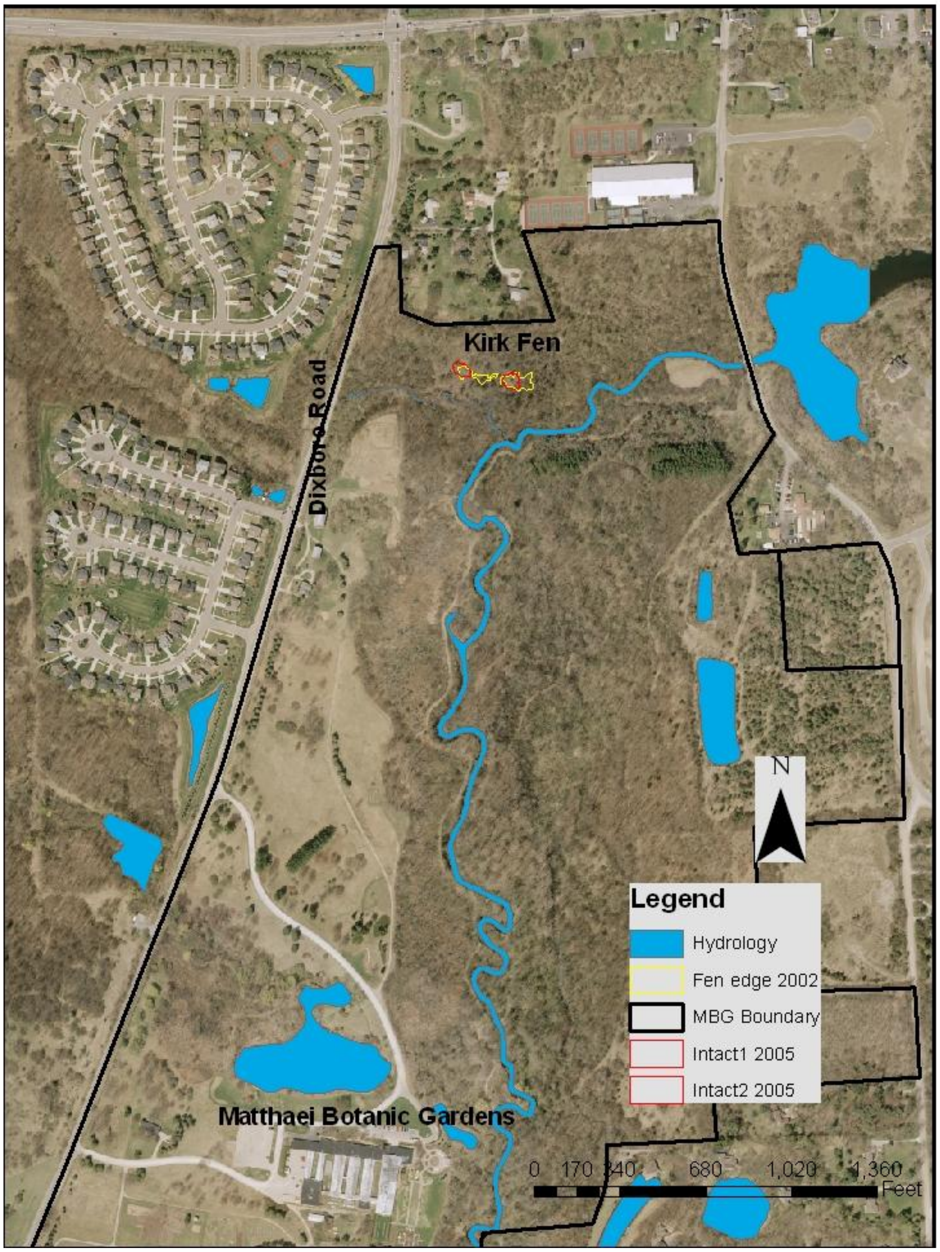

Figure 1.1 – Kirk Fen located at the north boundary of the University of Michigan, Matthaei Botanical Gardens

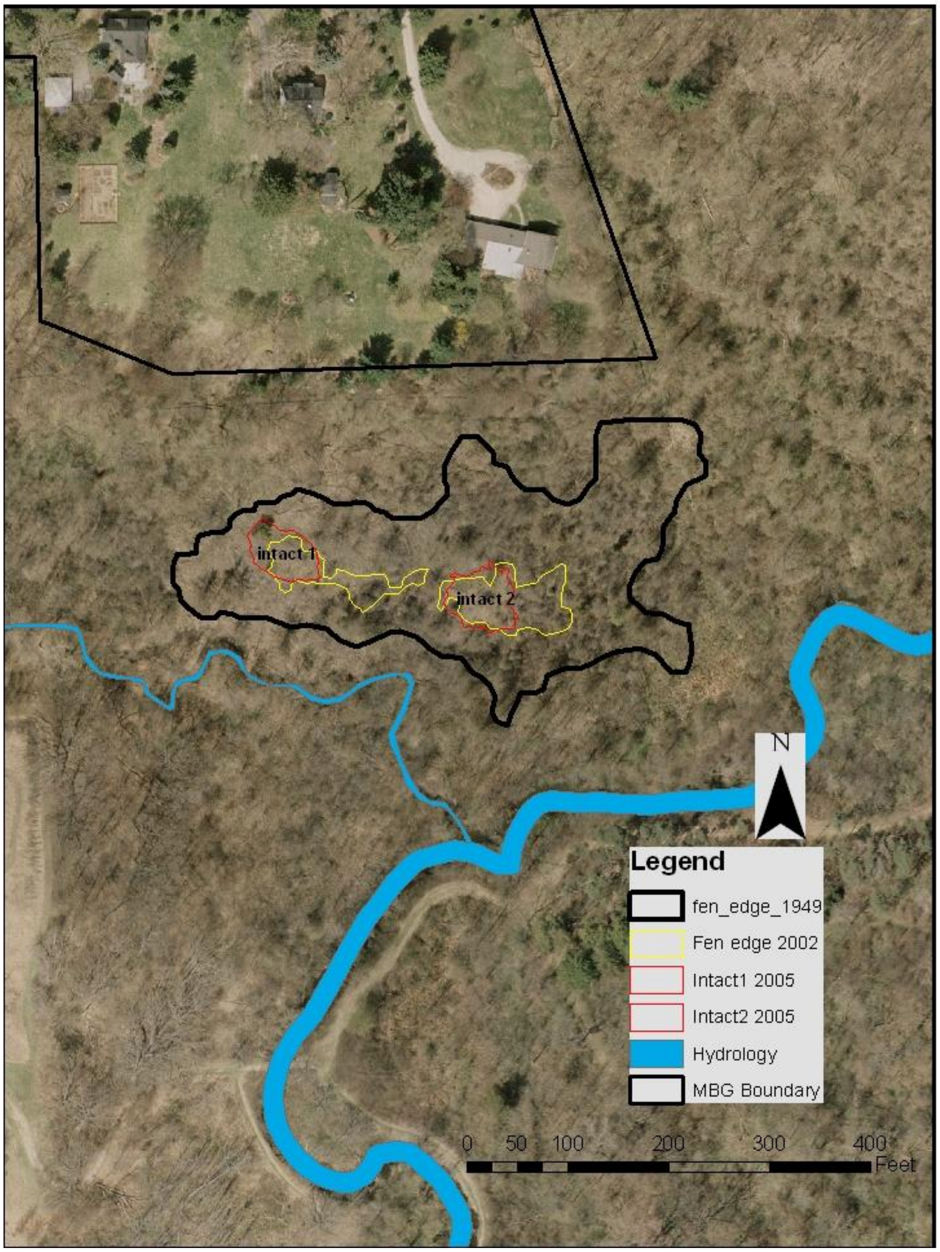

Figure 1.2 – Kirk Fen 1949 boundary and the 2003 and 2005 intact and open areas

II. RESTORATION ACTIVITIES AND MANAGEMENT IN KIRK FEN
FALL 2005 TO SUMMER 2009, APPROACH AND IMPLEMENTATION

While restoration in Kirk Fen consisted primarily of removing the existing woody shrubs and some trees, it also included management of some non-native forbs as well. This section reports on the methods and approach of restoration practices and non-native species management in Kirk Fen.

This chapter has three sections 1) site preparation, 2) woody species removal, and 3) adventive forb species management. Table 2.1 is a summary of the restoration progress and how it relates to Ruhfel's (2005) thesis.

SITE PREPARATION

One of the first steps in preparing the Kirk Fen site for restoration activities was to protect the highest quality, "intact" areas from trampling related to the removal of invasive trees and shrubs. In the fall of 2006 these areas were demarcated with caution tape. It was assumed that the general volunteers recruited to help with tree and shrub removal would not be made up of skilled botanists and would not completely appreciate the uniqueness of the Kirk Fen ecosystem; therefore, these groups were put to work in the more disturbed areas of the fen. Removal of shrubs in the higher quality, intact areas were done by smaller groups of volunteers and individuals who had a high level of woody identification skills and an understanding of the need for careful movement within sensitive areas.

Table 2.1 Restoration activity in relation to Ruhfel's (2005) Practicum.

2005 Plan	Related Practicum Activity
Removal of woody species in entire 1949 boundary area	• Woody species in 80% of the 1949 boundary area received cut-and-herbicide treatment by 2009 • Staff, sheriff public service crew, volunteers and student interns
Removal of invasive forbs in entire 1949 boundary area	• Invasive forb removal and herbicide treatment activity in the 1949 boundary area by fall 2010 • Garlic mustard pulled 2007 and 2008 (student interns) • Canada thistle addressed by cut-and-herbicide treatment and broadcast herbicide treatment 2007 and 2008 (student interns and staff) • Reed canary grass addressed by cut-and-herbicide treatment and broadcast herbicide treatment 2008 and 2010 (student interns and staff)

Surveillance and Monitoring	**Pilot Surveillance**
	Floral Inventory (author, volunteers, student intern and project paid help)
	• 2008, 3x/growing season
	  ○ intact areas, cut-phase 1 (A,B,C), cut-phase 2 (and individual areas within), and un-cleared area
	• 2009, 1x growing season
	  ○ intact areas, cut-phase 1, and areas A-L
	
	Dominance, abundance and cover (author, student intern and project paid help)
	• Key species
	  ○ Dominant highest-C species
	  ○ Dominant obligate wetland species
	  ○ Dominant Cyp can associates
	• Dominant species
	• Invasive species
	• 2008, 1x growing season
	  ○ intact areas, cut-phase 1 (A,B,C), cut-phase 2 (and individual areas within), and un-cleared area
	• 2009, 1x growing season
	  ○ intact areas, cut-phase 1, and areas A-L
	
	Cypripedium candidum rare species survey (author, student intern, and project paid help)
	• 2008, 1x growing season
	  ○ intact areas, cut-phase 1 (A,B,C), cut-phase 2 (and individual areas within), and un-cleared area
	• 2009, 1x growing season
	  ○ intact areas, cut-phase 1 (A,B,C), cut-phase 2

	(and individual areas within), and un-cleared area **Photo Documentation** (student intern, project paid help and author) • 2006 initial shrub removal efforts and site documentation • 2008 and 2009 formal photo-point documentation **Transect inventory and cover** (author, UM Herbarium staff, and project paid help) • 2009, 1x growing season • 5 transects

WOODY SPECIES REMOVAL

This section outlines the woody species targeted for removal, reports on the volunteer workdays conducted for Kirk Fen woody species removal, the methods used, and the progress of woody species removal in Kirk Fen.

TARGET SPECIES

Glossy buckthorn (*Rhamnus frangula*), the most prominent and densely populated woody species, was the primary target for removal along with honeysuckles (*Lonicera* spp.) and common buckthorn (*Rhamnus cathartica*). The original recommendation (Ruhfel 2005) was to remove all woody plants, including native species. However, on further reflection, it was decided to conserve many of the native woody plants including ninebark (*Physocarpus opulifolius*), hazelnut (*Corylus americanus*), tamarack (*Larix laricina*), and some musclewood (*Carpinus caroliniana*). A few sizable musclewood were cut during the first phase, as well as all wild grapes (*Vitis riparia*). Highbush cranberry (*Viburnum opulus*) was at first left standing, then later cut once they were distinguished as the European species rather than our native species (*V. opulus* var. *americanum*). Species to be preserved were marked with colored flagging during the first ecological workday at Kirk Fen in the fall of 2005 with colored field tape.

VOLUNTEER WORKDAYS

Shrub removal was originally planned to start at the outer boundaries of the intact areas and radiate out to the 1949 boundaries, however, the predominant volunteer force was an ambitious and revolving group of Washtenaw County public service volunteers; sometimes as many as thirty at a time. These volunteers, although typically enthusiastic, were not necessarily there for the altruistic motives of ecosystem restoration. Rather, they were fulfilling their community service sentences by working at Matthaei Botanical Gardens. On cold winter days, they were strongly motivated to stay busy and warm and less concerned with following the intended removal pattern. Student organizations also assisted. Some of these student groups came on a field trip for the University of Michigan School of Natural Resources and Environment course, Ecological Restoration, NRE 589. Additional help with shrub removal came from ecological workday volunteers. These volunteers ranged from the inexperienced to the very knowledgeable and from four years of age to adult. All were given tasks commensurate with their abilities. Usually activities took place on separate days for each group; however, on occasion an ecological workday coincided with the day the Washtenaw Sheriff's crew was also on site. In this case, all volunteers worked together in the same area except on one occasion: two children, ages four and six, became disenchanted with the work in the open area and more interested in working where fairies might be found. Luckily, we had just the spot and they, their parents, and a skilled ecological volunteer were directed to the wooded fen area at the confluence of the streams where the invasive shrubs were not as dense. In this way, their work could be useful and the children were content to be in a place where fairies could easily be imagined. After an impressive amount of work cutting invasive shrubs, fairy houses were constructed at the location.

Each volunteer workday started with an expression of appreciation for their participation, an introduction of the scope of the work, a brief description of prairie fen ecosystems, an overview of the intentions for the project and the site, and instructions regarding the tools to be used for the workday and their safe use. During public ecological workdays a guided tour of prairie fen woody species was given during a mid-point break. These introductions to the site, prairie fen ecosystems, and prairie fen woody species are an important workday function of public outreach and education.

WOODY SPECIES REMOVAL METHOD AND PROGRESS

During the first trials of shrub removal with chainsaws, the ground was quickly littered with fallen shrub debris and progress in the site with chainsaws soon became precarious and unsafe. To avoid unsafe conditions while still making good use of volunteer time, shrub removal evolved to a five step process:

1) Targeted shrubs and small trees were first cut at no more than waist height by volunteers using bow saws.

2) Cut debris was removed from the site and staged in small piles so that all cut materials were placed with the same basal to apical orientation to facilitate the later chipping process.

3) Chipping of the staged cut shrub material was either done the same day or at a later date by trained staff and students. Volunteers, untrained in chipper safety, helped by conveying the shrub debris closer to the chipper and/or handing the shrub debris directly to those running the chipper.

4) At a later date, staff, volunteers, and interns, trained in the safe use of the chain saw and gas-powered brush cutters, re-cut the remaining shrub stems within six inches of the ground.

5) Staff, student interns, and volunteers who were certified to use herbicides applied 25% to 41% glyphosate mixed with a wetland-certified surfactant (Cygnant) and colored dye within five minutes of the re-cut. Herbicide application was performed using a lightly pumped hand-held sprayer with the nozzle fully opened so that the spray was reduced to a light stream. The tip of the sprayer was held in direct contact with the cut stumps the herbicide was applied primarily around the outer stump rim at the cambium layer in order to minimize the amount of herbicide used and place the herbicide at the most effective location.

At the end of each cutting season, the areas cut were mapped using a GPS unit and a polygon layer for the Gardens digital maps was prepared using ArcView 9 GIS software.

The clearing of woody species from the winter of 2006 to the winter of 2009 occurred in two phases, each distinct in regard to the timing of re-cutting and herbicide treatment, as well as to the handling of the cut debris. Phase-one clearing was performed in the winter of 2005/2006. The first cut, re-cut, and herbicide treatment steps were carried out during the same winter season and the debris was removed from the site. By spring of 2006 the entire “cleared 1” area was open and cleared. The second phase of clearing occurred over two consecutive winters, during the months of January and February in 2008 and 2009. In this case, the first cut of this second phase was performed during the winter months of 2008. The re-cut and herbicide treatment were performed during at two different times: in one area, the second cut and herbicide treatment were made during the same year as the first cut (2008) and, in the other area, the re-cut and treating with herbicide occurred in the following winter (2009) (figure 2.1). Because this second phase work was located in the east portion of the site and farther away from the path leading to and from the site and the amount of cut stems were too great and would hamper further work, debris generated from cutting during this phase was stacked on site in small piles typically of an average height and width of five feet. The intention of these small piles was to ensure that the heat generated from either future winter burning of the piles or ignition during a prescribed fire would not sterilize the soil beneath. By late winter of 2009 the cleared phase-two area was entirely open. The cut phase 1 and the two different cut phase 2 areas are differentiated by way of three separate polygons in the Kirk Fen GIS database for tracking purposes (see figure 2.1). The area located at the easternmost end of the fen was not cut, leaving approximately 17% of the area inside the 1949 boundary not cleared.

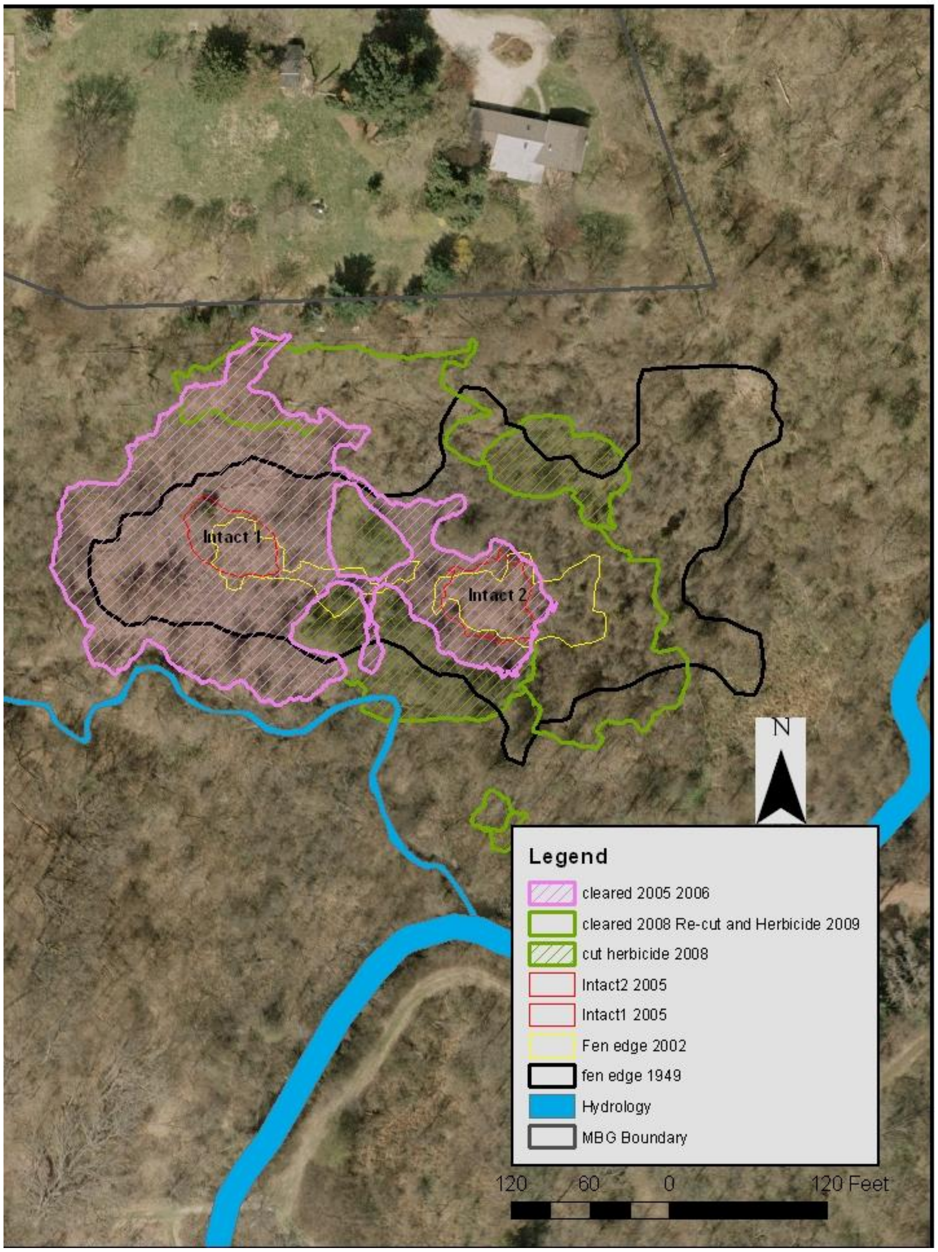

Figure 2.1 – Non-native invasive woody species removal in Kirk Fen 2005 to 2009.

INVASIVE FORB MANAGEMENT

The section reports on invasive forbs targeted for management and the methods used and progress of this effort. Refer to figure 2.2 for a map indicating the relative distribution of adventive forbs.

TARGET SPECIES

Invasive forb populations of garlic mustard (*Alliaria petiolata*), dame's rocket (*Hesperis matronalis*), reed canary grass (*Phalaris arundinacae*), and Canada thistle (*Cirsium arvense*) were noted during the spring of 2006 and addressed during the restoration process. Japanese knotweed (*Polygonum cuspidatum*) was discovered in 2008 but has not yet been addressed.

INVASIVE SPECIES REMOVAL METHODS AND PROGRESS

Garlic mustard and dame's rocket, was hand-pulled during the spring months of 2006 and 2007 by student interns. In the first year, the garlic mustard stand was very dense and it took several interns one day to pull the majority of plants in the population. A return visit during the same season was needed to complete the removal. The following year the stand was noticeably smaller and was removed by a few student interns in only one day. Garlic mustard was mostly found on the upper northwest gradient on mineral soil outside the 1949 fen boundaries. No further garlic mustard control has been performed.

During the summer of 2007 the population of reed canary grass at the south boundary of the intact 1 site was cut and bundled. Glyphosate at a 30%

concentration was applied to the cut ends. Two populations were discovered in 2007, but no attempt to control them occurred until the summer of 2009, when all three populations, including the first observed population, were cut and an application of 30% concentration of Glyphosate made to the cut ends by natural areas staff.

Canada thistle sprouted en masse during the summer of 2006 in the newly opened cut phase 1 area. The majority and thickest part of the population was found north of intact 1. Instead of leaving the population to eventually disappear with the expected rising of the ground water table, the plants were treated with herbicide in 2006 and 2008. Two herbicide approaches were used. Where stands were less dense, and native species were mixed within, the Canada thistle was cut and 30% glyphosate was applied to the cut ends. In the areas of dense populations, with little or no native species growing within the stand, a 3% glyphosate was sprayed on the entire plant and rosettes. In both instances a certified wetland surfactant (Cygnant) and a dye were added. After these two years of herbicide application no further control was administered, although this species continued to sprout in the wake of the shrub removal. However, populations are much smaller than those experienced following the first phase of woody removal.

Japanese knotweed was observed in 2008 during the surveillance of the north ends of the transect boundaries along the north MBGNA boundary fence, outside the 1949 Kirk Fen boundary. No attempt at management of this species has been made to date.

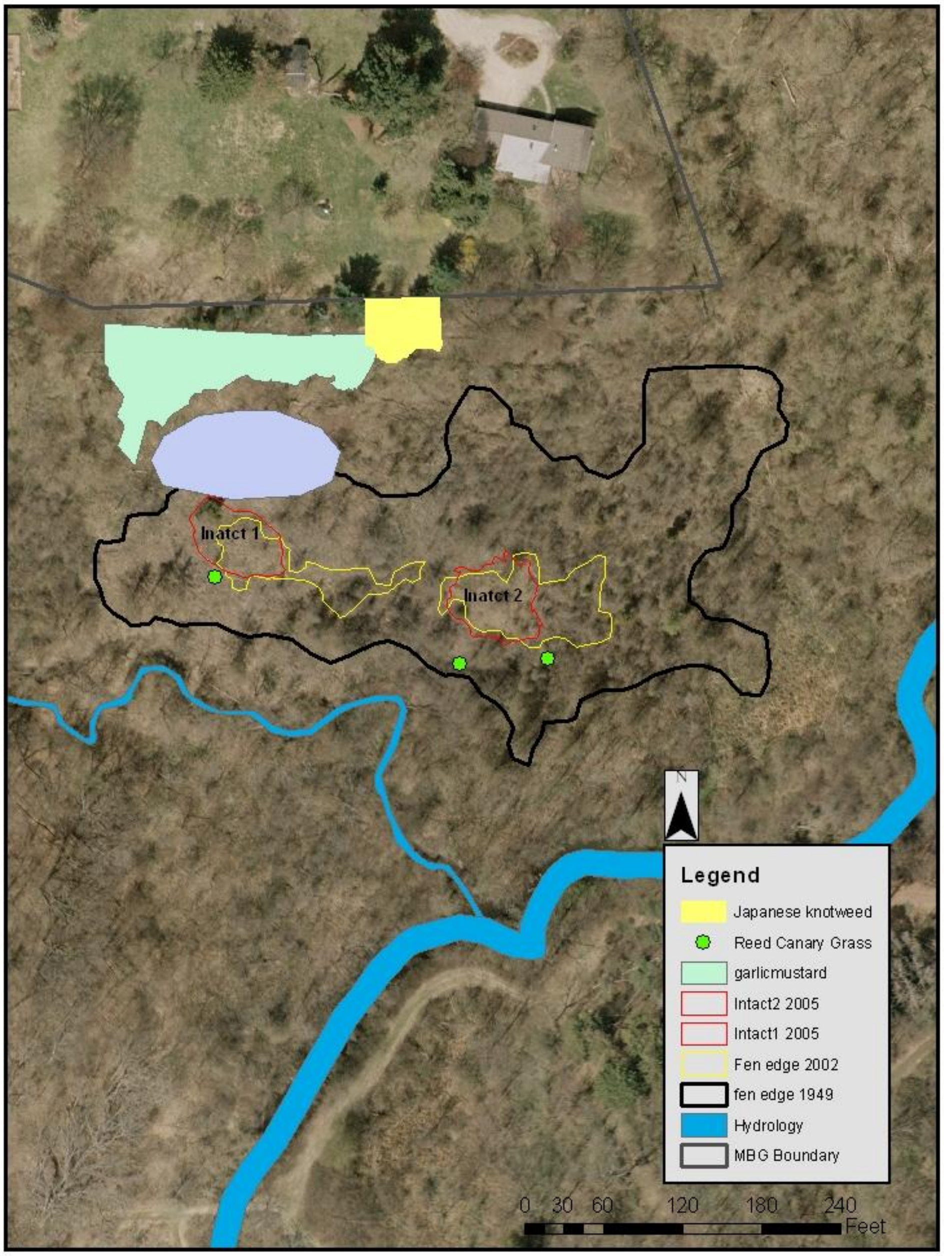

Figure 2.2 – Invasive herbaceous species controlled in Kirk Fen 2007 to 2009.

III. Kirk Fen Site-Specific Floral and Site Monitoring

This chapter explores the development of a site-specific monitoring program for Kirk Fen. It has three parts: 1) a literature review as it relates to monitoring, 2) floral inventory and pilot survey design and implementation in Kirk Fen in 2008 and 2009, and 3) a critique of the inventories, surveys, and photo documentation critique, limitations and costs.

Literature review – Assessment and methodologies

This section reviews literature for current assessment approaches and methodologies, their appropriateness for tracking floral and site changes and their application and incorporation into a monitoring program specific for Kirk Fen. This section has five parts: 1) monitoring for site change and development, 2) the importance of pilot surveys for monitoring development, baseline information and long-term site evaluation, 3) site assessment questions and attributes to be considered for measuring the success of restoration projects, 4) an examination of specific site analysis methodologies and how they apply to restored site monitoring, and 5) a literature review of the biology and ecology of the small white lady slipper (*Cypripedium candidum*). This orchid is rare and endangered in Michigan and was last seen in this site in 2007 and the development of a species-specific rare plant survey was seen as priority by MBGNA.

MONITORING FOR SITE CHANGE AND DEVELOPMENT

Monitoring is a routine and repeatable assessment of site change and development through time, measurable against site-specific objectives and goals with the expressed purpose that this information leads to logical management decisions (Elzinga et al. 1998) and is an integral part of adaptive management. Monitoring is designed so that natural area managers will develop management activities to guide the site towards articulated objective and goals. Often the objectives and goals may be adapted or changed based on the information learned from monitoring (Elzinga et al. 1998). Surveys and inventories are a point-in-time assessment of the site. When they are repeated through time, it is then considered monitoring. (For a complete glossary of monitoring terminology that is frequently used interchangeably but really have distinct meanings, see Appendix 3.1) Monitoring is not an attempt to determine cause and effect (Elzinga et al. 1998; Temperton et al. 2004) but rather to report on how changes are occurring through time. Additionally, because vegetation change cannot be monitored adequately by a single statistic (Bowles et al. 1996), several approaches should be considered for the particular information each conveys.

THE IMPORTANCE OF PILOT SURVEYS

Surveys for trend or spatial and temporal comparison within a monitoring program for restoration site analysis will profit from pilot surveys. Pilot surveys allow for the thoughtful exploration of monitoring approaches in a way that tests the rationale, reduces waste of resources and time, and avoids changes to the monitoring program along the way so that subsequent surveys cannot be compared directly to baseline data. Before initiating a monitoring program, pilot and trial site-specific inventories and surveys are therefore recommended to evaluate the parameters intended to be measured in a monitoring program and to develop the most practical and efficient ways for making field measurements. Additionally, results from pilot or trial inventories and surveys can directly aid in the development of management prescriptions (Palmer 1986; Elzinga et al 1998).

SITE ASSESSMENT QUESTIONS AND ATTRIBUTES FOR MEASURING THE SUCCESS OF RESTORATION PROJECTS

Wilhelm and Masters (1995) suggest that the questions most commonly asked by managers of remnant and restored landscapes are:

- What is the overall floristic quality of the site?
- Is floristic quality distributed more or less evenly throughout the site?
- To what extent is active management or passive neglect affecting floristic quality through time?

They further suggest ways in which to answer these questions. For overall floristic quality and distribution through the site they suggest conducting comprehensive floral inventories. To answer the question of distribution, a floral sampling along transects is recommended. To determine the extent of the effect of management practices, repeated floristic inventories at annual or other, periodic, intervals are suggested to be executed, as well as repeated sampling along an established transect through representative portions of the site.

The above preliminary questions generate the following questions:

- What attributes best describes and measure floristic quality?
- What are the best ways to describe and measure floristic composition?
- What are the best ways to measure site rebound after management activities?

Additional questions directly related to the Kirk Fen restoration are:

- What is the extent and population of invasive species?
- What is the extent and population size of the small white lady slipper orchid (*Cypripedium candidum*)?
- Are site attributes required to host a population of the small white lady slipper orchid present in Kirk Fen and which areas have these attributes?

And, because the main objective in removing woody vegetation is to raise the water table by reducing evapotranspiration stress to the ecosystem:

- Is flora a good indicator of wetness of the soil?

In choosing attributes to survey and apply to a long-term monitoring program Elzinga et al. suggest the following:

- Attributes and their measurement should be sensitive to change

- Attributes should be biologically meaningful and interpretive
- Measurements of attributes should lead to a logical management response
- Measuring attributes should not be costly
- Technical capabilities and skills to measure attributes are available
- Field error among observers acceptable.

Apfelbaum and Haney (2010) also suggest for landowners and organizations with limited resources that the methodology of monitoring for change be simple and easy, yet provide enough information to show responses and assess progress toward the stated goals and objectives in the restored area. Additionally, they suggest that the methodology and process be enjoyable. This last bit of advice is especially applicable to the development of a monitoring plan for Kirk Fen because it is likely that the implementation of a monitoring program for this site will have limited monetary and human resources within the organization and, therefore, the monitoring will most likely be carried out by volunteers. A monitoring program that is too arduous and painstaking will probably not appeal to volunteers.

SPECIFIC SITE ANALYSIS METHODOLOGIES

In this section various site analysis and assessments methodologies are described and explored for their relevance to addressing the type of questions and inquiries that pertain to natural areas monitoring of restored sites. Included in this section is 1) the Michigan Floristic Quality Assessment program and a description of floristic quality index, coefficient of conservatism, 2) measuring wetness in wetland sites, 3) other FQA generated attributes of interest, 4) rare plant assessment, 5) floristic dominance surveys, 6) transect inventory and cover, and 7) photo documentation.

Floristic quality assessment

This section examines the Floristic Quality Assessment (FQA) for the State of Michigan and a) its methodology to measure floristic quality from a comprehensive floral inventory, b) the way measures of floral quality index, mean coefficient of conservatism, mean coefficient of wetness, and other information are generated from the FQA, and c) how these measure floral change and rebound after restoration activity in a site.

To measure the floristic quality in a natural area, the Floristic Quality Assessment program (FQA) for the State of Michigan was created by a team of prominent Michigan botanists (Herman et al. 2001). The assessment of floristic quality through the FQA program is based on a comprehensive on-site floral inventory. The floral inventory is entered into the FQA program and information is generated about the floristic quality of the site. Much of the FQA is a methodology based on species conservatism and degree of faithfulness of plants to a specific habitat or set of environmental conditions. It can be used as a strong basis for natural areas assessment rationale (Wilhelm and Ladd 1988; Wilhelm 1992) and reported as a dispassionate, cost-effective, and repeatable methodology (Wilhelm and Masters 1995).

The FQA program assigns each floral species in the state of Michigan a Coefficient of Conservatism from zero to ten, which corresponds to its fidelity of inhabiting a conserved site with low anthropogenic disturbance. A coefficient value of ten represents native species confined to sites that have experienced the least disturbance and stress. While at the other end of the spectrum, a coefficient value of one represents native species typically found in the most disturbed sites. A coefficient value of zero is assigned to non-native and adventive species. Once the information from a comprehensive floral inventory is entered into the FQA a site floristic index (FQI), a mean coefficient of conservatism (Mean C), as well as other useful floral categorizations and distributions are generated.

Floristic quality index (FQI)

An FQI rating is indicative of the floristic quality of a site and represents the degree of conservatism or disturbance of the site based on flora alone. The FQI (along with the Mean C) serve as proxies for habitat integrity (Taft 2006). No measure of distribution or abundance is considered or assumed. The FQI is a repeatable measure from site to site but may be size limited (Goforth et al. 2001 as referred to by Herman et al. 2005). Thresholds have been established to articulate floristic quality of sites through FQI ratings. Appendix 3.2 summarizes the FQI thresholds and their significance.

Mean Coefficient of Conservatism (Mean C)

The FQA program also generates a Mean Coefficient of Conservatism (Mean C). The Mean C is an effective means of distinguishing recognized qualitative differences of site quality and the degree of conservatism and is purported to be more informative than traditional species diversity measures in assessing floristic integrity within community types (Taft et al. 2006). After fifteen years of repeated visits to re-measure sites using the Floristic Quality Assessment system in the Chicago regions, Wilhelm and Masters (2005) echo this sentiment and further state that the mean C values are evidently a "fundamental measurement of site quality." Additionally they find that the Mean C is not as size-dependent as the FQI and therefore can be utilized for smaller units of a larger site inventory. The Mean C was reported to detect changes solely associated with management prescriptions such as prescribed burns and to be the most sensitive approach to detect changes (Taft et al. 2006). For these reasons the Mean C is also used to evaluate the degree of rebound from disturbance of a site. For a measure of floristic quality of a site before restoration, a native Mean C of 3.0 indicates little evidence that modern management techniques can move it more than a few tenths, a native Mean C of 3.5 or higher indicates that the site has sufficient floristic quality to be at least of marginal natural areas quality, while a native Mean C of 4.5 or higher shows that the remnant is almost certain to have high natural area potential (Wilhelm and Masters 1995). For evaluating sites five to ten years after restoration activities, a Mean C 3.0 indicates little evidence of more than a few tenths increase is possible unless floral species reintroduction is implemented. Refer to Appendix 3.2 for Mean C indices and their significance for floral quality and restoration efforts.

Measuring wetness in wetland sites

After shrub removal in Kirk Fen, ground water is expected to rise to ground level. Using ground water-monitoring wells is the most direct determination of ground water levels, however, the combination of flora, soil, and the appearance of ground water at or near the surface can be adequate for determining the site's wetness (Wilhelm et al. 1992). This approach is used in wetland delineation for state and federal agencies. In particular, the presence and analysis of the native species is also a strong and useful measure of site wetness (Wilhelm et al. 1992).

Besides generating a floristic quality index (FQI) and mean coefficient of conservatism (Mean C), the FQA program generates a mean wetness index (Mean W) from the same comprehensive floral survey. Because floral species grow specifically in certain soil wetness regimes (Wilhelm 1992; Herman et al. 2001), each species in Michigan has been assigned a wetland coefficient ranging from -5 to 5. These values correspond to the fidelity of a species to a wetland ecosystem. Minus five indicates an obligate wetland species with a 99% probability that it will exist only in a wetland. A plus five indicates an upland species with a 1% probability of being found in a wetland. A table of the wetland value and corresponding designations can be found in Appendix 3.3.

Wilhelm (1992) states that the adaptability of native species to wet or dry ground is regarded a “profound” indicator of wetness. He further advocates that weedy adventive species be discarded in the analysis of site wetness since their presence informs us little about the wetness or dryness of site. He suggests that their adaptation is different in an ecological context and is based on agricultural history, whereas the adaptation of native species to local hydrologic gradients is the result of long evolutionary adaptations throughout much of the Holocene geological era and, therefore, their fidelity to site wetness gradients is more reliable and applicable to assessing site wetness.

Other FQA-generated attributes of interest

Besides generating a species list, FQI, Mean C, and Mean W, additional useful information that the FQA generates includes: percent native species, percent adventive species, and percent forb, tree, shrub, vine, grass, sedge, and bryophyte within the floral composition. These attributes can be informative for the evaluation of change in floral composition of the site and can facilitate setting goals of the particular site-specific floral composition to be attained in a particular ecosystem.

Rare plant assessment

To assess rare plant populations, set rare species management objectives, and develop a monitoring program of rare plant species, an ecological and biological model is an important tool. An ecological and biological model evaluates the species population as well as ecosystem structure. Rare plant species models include habitat and ecosystem components, biological relationships, ecology, biology, and natural history (Elzinga et al. 1998). Sometimes the biological relationships, ecology, and natural history are not documented, unknown, or not fully understood and needs to be hypothesized and inferred from literature reviews of closely related species and/or conversations with experts (Pavlik in Falk et al. 1996; Elzinga et al. 1998). Monitoring rare species habitat may be more sensitive to detecting change than monitoring the plant species directly especially when species population rebound to habitat change may be slow and/or asynchronous (Large et al. 2007). Additionally, habitat monitoring is important to include with rare plant monitoring so that, in lieu of evidence of a current population, the question if a habitat is currently able to host a particular species can be considered, especially if reintroduction of the species is desired (Elzinga et al. 1998).

Floristic dominance surveys

Flushes of floral species and floral successional changes are expected after restoration projects (Schwartz and Whitson 1987; Camill et al. 2004; Middleton et al. 2006; Reznicek communication 2007). Although the FQI and Mean C from a comprehensive floral inventory give a strong quantitative methodology to measure floristic quality, they do not, however, indicate floristic dominance within the site. Floristic dominance will be important to aid in the articulation of expected successional change through time, will further assist restoration managers with understanding floristic community composition during rebound, and can be utilized in setting monitoring goals and management objectives. Cover and abundance helps us to understand the floristic point-in-time dominance of a site and therefore can be incorporated along with the FQI and Mean C to measure disturbance rebound. A ranking system for abundance and cover, although subjective, is valuable qualitative information and can be used statistically, if so desired, by applying score values to each rank (Palmer 1986; Elizinga et al. 1998). Additionally, qualitative measurements are less intensively implemented than quantitative methods for measuring change and should be considered for projects with limited resources (Elizinga et al. 1998).

Transect inventory and cover

Another technique to analyze the floristic quality, distribution, cover, and site wetness is a sampling transect (Wilhelm 1992; Wilhelm and Masters 1995). Applied especially to wetland assessment, transects are set perpendicular to topological gradient (Wilhelm 1992; Professor D. A. Wilcox, personal conversation, 2008), such transects are called catenas.

A transect inventory and cover is a rigorous, exacting, and time consuming undertaking, however, this method gives a quantitative analysis of cover and distribution whereas additional cover surveillances are needed to accompany inventories to obtain similar information. Transects can be either simple line-intercept transects or larger quadrant transects. With a line-intersect transect, the survey records each species that crosses the line of sight and the length of its crossing is recorded to the nearest centimeter. Quadrant transects are oriented along a transect line and the species list, cover and abundance is recorded for a sampling square or rectangle situated on the line, and extending a certain distance from the line. Additionally, a qualitative cover and abundance system is devised for either type of transect. The survey results are then entered into the FQA program by selecting the "transect study" function from the menu. The FQA generates a species list, FQI, Mean C, Mean W, sequential Mean W, species relevance based on frequency and cover, as well as percent coefficient of conservatism ranking, percent native species, percent adventive species, and percent forb, tree, shrub, vine, grass, sedge, and bryophyte within the composition. Note that with this program cover and abundance are automatically generated, whereas, with the floral inventory program, the use of an additional abundance and cover survey is required to obtain this information. For an analysis for wetness, the program creates a sequential mean W by taking the wetness coefficients of each of three quadrants and averaging them sequentially. Additionally, this method can be a useful tool in the evaluation of high species turnover that has been documented in several reports as a result of environment gradients in the fen landscape (Picking and Veneman 2004; van der Hoek and Sykora 2006).

Photo documentation

Photographs are suggested as an integral component of monitoring and can be the primary method where resources prohibit other means of assessing site change (Elzinga et al. 1998). This is especially true if the photos are taken from specific and repeatable photo-points. Photo-point documentation is a low rigor method to document floral change in a landscape, requires no botanical knowledge to execute, and takes the least amount of time. To track changes in a site, copious use of photographs is encouraged (Elzinga et al. l998; Hall 2002) whether as a stand-alone method or complementary to other assessment methods. Maximizing photo views for each photo-point is encouraged (Hall 2002). To facilitate the process and lessen the time to conduct photo-monitoring, having many aspects taken from few points is encouraged over having many points with few aspects taken. Hall (2002) suggests these guidelines: a) permanent in-field marking posts or other easily recognized or findable point marking devices, b) a site-dedicated field notebook, c) a standardized recording form, and d) a specially constructed meter board with interchangeable photo identification labels. It is further recommended that the compass direction of each photo view as well as the distance from the camera to the meter board be recorded for each photo aspect. Each successive year, the photo of the previous year is placed in the field notebook to aid the photographer in capturing the same view and aspect. Additional photo views and points can be added as needed.

CYPRIPEDIUM CANDIDUM, THE SMALL WHITE LADY SLIPPER: SITE HISTORY, ECOLOGY, AND NATURAL HISTORY

This section examines the site history, ecology, biology and natural history of *Cypripedium candidum* (the small white lady slipper) and includes the following: 1) historical sightings in Kirk Fen of the small white lady slipper, 2) habitat and companion plants of the small white lady slipper, 3) life cycle and clump definition of the small white lady slipper, and 4) clump survival and prolonged dormancy of individual clumps and populations of the small white lady slipper.

Literature on *C. candidum* is limited, however, literature for *C. calceolus* (the yellow lady slipper) is abundant and, because of its close relationship to *C. candidum*), information for *C. calceolus* (Cribb 1997), may supplement needed information and establish a more comprehensive understanding of *C. candidum* (Pavlik in Falk et al. 1996; Elzinga et al. 1998).

Historical sightings in Kirk Fen of *Cypripedium candidum*

Cypripedium candidum was first recorded at the Botanical Garden native vascular flora checklist in a “seepage bog” (Bland 1971). *C. candidum* was again documented in a “seepage bog” and in a “weedy” habitat in 1972 in *The Michigan Botanist* (Williams and Ludwig 1972). However, in neither of these surveys, no specific reference is made regarding in which of the two seepage bogs mapped with these documents it was observed: the one to the south (Radrick Fen) or the one to the north (Kirk Fen). Ruhfel (2005) states *C. candidum* was sighted in Kirk Fen by botanist Ellen Elliot Weatherbee in 1995 and he also recorded *C. candidum* in his 2004/2005 floral inventories of the fen. The last time *C. candidum* populations in Kirk Fen were sighted was in 2006 and 2007 by the author and several volunteers at which time they consisted of three small non-flowering groups of five or fewer leaves.

Habitat and companion plants of *Cypripedium candidum*

Cypripedium candidum occurs in fewer and less varied habitats than any other native cypripedium (Case 1987). *C. candidum* habitat in Michigan is primarily prairie fens and lakeplain prairies (Higman and Penskar 1998). It can be found in other marly or alkaline sites with ground water seepage, including open marley bogs and swampy meadows; growing where there is moisture and full sunlight (Voss 1972). Other reported ecosystems and habitats include the Great Lake shores in the east; swale margins, marshes, and wet prairies in the western Great Lakes Region (Case 1987).

It has been observed that *C. candidum* grows best in open areas (Curtis 1946 cited in Stuckey 1967) and Case (1987) states that *C. candidum* is the most sun loving of the Great Lakes cypripediums. However, it also suggested that it grows best with some direct sun in the morning or evening, with companion plants of sedges and grasses that do not shade, but give some protection from full sun, as well as providing a microclimate of cool soil, fresh moving air, and humidity (Cribb 1997).

Case (1987) describes *C. candidum* as a plant of mesic meadows, which was formerly abundant in the prairies of North America, and that it is subject to stem rots and grows best in soil rich in clay that is strongly structured with good pellet formation, as in marl. He further reports that “it is not a wet-site plant” and despite what the literature says, in nature, it grows in sites that dry out later in season and in soil with a pH of 7-8.

Competition is the most inhibiting factor for orchid populations, and when they are observed growing in areas invaded by woody species, populations declined in number and vigor and rapidly disappeared (Curtis 1946 cited in Stuckey 1967). Case (1987) states that few *C. candidum* plants grow in shade, and those that are found in shade are old plants crowded and encroached upon by shrubs.

Associated plants include, but not limited to: tamarack (*Larix laracina*), grass-of-Parnassus (*Parnassia glauca*), shrubby cinquefoil (*Potentilla fruticosa*), Ohio goldenrod (*Solidago ohioensis*), Riddell's goldenrod (*Solidago riddelii*), Indian grass (*Sorghastrum nutans*), hardstem bulrush (*Schoenoplectus acutus*), common boneset (*Eupatorium perfoliatum*), little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), bluejoint grass (*Calamagrostis canadensis*), whorled loosestrife (*Lysimachia quadriflora*), marsh fern (*Thelypteris palustris*), alder-leaved buckthorn (*Rhamnus alnifolia*), red osier dogwood (*Cornus sericea*), golden Alexander (*Zizia aurea*), marsh bellflower (*Campanula aparinoides*) and sedges (Case 1987; Voss 1972; Higman and Penskar 1998). Case (1987) reports *C. candidum* can be found along with small yellow lady slipper.

Life cycle and clump definition of *Cypripedium candidum*

It is reported that twelve years is required from germination until flowering size in reached for the genera, *Cypripedium* (Cribb 1997). Seed germination occurs in the dark, approximately 2-5 cm below ground surface for most species, and probably occurs in spring or early summer. However, *Cypripedium calceolus* protocorms have reportedly been found in December (Cribb 1997). The life cycle of *C. calceolus* (the yellow lady slipper) is divided into ten stages: seed, three underground protocorm stages, and a juvenile, young clump and adult clump. The three clump stages have both an active, growing aboveground phase and a dormant, over-wintering underground phase (Nicolè et al. 2005). Like other Cypripediums, *Cypripedium candidum* is a perennial plant. Its perennial growth cycle is as follows: buds on roots at least two or three year old grow and form clumps. Growth commences in spring, the plants flower between the third week of May to the third week of June in Michigan (Higman and Penskar 1998) and set seed in autumn. Clumps survive winter in dormancy with the shoot tips at or just below the soil surface.

Mature plants of *Cypripedium candidum* can form very dense clonal clumps. These clumps can be made up of one or more indistinguishable genets and ramets. Nicolè et al. (2005) report that the clump designation is a more practical and reliable field unit than the genet or the ramet. They defined three categories of clumps: adult clumps having more than seven stems, young clumps having three to seven stems, and juvenile clumps having fewer than three stems.

Clump survival and prolonged dormancy of individual clumps and populations of *Cypripedium candidum*

C. calceolus clump survival is often size dependent (Peterson and Jones 1997 cited by Nicolè et al. 2005). Shefferson (2006) showed that survival was lower for smaller plants and survival increased with increasing number of sprouts during the growing season preceding dormancy of *Cypripedium calceolus*, and populations with >20% adult clumps appear to be relatively stable and less sensitive to environmental variations than those with fewer adult clumps.They suggest higher adult clump longevity introduces more inertia to population dynamics and persistence of *C. calceolus* populations is linked to slow changes in its habitat as with successional processes over centuries. Because of their close relationship, clump survival for *C. calceolus* can be assumed for *C candidum* clump survival until more direct evidence for *C. calceolus* clump dynamics and survival is found.

Although Cribb (1997) reports that prolonged dormancy is unusual for the genus *Cypripedium*, there is good indication that *Cypripedium candidum* can survive for a season or more without producing aerial shoots based on research reports on *Cypripedium calceolus*. Prolonged adult dormancy of *C. calceolus* may play an important role in population dynamics, adult survival, and seed persistence (Nicolè et al. 2005; Shefferson et al. 2003). *C. calceolus* adult dormancy is possibly influenced by environmental factors, and adult survival and seed persistence are key factors maintaining population stability and persistence (Nicolè et al. 2005). Vegetative genets of *C. calceolus* are more likely to go dormant the following year than flowering genets and once dormant they often remain dormant (Shefferson et al. 2003). They also report that there was no cost of flowering to clump survival or future flowering and that flowering individuals tended to exhibit a strong tendency to remain flowering the following year.

For clump dormancy designation, Nicolè et al. (2005) assigned the attribute of dormant to those clumps of *C. calceolus* that disappeared for fewer than four consecutive years (Shefferson et al. 2003; Nicolè et al. 2005) and those clumps not seen for greater than four years are considered dead.

IMPLEMENTATION AND DESIGN OF INVENTORIES, SURVEY, AND PHOTO DOCUMENTATION IN KIRK FEN IN 2008 AND 2009

This section documents 1) a pilot survey field approach and implementation in Kirk Fen, 2) the floral inventory process and implementation that was used, 3) a pilot *Cypripedium candidum* population and site survey design, implementation and process, 4) a dominance survey design and implementation, 5) a photo-point documentation implementation and process and 6) a line-intersect transect implementation and process.

PILOT SURVEY FIELD APPROACH AND IMPLEMENTATION IN KIRK FEN

The initial surveys in 2008 were conducted in each management zone. The management areas and the corresponding surveys were: the two separate intact areas, the areas cleared of woody invasive species in 2005 and 2006 (cleared phase 1), the areas cleared in 2008 (cleared phase 2), and the un-cleared areas (refer to figure 2.1). Surveys conducted were floral inventory, dominance survey, and *Cypripedium candidum* survey. However, it became apparent when conducting the 2008 pilot surveys that there were distinct zones of flora and site wetness and that the management divisions in most cases spanned more than one zone. It is well documented that fens have distinct plant communities and vegetation zones found along topological gradients (Curtis 1959 cited by Thompson 1968; Boyer and Wheeler 1989; Nekola and Lammers 1989; Koerselman et al. 1990; Bowles et al. 1996; Amon et al. 2002; Nekola 2004; Bowles et al. 2005; Picking and Veneman 2005; Austin et al. 2007; Spieles et al. 2010). Smaller areas can lead to a more thorough inventory (Wilhelm and Masters 1995) and be examined for floristic quality patterns. Therefore, for the second survey season in 2009, a grid of survey areas was created; the two intact sites and areas A – L were created (refer to figure 3.1). It was hoped that the smaller units would be more easily surveyed, especially for abundance and cover. Additionally, surveys can be combined to correspond to management zones and analyzed separately to evaluate floral distribution in the site or topological gradients. Each unit was delineated on a map and photo-point posts and landmarks were used to orient the survey participants in the field. Each of the newly delineated areas had a comprehensive floral inventory, dominance survey, and *Cypripedium candidum* survey conducted in 2009. Additionally, the cleared-phase 1 area was surveyed as it had been in 2008. The 2009 survey areas were screen digitized as polygons and incorporated into the Kirk Fen geo-reference database.

Photo-point documentation was conducted for the years of 2008 and 2009. A transect survey was also conducted in 2009 utilizing five transect lines (figure 3.2).

A complete set of survey sheets, floral inventories, photo-point photography, and line-transect photos can be found in the Matthaei Botanical Gardens research files.

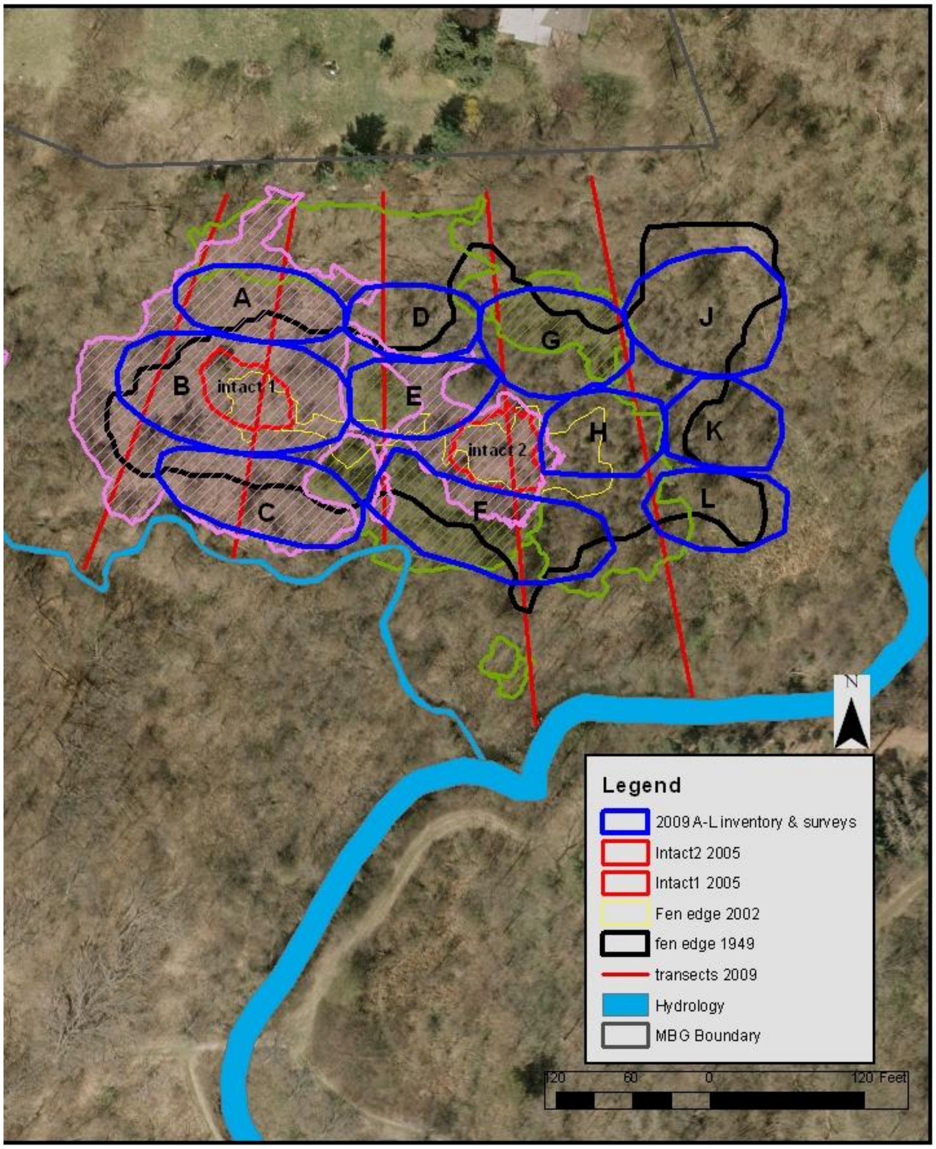

Figure 3.1 – 2009 floral inventory and pilot survey areas. Areas include intact 1, intact 2, and areas A to L

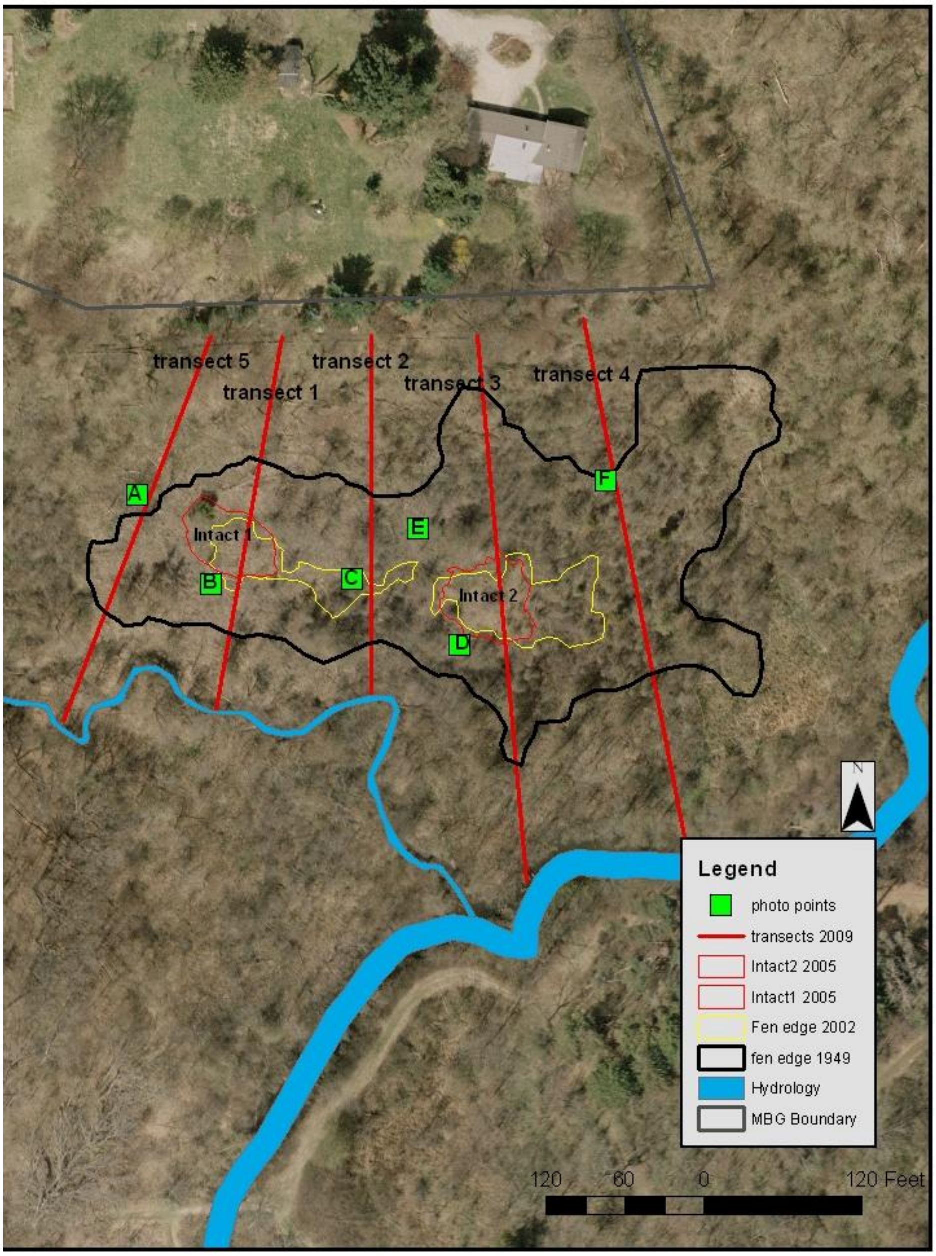

Figure 3.2 – Photo points and 2009 line-intercept transects in Kirk Fen

FLORAL INVENTORY PROCESS AND IMPLEMENTATION

To help facilitate the inventory process and to prompt the search for specific species, previous inventories were used as a checklist. In 2008, three volunteer botanists and the author visited the site three times during the growing season (early-, mid- and late-summer), and conducted floral inventories on each visit. An additional floral inventory was conducted in late summer 2009 with a volunteer botanist and the author. During both years, one person served as recorder while the other participants searched for and called out species names to the recorder. A complete floral inventory was made of each area by indicating the corresponding names from the previous inventory list and adding species to the list as needed. Once the group was no longer finding new species, the checklist was consulted for species not found on that day and a search was conducted for those species. Once all participants had agreed that no more species were likely to be found and that a comprehensive species list of the area had been made, the participants stopped inventorying. The time each inventory began and ended was recorded.

Inventories were entered into the FQA program. Each report was amended to count prairie fen species and indicators and *Cypripedium candidum* associates. Because the number, terminology, or the dominant plants found within a zone reported in the literature are not necessarily in agreement, for this study, the zones, corresponding species, and indicator species for prairie fens in Michigan as reported by the Michigan Natural Features Inventory (Spieles et al. 2010) were used. For more information on the MNFI prairie fen zones and their sub-zones see

Appendix 3.4. Floral type composition was calculated by combining the separate floral types generated in the FQA (native adventive tree, shrub, woody vine, forb, grass, and sedge) into three general categories: woody, forb and graminoid.

PILOT *CYPRIPEDIUM CANDIDUM* POPULATION AND SITE SURVEY DESIGN, IMPLEMENTATION, AND PROCESS

The *Cypripedium candidum* survey approach is a point-in-time inventory that combines habitat and population inquiries. The attributes of this survey are based on the ecology, life cycle, and population dynamics of the small white lady slipper or the yellow lady slipper (*Cypripedium calceolus*) when information is lacking specifically for the white lady slipper. The first part addresses the habitat and environmental aspects important for *C. candidum* vigor and includes soil pH and temperature, presence of visible ground water seepage, the type of sunlight, and available protection given by sedges and grasses. The second part of the survey offers an indication of the presence or absence of all of the known associate plants. The third part addresses the threats to *C. candidum* establishment and continued survival: shrub encroachment and forb composition. The final part addresses colony assessment of the species; size, type of clones, and fecundity.

This survey relies on the floral inventory to record all *Cypripedium candidum* associate flora present or absent. To expedite the time and effort, two or more participants conducted this survey. The field survey data sheet for this can be found in Appendix 3.5.

Since no small white lady slippers were actually found in either year, the colony assessment part of the survey was not conducted. Additionally, soil attributes were not examined.

Dominance survey design and implementation

This survey was designed to capture floral succession change and rebound by way of looking at floral community dominance and distribution in the site. The intention is to evaluate the dominance of key attributes through abundance rankings and cover classes. To facilitate this approach a survey form was developed with standardized abundance ranking and cover classes. Ranking and classes were chosen to minimize time and error. The rankings for estimating abundance adopted for this survey are those used within the Michigan Natural Features Inventory (MNFI) organization. The abundance ranks are: dominant, abundant, common, occasional, uncommon, scarce, and "local" used as a modifier for the previous rankings. These rankings are not specifically defined by MNFI but are intended to be intuitive (B. Slaughter, email, 2007). The classification used for cover estimates were elected to be the least confusing or debatable between field surveyors yet sensitive to convey measurable differences. Covers used were: > 75%, 51-75%, 26-50%, 6-25%, 1-5%, and <1%.

For the first part of the survey, key attributes of high coefficient species, obligate species, invasive species, and *Cypripedium candidum* associates were recorded. These plants are expected to make up the floral community after restoration: a plant community with abundance and high cover of species of high conservation, a plant community dominated by obligate wetland species, and a plant community high in *Cypripedium candidum* associates. To evaluate these attributes the abundance and cover were recorded for the two species of the highest conservatism coefficient, the two most dominant obligate wetland species, and the two most dominant *Cypripedium candidum* associates. Therefore, two species were selected primarily on the category of key interest (highest C, OBL, and *C. candidum* associate), then secondly on the most visually dominant species for each key category. This survey relies on the floral inventory conducted of the area and is consulted for the species of each key category. The second part of the survey focuses on documenting what species dominates the survey area regardless of conservative or wetland coefficient category. Therefore, the three most visually dominant species and their abundance and cover were recorded. And, because the condition of invasive plant species is a primary concern, the third part of the survey recorded all invasive species abundance and cover.

To avoid bias, two or more people conducted this survey. The species for each section were jointly agreed upon. Then each participant independently estimated abundance and cover. These independent estimates were then immediately compared. If the abundance rank and cover class was different for each participant, a discussion was held and, if needed, compromise was reached and recorded. In the rare case of a wide divergence of opinion, a middle abundance rating and cover class was recorded. A sample pilot field survey sheet can be found in Appendix 3.6.

PHOTO-POINT DOCUMENTATION IMPLEMENTATION AND PROCESS

The intent of photo documentation in Kirk Fen was to document the progress of the project and the floral changes within the 1949 boundaries, and as a means of conveying the progress of the project to audiences of varying experiences of restoration and plant communities. In the winter of 2005/2006 informal photo documentation of the clearing process was initiated as shrub removal began to capture the scope of the work involved and the key participants. In the summer of 2008, a natural area intern, following the guidelines as enumerated by Hall (2002), developed a photo-point protocol for MBGNA and began formal photo documentation of the site. Further photo-point documentation was conducted in 2009. Additionally, new photo-points were added in 2009 to include the easternmost boundaries of the site as well as additional aspects from some of the previous photo-points.

Wooden field marking posts were placed and all photo-points were digitized and a map developed with important landmarks (figure 3.2). In 2009, the map was placed in the notebook along with the previous year's photos to aid the photographer in locating the points and to indicate the direction and scope of each photo point view. A standardized recording form was created. And a specially constructed meter board with interchangeable photo identification labels constructed. The distance and compass direction of original photos were recorded. A Canon EOS300D with a 6.3 megapixel, 22.7 x 15.1 mm CMOS image sensor was used with lenses of 18, 28, and 50mm focal length. The aperture was set at f/8. All photos were copied to a disc and filed in the research file and downloaded on the media drive at MBGNA.

LINE-INTERSECT TRANSECT IMPLEMENTATION AND PROCESS

The express purpose of conducting transect surveys was to compare floristic quality patterns within the site, serve as a baseline if transects were to be revisited at a later date, and to compare findings to the other simpler and informal surveillances of cover and frequency.

Before beginning, one sample quadrant was executed, however, the amount of trampling that occurred was deemed unacceptable. Therefore, a line-transect approach was adopted even though a line-transect would predictably miss unique and infrequent species.

Five transects were established perpendicular to the topological gradient during the summer of 2009. They were chosen to be roughly equidistant from one another, to include the 1949 fen boundaries, and to transverse through management areas including the intact sites (figure 3.2). Transect lines were determined and digitized on-screen in the Arc9 GIS, and a GPS unit was utilized to flag the transects in the field. Each line-transect inventory consisted of a comprehensive species list and cover measure of each species encountered from chest height to ground level.

To facilitate the process, a measuring tape was utilized to serve three purposes: to delineate the beginning and end of each five meter length of the transect, to delineate the line vertical plane in which to record species, and to measure the cover distance for each species that crossed the line plane. The measuring tape was secured by utilizing stainless steel T-stakes; one to secure the end clip of the tape measure and the other to drape the measuring tape's spool over. The measuring tape was passed through thickets when present; otherwise the tape was simply pulled taut from one T-stake to the other (figure 3.3). Alternate five meters from north to south were surveyed along each transect line. Species were recorded if any part of the plant crossed the vertical plane of the measuring tape and the area of the plant that transversed the plane was recorded to the nearest centimeter. The amount of time spent was recorded for each five-meter section and a photograph was taken of the inventoried five meters. One or two people performed this inventory at a time. In the case when two people conducted this survey, one served as recorder and helped the surveyor track the progress along the five meters.

Fig 3.3 Photo depicting a typical line-intercept field set-up in Kirk Fen 2009

KIRK FEN FLORAL INVENTORIES, SURVEYS, AND PHOTO DOCUMENTATION; CRITIQUE, LIMITATIONS, AND COSTS

This section examines and critiques the pilot surveys for relevance to natural areas restoration analysis, the ability to satisfy their original intent, logistics, and costs, and their limitations. This chapter begins with an introductory section of critique criteria followed by a critique of each pilot survey and includes: 1) criteria for survey critique, 2) floral inventories and Floristic Quality Assessment in Kirk Fen for 2008 and 2009, 3) dominance survey, 4) the small white lady slipper (*Cypripedium candidum*) survey, 5) photo-point documentation, 6) line-intercept transect inventory and cover. Each of these critiques are divided into five subsections: a) intention, b) approach, c) relevance of floral inventories to natural areas management and limitations related to the considerations above, d) logistics and time and cost of conducting floral inventories, e) the limitations of the pilot 2008-2009 inventories as they were conducted, and f) a summary for quick reference.

CRITERIA FOR SURVEY CRITIQUE

Surveys will be critiqued to the following criterion suggested by Elzinga et al. (2005):

- Sensitive to change
- Biologically meaningful and interpretive
- Leads to a logical management response
- Cost

- Technical capabilities to measure attributes, and
- Field error acceptance

Additionally each survey will be assessed if they captured the following information related to site quality and site rebound after restoration (Wilhelm and Masters 1995).

- Overall floristic quality of the site
- Floristic quality distribution in the site

And, because surveys must be sensitive to the Botanical Gardens and Arboretum's limited resources and its objectives for mission-related society and club participation, each survey will be assessed for:

- Ease of implementation
- Ease of manipulating the information relevant to natural area management decisions and goals
- Time and cost for one survey season
- Resources needed
- Suitability and application to volunteer participation

Floral inventories and Floristic Quality Assessment in Kirk Fen for 2008 and 2009

Intention

The intention of conducting a comprehensive floral survey was to compare site floristic quality to that reported in 2005 (Ruhfel 2005) and capture floristic distribution within the site as it relates to management areas and topological variance.

Approach

The original surveys in 2008 were conducted in areas defined by the management zones. Later evaluation of the data collected led to the decision to divide the site into the distinct flora and wetness zones revealed by this initial effort. This method of dividing the site to smaller units for the 2009 inventories and surveys, better captured floristic quality, composition, distribution, and wetness zones.

The 2008 inventories were conducted by a group of four individuals at three different times during the growing season: June, July, and August. In 2009, two individuals made one visit in late summer. When comparing the species list between 2008 and 2009, some important species were not detected in 2009. This raises the question: Were these species simply missed in 2009 or were they in fact not present?

Relevance to natural areas management

Using the information from the FQA program provides clear and interpretive measures to assess natural areas and make logical objective-based management decisions. Measures are sensitive to change and applicable to proximal and distal monitoring goals. Additionally, the FQA information is a regionally regarded means of site assessment, therefore, it is invaluable when writing grant proposals as well as when having site comparison discussions with other regional natural areas managers and mission-related groups. Additionally, FQI generated floral inventories are easily exported into a common delineated document and amended in Microsoft Excel to include prairie fen species and indicators, a list of *Cypripedium candidum* associates, and to combine the generated species physiognomy categories to larger categories of woody, forb, and graminoid.

Note: floral inventories do not convey the floral composition relevance and dominance, which limits natural areas managers understanding and documentation of spatial and temporal dominance.

Logistics, ease, cost, and time to conduct floral inventories

Floral inventories are relatively easy to conduct. It is a compilation of the species present. No other assessment of relative amount or cover is needed. However, because the FQA is based on a comprehensive inventory there is a low tolerance of field error and this necessitates the need for experienced botanists, amateur of professional, to conduct the floral inventories. Currently, staff may not be available for this intensive inventory work and MBGNA's volunteer base is limited. In the future, a grant-funded intern or individual could be hired and assistance might be found from a mission-related group focused on botany, such as the Michigan Botanical Club.

Data entry into the FQA is uncomplicated and the information generated is easily entered into specially made attribute tables into a site-specific geo-database to expediently manipulate and extract spatial relevant species information.

The cost of implementing floral inventories was estimated from the 2008 and 2009 inventories. Time for organizing and conducting this site-specific floral inventory was estimated. Additional time for entering data into the FQA and manipulating the information was also estimated. Miscellaneous costs include printing of checklist inventories, a hand-lens, and time for lab identification of unknown species. These are summarized in the table below. Two costs are estimated, one for an intern and one for staff, since experienced interns may be difficult to find.

Table 3.1. Estimated costs of conducting three floral inventories in Kirk Fen by a paid intern and paid staff

Activity or Materials	**Time (hrs)**	**Cost/hr intern**	**Total**	**Cost/hr staff**	**Total**
Intern or staff- 3 visits/yr	24	$20.00	$480.00	$30.00	$720.00
materials and misc. costs		$200.00	$200.00	$200.00	$100.00
inventory prep and volunteer recruitment	8	$20.00	$160.00	$30.00	$240.00
FQA	20	$20.00	$400.00	$30.00	$600.00
Kirk Fen geodatabase	20	$20.00	$400.00	$30.00	$600.00
Total cost one year inventory Kirk Fen			**$1,640.00**		**$2,260.00**

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Because of the changing site landscape, an accessible and reliable field GPS unit would aid in keeping the survey team within the designated inventory area and would further allow for more exact temporal and spatial comparison of each area.

Limitations of pilot inventories in Kirk Fen 2008-2009

As mentioned above, floral inventories as conducted in 2008 crossed zones and topographies. Therefore, the areas' Mean C and Mean W may not be as informative to area-specific qualities of the site as are the results from the areas as they were divided in 2009. However, the combination of the floral inventories constitutes viable baseline data for FQI and Mean-C. Although the approach of dividing the site was more logical in 2009, the floral inventories conducted in 2008 were more thorough. More botanists with greater expertise participated in taking the inventories in 2008 and they surveyed the site more often. However, the surveyors in 2009 were aware of their limited botanical skills and spent more time in inquiry and discussion; therefore, the thoroughness of each survey should not be disregarded. It is the lack of repeated visits that most limits the information of the 2009 surveys.

Direct correlation between areas from 2008 to 2009 was limited to the intact areas and the cut-phase 1 area. Indirect correlations may be made between the areas that overlay the cut-phase area, but an initial attempt showed such a wide variance of species that it was not pursued.

Summary of floral inventories critique and limitations

- Dividing the site in smaller units was beneficial in conducting a thorough inventory and captures better data to answer the three main questions for natural areas managers.
- Conducting floral inventories several times during the growing season best captures all species.
- Floristic quality assessment generated attributes: are sensitive to change, are biologically meaningful and interpretive, lead to better management response, enhance the understanding of site rebound after restoration efforts, aid in writing peer review literature and grant proposals, and allow more informative communication with the natural areas community and mission-related groups.
- There is a low tolerance of error and necessitates highly skilled botanical expertise.
- Field assistance can be found from a mission-related botanical group such as the Michigan Botanical Club.
- A GPS unit in the field would be helpful in delineating the individual areas while conducting floral inventories.
- The cost is estimated at $1640.00 if a paid intern is used vs. $2260.00 for paid MBGNA staff.
- Floral inventories are limited as to information regarding floral community dominance of the site.

- The limited number of visits during the season affected the comprehensiveness of the 2009 reports, while the 2008 inventories were limited by the way the site was divided.

THE SMALL WHITE LADY SLIPPER (*CYPRIPEDIUM CANDIDUM*) SURVEY

Intention

This first part of this survey was intended to assess the site for *Cypripedium candidum* habitat. Site attributes likely to host the small white lady slipper were summarized and may be more sensitive to change than measuring the white lady slipper population itself. Furthermore, if *C. candidum* is unable to respond due to prolonged dormancy conditions, knowing the areas where *C. candidum* may likely grow can guide management decisions regarding reintroduction to the areas most likely to support them.

Approach

This site has many microhabitats and topological gradients that were better assessed by smaller areas surveyed in 2009. The 2008 and 2009 surveys were conducted in late season. Mid-season assessment might produce better results regarding the protection and/or stress of surrounding flora. Additionally, ground water assessment would be better done in mid-season when precipitation is less likely to influence ground water levels.

Relevance to natural areas management

Investigation of suitable habitat is directly relevant to natural areas management, it is biologically meaningful and interpretive, and can lead to appropriate management action. However, not all habitat attributes can logistically lead to management action. Soil pH and temperature cannot be reasonably changed, however, knowing these attributes does directly relate to *Cypripedium candidum* habitat identification. Ground water visibility can be addressed by further mitigation of the Kirk Brook watershed or Kirk Brook re-sedimentation. The other attributes relate directly to the flora and ecosystem structure and these can be directly acted upon. Note that in the third section, which evaluates forb and shrub threats, there is an additional habitat inquiry and, therefore, an extension of the first part.

Since the checklist of *Cypripedium candidum* plant associates is redundant to the floral inventory and it is not necessary to be done separately in the same year that a comprehensive floral inventory is conducted.

The clump portion is biologically measurable and interpretive; directly relates to the survival, fecundity, and size of the white lady slipper population; can be directly measured and used for object-based monitoring; is sensitive to long-term habitat disturbance and change; and aids in object-based monitoring and management response.

Logistics, ease, cost, and time to conduct floral inventories

There are no particular botanical skills necessary to execute the site or the population parts of the survey and some field error is acceptable. The clump assessment portion was not acted on in 2008 or 2009, as there were no small white lady slippers to measure. It is assumed that this portion of the survey will take more time than the habitat portion.

This survey is relative easy and enjoyable to conduct and is applicable to volunteer participation.

GIS skills are needed to enter the data into the Kirk Fen geo-database.

The cost for conducting this survey is based on the 2008 and 2009 surveys. The time to conduct the population portion is estimated. The hourly cost is an estimate for a paid summer intern. Two tables are given below; one without conducting the clump population portion and one that includes it in case spontaneous repopulation of the *Cypripedium candidum* does occur.

Table 3.2. Estimated cost for conducting the *Cypripedium candidum* site survey for one season.

Activity or Material	**Time (hr)**	**Cost (intern)**	**# Surveys**	**Total**
average full survey time w/o Cyp can population	0.25	$20.00	11	$55.00
survey prep, volunteer enlistment	4	$20.00		$80.00
data entry, attributes tables	0.17	$20.00	11	$37.40
Total cost for one year survey in Kirk Fen				$172.40

Table 3.3 Estimated cost for conducting the *Cypripedium candidum* site and population survey for one season.

Activity or Material	**Time**	**Cost (intern)**	**# Surveys**	**Total**
estimated average full survey time w/ Cyp can population	0.5	$20.00	11	$110.00
survey prep, volunteer enlistment	4	$20.00		$80.00
data entry, attributes tables	0.17	$20.00	11	$37.40
Total cost for one year survey in Kirk Fen				$227.40

Limitations of the 2008 and 2009 surveys

The 2008 and 2009 surveys were conducted late-season; therefore there may have been more emphasis on forb competition.

Soil pH and temperature were not conducted nor was *Cypripedium candidum* clump measurements taken, as there were no *C. candidum* to measure.

Summary of *Cypripedium candidum* survey critique and limitations

- Habitat assessment attributes in this survey (including forb competition and shrub encroachment) are important to gauge the likelihood of small white lady slipper presence, survival and population increase. These attributes are sensitive to change, biologically meaningful, and interpretive, and can directly lead to management response.
- The clump assessment directly relates to the survival, fecundity, and size of the white lady slipper population; therefore, the clump assessment is sensitive to change, and biologically meaningful, and interpretive and can lead to management response.

- The presence/absence of *Cypripedium candidum* plant associates is redundant to the floral inventory and unnecessary for this survey as long as a comprehensive floral inventory is made in the same year.
- Thatch is an important habitat assessment and should be added to the new survey sheets.
- Field error is unlikely for all parts of the survey and acceptable.
- No particular technical skills are need to perform any part of the survey and can be easily performed by volunteers and student interns.
- Mid-season is the best time to conduct this survey for estimating both the relative protection or competition of forbs and the presence of ground water.
- Additional GIS skills will be needed to enter data into the Kirk Fen geo-database.

DOMINANCE SURVEY

Intention

The dominance survey was designed to capture species dominance in the site. Attributes were chosen to evaluate community composition as it relates to restoration rebound. Specifically high-coefficient species, obligate species, invasive species, and *Cypripedium candidum* plant associates were chosen as these seemed the most indicative to the intentions of this site-specific restoration project.

Approach

The surveys done using the new site divisions in 2009 were the best approach. The areas were small enough for a thorough assessment, whereas those done in 2008 were larger areas, and in the case for the cut-phase 2 areas, were too incongruent in location and unrelated to the topological gradients and areas to adequately give a realistic floristic dominance depiction.

Conducting the survey once a year needs to be further assessed for appropriateness. For the high-C and dominant species portion it appears that these surveys may be directly skewed by the time of year in which they are done. The invasive portion of the survey does not seem as sensitive to the time in the growing season, although it would be advantageous to conduct this part of the survey in mid-season when invasive species are not obscured by later fall-blooming species and management decisions can be made and executed during the same season.

Relevance to natural areas management

Because there is variable ground water availability and micro-topography within a prairie fen, different wetland species types dominate the various zones and micro-habitats. Therefore measuring for obligate species is not biologically informative or interpretive. Additionally, plant associates of *Cypripedium candidum* do not necessarily have to be dominant in the site to support *Cypripedium candidum*, so again this portion of the survey is not biologically meaningful or interpretive. Therefore collection of obligate wetland species and

Cypripedium candidum plant associates data should not be pursued in future surveys.

Measuring high-coefficient (high-C) dominance is biologically informative and interpretive and may contribute to the understanding of restoration site rebound and complements the next part of the survey that records the three dominant species, however, it may not lead to meaningful management responses.

The three dominant species is a useful indicator to assess the dominant floristic index of the site and is a measurable, biologically significant and interpretive attribute for site rebound trend of floristic quality after disturbance and restoration efforts. However, this measurement may only serve to document floral dominance change and not lead to management response.

The third part of the survey, the invasive abundance and cover, is of paramount concern to natural areas management and is a basic parameter to monitor for restoration projects. This portion of the survey categorically gives the manager an objective analysis of invasive populations and these measurements can be tied directly to measuring for the success of management response.

Logistics, ease, cost, and time to conduct dominance surveys

The skill set necessary to accomplish the dominance survey is not as rigorous as that needed for a comprehensive floral inventory. One novice botanist, accompanied by one or more beginner or novice botanical volunteers, can easily accomplish this survey. The invasive portion is the least botanically challenging and can be accomplished by anyone with limited botanical skills. Because the abundance ratings and cover classes are broad, there is little probability of field error. Additionally, by having two or more people conduct the survey, agreement and/or compromise further lowers the probability of field error. The survey is relatively enjoyable, low stress, and is appropriate for mission-related organizations.

The cost for conducting one survey for dominance including the high-C, the three most dominant species, and the invasive species were estimated from the times recorded for the 2008 and 2009 surveys and are reported below:

Table 3.4. Estimated cost of conducting one mid-year dominance survey by a paid intern assisted by volunteers.

Activity or Material	**Time (hour)**	**Cost/hr (intern)**	**# Surveys**	**Total**
High-C species	0.1	$20.00	11	$33.00
Dominant species	0.1	$20.00	11	$33.00
Invasive species	0.2	$20.00	11	$55.00
survey prep, volunteer enlistment	4	$20.00		$240.00
data entry, attributes tables	0.2	$20.00	11	$55.00
misc costs		$100.00		$100.00
Total for three surveys				**$516.00**

Since conducting the high-C and three dominant species may be more of a long-term study and not necessarily useful in setting proximate and distal parameters for monitoring, the cost for conducting this portion of the survey can be factored out. The cost for just the invasive species would then be closer to $450.00.

Limitations of dominance surveys in Kirk Fen 2008-2009

One visit was made for each survey each year. The data collected may be skewed to preferentially reflect a greater dominance of late-season flowering species and smaller stature species may not be as well represented as they should be.

Summary of dominance survey critique and limitations

- The portions measuring abundance and cover of obligate species and *Cypripedium candidum* plant associates were not biologically meaningful and unnecessary to continue.
- Measuring abundance and cover of high-C and the three dominant species is biologically meaningful, sensitive to change, and does leads to greater restoration rebound knowledge but does not necessarily lead to logical management response.
- Measuring invasive species abundance and cover is biologically meaningful, sensitive to change, and leads directly to logical management response.
- Cost is a little over $500.00 for one visit per year by a paid intern for high-C, three dominant species, and invasive species or $450.00 for invasive species survey alone.
- Novice botanical experience is needed for the high-C and three dominant species surveys and beginner experience for the invasive species survey.
- Field error is unlikely, especially if conducted by a group.

- This survey is suitable for volunteers.
- The best time of year or number of times during the growing season to conduct the high-C and three dominate species surveys still needs to be determined. For invasive species inventory, one visit mid-season is ideal.

PHOTO-POINT DOCUMENTATION

Intention

The intention for photo-point documentation was to capture a representation of the site during rebound and to extract gross information from the photos for easily understood conveyance of site conditions to a wide array of audiences. It was further intended to be a part of a diverse monitoring program and to be the most basic measurement of site change.

Approach

With the additional photo-points in 2009 the entire site was captured during the second year. Using the guidelines described by Hall (2002) facilitated the replication of views. The time of year and the frequency to visit the site should be reviewed. Mid-year may be a better time of approach and, because photo-documentation is not sensitive to small changes, photo-documentation can occur biannually or at greater intervals.

Relevance to natural areas management

Although photo-point documentation is a qualitative assessment it can be used in a monitoring program for measurable goals and objectives and can be adapted to quantify vegetation, if desired. This method is biologically meaningful and interpretive, can be applied to monitoring goals and objectives, and leads to management response. Additionally this method is the easiest method to convey site change to diverse audiences.

Logistics, ease, cost, and time to conduct photo-point documentation

Taking multiple photos at small aperture increments reduced field error. Incorporating the photos from the previous year into the field book aided in capturing the identical view and scope and also reduced field error; however, some error in this is acceptable. The most limiting aspect of this survey is capturing the same type of light for each photo-view. This may require multiple visits during a designated time period.

No botanical skills are needed although basic photography skills and the ability to use a compass are needed. The use of a GPS unit will also be needed unless a designated GPS staff member finds and marks all photo-points ahead of photo-documentation. Using two people to conduct this survey facilitates the process but one person can accomplish the task. A high definition manual override digital camera of at least 6.3 megapixels is necessary with lenses of 18, 28, and 50mm focal length. Photo-point documentation is an enjoyable, low stress task that would be perfect for a volunteer with experience with digital photography and who is detail-oriented.

Time needed is based on 2009 photo-point documentation efforts. Miscellaneous costs include additional card stock and the printing of previous photos. Note that two estimates are given, one based on purchasing a camera and another without.

Table 3.5. Estimated cost for one mid-season photo-point documentation in Kirk Fen with and without volunteer participation and equipment.

Activity or Materials	**Time (hr) intern**	**Cost**	**Total**
Field photography	8	$20.00	$160.00
Misc supplies		$100.00	$100.00
Preparation	2	$20.00	$40.00
digital camera		($800.00)	($800.00)
Total cost for one visit, one season **($1100.00)**			**$300.00**

Limitations of the 2008 and 2009 photo-point documentation

The photos taken for this practicum were of high quality, however, consistency of time of day and year was lacking. For site comparison, photo-documentation should be taken at the same time of year and, ideally, with similar lighting.

Summary of photo-point documentation critique and limitations

- It is a basic and easy method to document and convey site change that does not require botanical knowledge.
- Although a qualitative assessment, it can be assessed quantitatively if desired

- It is sensitive to change, biologically meaningful and interpreted, and can be utilized in logical management response.
- Field error is unlikely using the protocols set by Hall (2002) and some field error is acceptable.
- Technical skills needed include digital photography and compass abilities.
- It is suitable for a volunteer project.
- Site visits ideally should be made at one consistent time of the season and with similar lighting.
- Photo-documentation can occur biannually or larger intervals.
- Cost is $300.00 if camera equipment is available. Otherwise a one-time cost of $800.00 for a high fidelity digital camera with lenses may be necessary.

LINE-INTERCEPT TRANSECT INVENTORY AND COVER

Intention

This practicum utilized the line-intercept transect method to create the most quantitative baseline measure of the site and to compare with other methods of measuring floristic quality and floral community distribution and composition.

Approach

The approach of setting up catenas was ideal in capturing wetness differences in the site along the topological gradients. Setting the lines to intersect key areas such as the intact areas, cut-phase areas, and no-cut areas gave good baseline documentation of the site and captured the floral diversity and distribution in the site.

Relevance to natural areas management

This method is the most accurate method of measuring cover and relevance of floral composition in a site and an excellent method to identify site wetness as measured by flora. This method captures seedlings and smaller flora where the abundance and cover method will often concentrate on the larger and most obvious plants and species. Photos for each five meters can be instrumental in visually documenting the site progress as restoration proceeds. This survey can be conducted every three to five years and still be sensitive to site change, biologically meaningful and interpreted, and assist with logical management response. Therefore, this method might be considered to incorporate into long-term monitoring programs and conducted every one to five years.

Logistics, ease, cost, and time to conduct line- transect surveys

The process proved to be arduous and exacting. Having two people to conduct the survey streamlined the process and was useful for discussion of species identification. Additionally, it was a more pleasant experience than when conducting the inventory alone. The total time for conducting this survey was nearly twenty hours including a photo shot of each five meters. Errors in cover measurement can be easily minimized and made acceptable; however, correct species identification are key to the success of this monitoring. Participants need skills in identifying seedlings, mature plants, and the degraded remnants of spring flora. Because of this and its arduous and exacting nature, it may prove difficult to enlist volunteers. Hiring a grant-supported student intern may be necessary to conduct this survey, but finding students with the needed skills may also prove to be difficult. This may, however, be a good opportunity to enlist the assistance a very knowledgeable volunteer from a mission-related group such as Michigan Botanical Club.

No particular skills are necessary to enter the species and cover into the FQA program. GIS skills are necessary to enter the information from the FQA into the Kirk-Fen geo-database.

The time to conduct five line-intercept transects with photo documentation is based on the 2009 line-intersect survey. The cost shown here is based on a paid intern.

Table 3.6. Estimated cost for conducting five line-transects in Kirk Fen

Activity or Materials	Time (hr)	Cost	Total
field survey	20	$30.00	$600.00
field prep	3	$30.00	$90.00
misc cost		$100.00	$100.00
volunteer recruitment	5	$30.00	$150.00
data entry FQA	5	$30.00	$150.00
data entry GIS	5	$30.00	$150.00
Total cost for conducting 5 line-transects			**$1240.00**

Limitations of the 2009 surveys

Consistency of the measurement for heights and layers of vegetation were lacking until a system was decided upon. Furthermore, inventories included only shrub and groundcover layers and did not include overhead or understory canopies. Therefore further line-intersect data could include the other cover strata but direct comparison to the 2009 transects can only be made to the groundcover and baseline data. Some species were unidentified but these were few and in no way would skew results. Spring flora could have been underrepresented because of the time of year the survey was conducted. The line-transect method predictably missed some species and therefore Mean C values may be conservative. Species in close proximity to transects were noted. Finally, Transect 5, the westernmost transect line, might be too far off the 1949 boundaries to be meaningful.

Summary of line-intercept transect critique and limitations

- Is sensitive to site change, biologically meaningful and interpreted, can be used to direct logical management response.
- Field cover measurement error is minimal because of the nature of the survey; however, flora identification error is unacceptable.
- A high degree of botanical expertise is necessary.
- Mission related volunteers such as members of the Michigan Botanical Club could be enlisted to assist.
- Because of the cost of conducting this survey, three to five year intervals are suggested during site rebound years and every five years thereafter.

IV. Floral Response in Kirk Fen in 2008 and 2009

This chapter reports on temporal and spatial vegetation patterns in Kirk Fen from inventories and pilot surveys conducted in 2008 and 2009. Nine reports are given: 1) An analysis of floral inventories in the intact areas from 2005 to 2009; 2) Comparison of the larger opened 1949 boundary site in 2008/2009 site to 2004/2005 intact areas; 3) Spatial analysis of individual 2009 floral inventories; 4) Floral dominance surveys 2008 and 2009; 5) *Cypripedium candidum* site survey 2008 and 2009; 6) Line-intercept transect inventory and species relative cover; 7) Comparison of line-intercept transect report to floral inventories, dominance surveys, and site surveys, 8) Questions this study raises, and 9) Restoration practices in prairie fens based on this study.

ANALYSIS OF FLORAL INVENTORIES IN THE INTACT AREAS FROM 2005 TO 2009

The 2004/2005 intact area and the 2008/2009 intact areas are spatially related to each other, although the 2004/2005 intact area (figure 1.2) is a slightly greater area than the 2008/2009 intact area. Floristic information reported on in this section was generated by the Floristic Quality Assessment program from comprehensive inventories conducted of the intact areas in 2004, 2005, 2008, and 2009. Summary tables of the data from the inventories as reported here can be found in Table 4.1 and a summary data comparison can be found in Table 4.2. A list of species for the intact areas for 2009 is located in Table 4.3.

The FQI (Floristic Quality Index) for 2008/2009 (40.5) was 5.7 points less than that for 2004/2005 (46.2), however, the intact areas may be too small to effectively apply this index (Goforth et al. 2001 cited by Herman et al. 2005).

The native Mean C (Mean Coefficient of Conservatism) was 0.2 points less (4.5) than 2004/2005 (4.7) yet continues to indicate that the intact remnants have natural areas potential (Wilhelm and Masters 1995) and be irreplaceable by mitigation (Wilhelm 1992; DuPage County Stormwater Management Committee cited by Herman et al. 2005). With proper stewardship, one could expect that this value would remain essentially constant over time (Wilhelm and Masters 1995). Additionally, it is not unusual to see a 0.1 to 0.2 decrease in Mean C after clearing efforts (Wilhelm and Masters 1995).

Additionally, an increase in wetland species weight in the inventory occurred with the Mean W (Mean Wetness) increasing from -1.8 to -2.7 and raising the wetland category of the intact area from FACW- (Facultative Wet Minus) to FACW (Facultative Wet).

The percent low-, mid- and high-C species remained relatively the same with low-C species continuing to dominate the intact area. High-C species increased slightly from 15% to 17% even with the loss of seven significant high-C species. Important floral species lost include: *Elymus lanceolatus, Carex buxbaumii, Cypripedium candidum, Hypoxis hirsuta, Salix candida,* and *Valeriana uliginosa*. *Valeriana ciliata* was inventoried in 2008 but not in 2009. Both *Cypripedium candidum* and *Valeriana uliginosa* were last seen during the spring and summer of 2006 and 2007.

Species diversity decreased from 113 species to 87. There were fifteen fewer native species in the 2008/2009 inventory (80 native species) than in the 2004/2005 inventory (95 native species) and eleven fewer adventive species in the 2008/2009 inventory (seven adventive species) than in the 2004/2005 (18 adventive species). However, with the proportionate decrease of native species and adventive species, the percent native species was 7.9% greater in 2008/2009 (92%) than in 2004/2005 (84.1%).

Other species distribution changes also occurred. There were 4.6% fewer native woody species in the 2008/2009 inventory (22.9% in 2004/2005 vs. 18.3% in 2008/2009), 6.8% more native forbs (46.0% in 2004/2005 vs. 52.8% in 2008/2009), and 3.9% more native graminoids (13.3% in 2004/2005 vs. 17.2% 2008/2009). Adventive woody species decreased from 4.4% to 2.2%, adventive forbs decreased from10.6% to 5.7% and adventive graminoid species increased from zero from 0.9%.

There were six prairie fen indicator species in both the 2004/2005 and 2008/2009 inventories, however, prairie fen species decreased by two for a total prairie fen species count of twenty-three in 2008/2009. All prairie fen zones were represented in the intact areas both years. And although the 2008/2009 inventory had three fewer sedge meadow species, the largest prairie fen zone was represented by sedge meadow species in both inventories with prairie fen species represented in all zones including two species in the calcareous seep zone.

There were fifteen *Cypripedium candidum* associates reported in both the 2004/2005 and the 2008/2009 inventories.

SUMMARY

Although the FQI decreased, the area in review may not be of sufficient size to reliably apply this index (Goforth et al. 2001 cited by Herman et al. 2005). Although the native mean C index decreased from 4.7 to 4.5, it is not unusual to see this after clearing efforts. Important changes have occurred within the intact areas and these intact areas remain at the threshold signifying that they have natural area potential and with proper stewardship one could expect that this value would remain essentially constant over time (Wilhelm and Masters 1995). A significant increase in Mean W occurred (-1.8 to -2.7) bringing this area from FACW- to FACW. Percent C distribution in 2008/2009 was analogous to that of 2004/2005 with slightly more high-C species in 2008/2009. Low-C and mid-C species dominated both inventories in analogous proportions. There was a decrease in percent native and adventive woody species and a decrease in percent adventive forbs and graminoids with a concurrent and equal increase in percent native forbs and graminoids. Overall, native species increased by 7.9% from 84.1% in 2004/2005 to 92.0% in 2008/2009. The number of prairie fen indicator species remain at six, however, prairie fen species decreased by two. All prairie fen zones were represented with the sedge meadow component continuing to be the greatest component as it was in 2005 and *Cypripedium candidum* associate species remained at fifteen.

However, even with these encouraging changes, native species diversity decreased and seven important species were not detected in 2009 including two endangered species; *Cypripedium candidum* and *Valeriana ciliata*.

Table 4.1 Summary table of inventory data 2008 and 2009

inventory	FQI	FQI w/Ad	Mean C	Mean C w/ Ad	Mean W	Wet class	Mean W w/a	Wet class w/ad	# IF	# SM	# CS	# WF	T PF sp	# PF indicator	CC sp	MNFI CC assoc	% C 0-3	% C 4-6	% C 8-10	# S	# NS	% NS	# AD	% AD	% W	%F	%G	% W ad	% F ad	% G ad
									6	21	5	7	39	8	20	15														
2004/2005	46.2	42.3	4.7	4.0	-1.8	FACW-	-1.3	FAC+	3	17	1	4	25	6	15	11	44.0	41.0	15.0	113	95	84.1	18	15.9	22.9	46.0	13.3	4.4	10.6	0.9
Intact 1&2_2008 & 2009	40.5	38.8	4.5	4.2	-2.7	FACW	-2.4	FACW-	3	14	2	4	23	6	15	9	45.0	38.0	17.0	87	80	92.0	7	8.0	18.3	52.8	17.2	2.2	5.7	0.0
Int 1&2_2008	36.7	35.4	4.5	4.2	-2.5	FACW	-2.3	FACW-	2	17	2	4	25	6	15	9	44.0	39.0	17.0	71	66	93.0	5	7.0	21.1	52.1	17.0	2.8	4.2	0.0
Int 1&2_2009	33.2	31.4	4.4	3.9	-2.9	FACW	-2.6	FACW	3	14	0	4	21	5	13	8	47.0	39.0	14.0	64	56	88.9	7	11.1	17.4	52.4	15.8	3.2	7.9	0.0
Intact 1_2008	31.3	29.9	4.3	4.0	-2.7	FACW	-2.5	FACW	2	16	0	3	21	5	13	8	46.0	40.0	14.0	57	52	91.2	5	8.8	19.4	54.4	15.8	3.5	5.3	0.0
Intact 2_2008	34.0	32.3	4.6	4.2	-2.5	FACW	-2.2	FACW-	2	15	2	4	23	6	15	9	47.0	35.0	18.0	60	54	90.0	6	10.0	16.7	50.1	20.0	3.4	6.7	0.0
Intact 1 2009	31.5	29.7	5.1	4.5	-3.1	FACW	-2.9	FACW	2	14	0	2	18	4	12	8	36.0	45.0	18.0	44	39	88.6	5	11.4	15.9	56.9	13.6	4.6	6.8	0.0
Intact 2 2009	29.2	27.5	4.3	3.8	-2.5	FACW	-2.2	FACW-	3	14	0	4	21	5	13	8	49.0	38.0	13.0	53	47	88.7	6	11.3	18.9	51.0	15.0	3.8	7.6	0.0
2008 all	43.5	40.3	4.0	3.4	-1.7	FACW-	-1.2	FAC+	2	16	2	6	26	7	15	11	43.0	49.0	9.0	138	119	86.2	19	13.8	21.7	50.7	10.8	6.5	7.1	0.0
2009 all	45.0	41.6	4.1	3.5	-1.7	FACW-	-1.2	FAC+	3	16	0	6	25	6	13	8	52.0	38.0	9.0	144	122	84.7	22	15.3	25.0	48.0	9.8	6.3	7.7	1.4
Clear phase 1_2008	29.9	27.3	3.6	3.0	-1.9	FACW-	-1.3	FAC+	1	9	0	2	12	4	8	5	55.0	40.0	5.0	84	70	83.3	14	16.7	14.3	55.9	10.7	7.2	9.6	0.0
Clear phase 1_2009	31.9	29.2	3.8	3.2	-2.2	FACW-	-1.5	FACW-	2	14	0	2	18	3	9	7	56.0	38.0	6.0	86	72	83.7	14	16.3	21.0	50.1	10.5	8.2	8.2	0.0
Clear phase 2 all_2008	29.0	25.9	3.4	2.7	-0.9	FAC+	-0.3	FAC	0	9	0	5	14	4	8	4	61.0	38.0	1.0	89	71	79.8	18	20.2	24.7	48.3	3.3	10.1	10.1	0.0
Clear phase 2 btwn 1,2_2008	13.5	11.0	5.5	3.7	-4.2	FACW+	-3.1	FACW	1	2	0	1	4	2	4	1	33.0	67.0	0.0	9	6	66.7	3	33.3	11.1	55.5	0.0	11.1	22.2	0.0
Clear phase 2 S of 2_2008	24.3	22.0	3.6	3.0	-1.3	FAC+	-0.6	FAC-	0	3	0	4	7	2	1	0	49.0	51.0	0.0	55	45	81.8	10	18.2	25.5	49.1	3.6	14.5	3.6	0.0
Clear phase 2 2008	24.5	22.2	3.4	2.8	-1.2	FAC+	-0.6	FAC-	0	8	0	4	12	3	7	4	60.0	39.0	2.0	62	51	82.3	11	17.7	19.4	48.4	0.0	6.5	11.3	0.0
Uncleared_2007 & 2008	16.7	13.8	3.8	2.6	-1.9	FACW-	-0.6	FAC-	0	1	0	2	3	1	3	0	61.0	39.0	0.0	28	19	67.9	9	32.1	21.4	42.9	3.6	17.9	14.3	0.0
A 2009	20.8	18.7	3.2	2.6	-0.8	FAC+	-0.4	FAC	0	6	0	1	7	0	2	0	63.0	35.0	2.0	52	42	80.8	10	19.2	32.7	38.4	9.6	11.5	5.7	1.9
B 2009	26.5	24.7	4.0	3.4	-3.2	FACW	-2.7	FACW	2	12	0	2	16	4	9	5	54.0	37.0	10.0	52	45	86.5	7	13.5	15.3	55.7	13.4	5.7	7.7	0.0
C 2009	28.7	25.9	4.0	3.2	-2.2	FACW-	-1.4	FAC+	2	8	0	3	13	2	6	2	53.0	41.0	6.0	64	52	81.3	12	18.8	17.2	48.5	14.1	9.4	7.9	1.6
D 2009	21.6	18.8	3.8	2.9	-2.2	FACW-	-1.3	FAC+	1	7	0	2	10	1	5	1	60.0	36.0	5.0	42	32	76.2	10	23.8	23.8	45.3	4.8	9.5	14.3	0.0
E 2009	26.5	25.1	4.4	3.9	-2.6	FACW	-2.4	FACW-	3	8	0	1	12	3	8	3	46.0	41.0	12.0	41	37	90.2	4	9.8	14.6	53.6	19.5	4.9	4.9	0.0
F 2009	20.6	18.9	3.2	2.7	-2.1	FACW-	-1.4	FAC+	2	7	0	4	13	2	5	2	65.0	35.0	2.0	49	41	83.7	8	16.3	14.2	51.0	14.3	8.1	8.1	0.0
G 2009	25.8	23.7	3.7	3.1	-2.5	FACW	-2.0	FACW-	1	11	0	3	15	3	8	3	60.0	35.0	5.0	57	48	84.2	9	15.8	21.1	50.9	10.6	7.1	8.8	0.0
H 2009	29.0	27.3	4.2	3.8	-2.9	FACW	-2.5	FACW	3	13	0	3	19	5	11	6	49.0	40.0	11.0	53	47	88.7	6	11.3	15.0	54.7	17.0	3.8	7.6	0.0
J 2009	20.7	18.2	3.2	2.4	-1.0	FAC+	-0.4	FAC	0	5	0	3	8	1	2	0	66.0	34.0	0.0	56	43	76.8	13	23.2	30.3	41.0	1.8	10.7	10.7	1.8
K 2009	13.8	12.3	3.4	2.8	-1.7	FACW-	-1.0	FACW-	0	2	0	1	3	1	1	0	60.0	40.0	0.0	20	16	80.0	4	20.0	50.0	25.0	5.0	20.0	0.0	0.0
L 2009	18.7	17.5	3.5	3.1	-2.1	FACW-	-1.7	FACW-	0	2	0	4	6	2	2	0	52.0	47.0	0.0	32	28	87.5	4	12.5	28.1	53.2	6.2	6.2	6.3	0.0

Table 4.2 – Data comparison from floral inventories conducted in Kirk Fen of the intact areas 2004/2005 to 2008/2009.

FQI, MEAN C, MEAN W

inventory	FQI	Mean C	Mean W	Wet class
2004/2005	46.2	4.7	-1.8	FACW-
intact 1&2_2008 & 2009	40.5	4.5	-2.7	FACW

FQI, Mean C, Mean W survey results of intact area, 2004/2005 and 2008/2009

- - 5.7 FQI
- - 0.2 Mean C
- - 0.9 Mean W (increased mean wetland species)
- + Wetland Classification

PERCENT C DISTRIBUTION

inventory	% C 0-3	% C 4-7	% C 8-10
2004/2005	44.0	41.0	15.0
intact 1&2_2008 & 2009	45.0	38.0	17.0

Percent C Distribution comparison of intact area, 2004/2005 and 2008/2009

- + 1.0% low-C species
- - 3.0% mid-C species
- + 2.0% high-C species

High-C species lost from 2005:
Carex buxbaumii, Cypripedium candidum, Hypoxis hirsuta, Salix candida, Valeriana ciliata, and Valeriana uliginosa. Cypripedium candidum and *Valeriana ciliata* were both seen the spring and summer of 2006 and 2007. *Valeriana ciliata* was also seen and inventoried in 2008.

SPECIES RICHNESS

inventory	# S	# NS	% NS	# AD	% AD
2005	113	95	84.1	18	15.9
intact 1&2_2008 & 2009	87	80	92.0	7	8.0

Species richness and distribution of native and adventive species comparison of intact area, 2004/2005 and 2008/2009

- - 26 total species
- - 15 native species
- - 11 adventive species
- + 7.9 % percent native species
- - 7.9 % percent adventive species

SPECIES TYPE DISTRIBUTION

inventory	%W	%F	%G	% W ad	% F ad	% G ad
2005	22.9	46.0	13.3	4.4	10.6	0.9
intact 1&2_2008 & 2009	18.3	52.8	17.2	2.2	5.7	0.0

Species type distribution and comparison of intact area, 2004/2005 and 2008/2009

- - 4.6% native woody species
- + 6.8% native forbs
- + 3.9% native graminoid species
- - 2.2% adventive woody species
- - 4.9% adventive forbs
- - 0.9% adventive graminoid species

PRIARIE FEN SPECIES

	# IF	# SM	# CS	# WF	T PF sp	# PF indicator sp
MNFI Prairie fen species	6	21	5	7	39	8
2005	3	17	1	4	25	6
intact 1&2_2008 & 2009	3	14	2	4	23	6

Prairie fen species distribution and comparison of intact area, 2004/2005 and 2008/2009

- - 1 total prairie fen species
- no change inundated fen species
- - 2 sedge meadow species
- + 1 calcareous seep species
- no change wooded fen species
- no change prairie fen indicator species

CYP CAN ASSOC SPECIES

	CC sp	MNFI CC assoc
	20	15
2005	15	11
intact 1&2_2008 & 2009	15	9

Cypripedium candidum associates comparison of intact area, 2004/2005 and 2008/2009

- no change Cyp can associates
- - 2 MNFI Cyp can associates

Table 4.3 – List of species in the intact areas of Kirk Fen 2008/2009.

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Allium cernuum	5	5	UPL	Nt P-Forb
Andropogon gerardii	5	1	FAC-	Nt P-Grass
Andropogon scoparius	5	3	FACU	Nt P-Grass
Asclepias incarnata	6	-5	OBL	Nt P-Forb
Aster firmus	4	-5	OBL	Nt P-Forb
Aster lanceolatus	2	-3	FACW	Nt P-Forb
Aster lateriflorus	2	-2	FACW-	Nt P-Forb
Aster nemoralis*	10	-5	OBL	Nt P-Forb
Aster novae-angliae	3	-3	FACW	Nt P-Forb
Aster puniceus	5	-5	OBL	Nt P-Forb
Aster umbellatus	5	-3	FACW	Nt P-Forb
Bidens frondosus	1	-3	FACW	Nt A-Forb
Bromus latiglumis	6	-2	FACW-	Nt P-Grass
Carex granularis	2	-4	FACW+	Nt P-Sedge
Carex leptalea	5	-5	OBL	Nt P-Sedge
Carex pellita	2	-5	OBL	Nt P-Sedge
Carex sterilis	10	-5	OBL	Nt P-Sedge
Carex tetanica	9	-3	FACW	Nt P-Sedge
Carpinus caroliniana	6	0	FAC	Nt Tree
CIRSIUM ARVENSE	0	3	FACU	Ad P-Forb
Cirsium muticum	6	-5	OBL	Nt B-Forb
CIRSIUM VULGARE	0	4	FACU-	Ad B-Forb
Clematis virginiana	4	0	FAC	Nt W-Vine
Cornus alternifolia	5	5	UPL	Nt Tree
Cornus amomum	2	-4	FACW+	Nt Shrub
Cornus foemina	1	-2	FACW-	Nt Shrub
Cornus sericea	2	-3	FACW	Nt Shrub
Eleocharis rostellata	10	-5	OBL	Nt P-Sedge
Epilobium coloratum	3	-5	OBL	Nt P-Forb
Equisetum arvense	0	0	FAC	Nt Fern Ally
Equisetum fluviatile	7	-5	OBL	Nt Fern Ally
Erechtites hieracifolia	2	3	FACU	Nt A-Forb
Eupatorium maculatum	4	-5	OBL	Nt P-Forb
Eupatorium perfoliatum	4	-4	FACW+	Nt P-Forb
Eupatorium purpureum	5	0	FAC	Nt P-Forb
Euthamia graminifolia	3	-2	FACW-	Nt P-Forb
Fraxinus pennsylvanica	2	-3	FACW	Nt Tree
Galium boreale	3	0	FAC	Nt P-Forb
Gentianopsis crinita	8	-4	FACW+	Nt A-Forb
Glyceria striata	4	-5	OBL	Nt P-Grass
Hierochloe odorata	9	-3	FACW	Nt P-Grass

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Juncus brachycephalus	7	-5	OBL	Nt P-Forb
Juncus dudleyi	1	0	FAC	Nt P-Forb
Juncus nodosus	5	-5	OBL	Nt P-Forb
Juncus torreyi	4	-3	FACW	Nt P-Forb
Juniperus virginiana	3	3	FACU	Nt Tree
Larix laricina	5	-3	FACW	Nt Tree
Lobelia kalmii	10	-5	OBL	Nt P-Forb
Lobelia siphilitica	4	-4	FACW+	Nt P-Forb
Lycopus americanus	2	-5	OBL	Nt P-Forb
Lysimachia quadriflora	10	-5	OBL	Nt P-Forb
LYTHRUM SALICARIA	0	-5	OBL	Ad P-Forb
Muhlenbergia glomerata	10	-4	FACW+	Nt P-Grass
Oxypolis rigidior	6	-5	OBL	Nt P-Forb
Parnassia glauca	8	-5	OBL	Nt P-Forb
Phalaris arundinacea	0	-4	FACW+	Nt P-Grass
Physocarpus opulifolius	4	-2	FACW-	Nt Shrub
Picea glauca	3	3	FACU	Nt Tree
Potentilla fruticosa	10	-3	FACW	Nt Shrub
PRUNELLA VULGARIS	0	0	FAC	Nt P-Forb
Pycnanthemum virginianum	5	-4	FACW+	Nt P-Forb
Rhamnus alnifolia	8	-5	OBL	Nt Shrub
RHAMNUS CATHARTICA	0	3	FACU	Ad Tree
RHAMNUS FRANGULA	0	-1	FAC+	Ad Shrub
Rubus pubescens	4	-4	FACW+	Nt P-Forb
Rubus strigosus	2	-2	FACW-	Nt Shrub
Rudbeckia hirta	1	3	FACU	Nt P-Forb
Salix bebbiana	1	-4	FACW+	Nt Shrub
Salix petiolaris	1	-4	FACW+	Nt Shrub
Schoenoplectus acutus	5	-5	OBL	Nt P-Sedge
Scirpus atrovirens	3	-5	OBL	Nt P-Sedge
Senecio aureus	5	-3	FACW	Nt P-Forb
SOLANUM DULCAMARA	0	0	FAC	Ad P-Forb
Solidago altissima	1	3	FACU	Nt P-Forb
Solidago canadensis	1	3	FACU	Nt P-Forb
Solidago nemoralis	2	5	UPL	Nt P-Forb
Solidago ohioensis	8	-5	OBL	Nt P-Forb
Solidago patula	6	-5	OBL	Nt P-Forb
Solidago riddellii	6	-5	OBL	Nt P-Forb
Solidago uliginosa	4	-5	OBL	Nt P-Forb
Thalictrum dasycarpum	3	-2	FACW-	Nt P-Forb

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Triglochin palustris	8	-5	OBL	Nt P-Forb
TYPHA ANGUSTIFOLIA	0	-5	OBL	Ad P-Forb
Typha latifolia	1	-5	OBL	Nt P-Forb
Valeriana ciliata	10	-5	OBL	Nt P-Forb
Zizia aurea	6	-1	FAC+	Nt P-Forb

* likely *Aster borealis* (9)

COMPARISON OF THE LARGER 1949 BOUNDARY SITE IN 2008/2009 TO THE 2004/2005 INTACT AREAS

All inventories were combined for 2008 and 2009 to compare the entire 1949 boundary site (and slightly beyond) to the smaller but intact areas in 2004/2005. The intention of this analysis is to see how the larger and mostly cleared site is progressing to the goal of becoming a greater high quality site that mirrors the floristic qualities of the smaller intact areas as reported in 2005. The inventories combined include the intact areas, the cleared areas, and uncleared areas (figure 1.2). A summary table of the data from the inventories can be found in Table 4.1. A list of species for the entire site from 2008 and 2009 is located in Table 4.4.

The native FQI in 2008 (42.5) and 2009 (45.0) indicates that the greater 1949 site is a wetland of sufficient native character and of rather profound environmental importance in terms of regional natural areas perspective (Wilhelm 1992). This area also possesses sufficient conservatism and richness that it is floristically important from a statewide perspective (Herman et al. 2005) and it is a wetland that cannot be realistically be replaced by mitigation (Wilhelm 1992; Wilhelm and Masters 1995). These high numbers for the combined inventories in 2008 and 2009 are directly linked to the higher diversity of species reported. There were 138 and 144 species reported in 2008 and 2009, respectively, of which 119 and 122 were native species and 19 and 22 were adventive species. In comparison, the inventories taken in 2005 showed 113 species made up of 95 native and 18 adventive species. Because the larger site includes more topological gradients than the intact areas, higher species diversity is expected.

The native mean C indexes were 4.0 and 4.1 for 2008 and 2009 respectively. Although this value is lower than that reported for the remnant intact areas in 2005 (4.7), the indices reported for the larger site in 2008/2009 exceeds the Mean C threshold of 3.5 and indicates an area with sufficient floristic quality to be of at least of marginal quality area and potential (Wilhelm and Masters 1995), a “critical” wetland, (DuPage County Stormwater Management Committee cited by Herman et al. 2005) and irreplaceable by mitigation and unconscionable to do so (Wilhelm 1991, 1992, and 1993 cited by Herman et al. 2005). The Mean W for both years was reported at -1.7 (FACW-) and comparable to that reported in 2005 (-1.8, FACW-).

High-C percentages for 2008 and 2009 were 9.0% for both years, lower than that reported for the intact area in 2005 (15.0%).

The percent native species reported for 2008 (86.2%) to 2009 (84%) were comparable to that reported in 2005 (84.1%).

Floral inventory species distributions of native woody species in 2008 (25.0%) and 2009 (21.7%) was similar to that reported in 2005 (22.9%). Native forb species for 2008 (50.7%) and 2009 (48.0%) were both slightly higher than 2005 (46.%) and the graminoid components in 2008 (10.8%) and 2009 (9.8%) were lower than 2005 (13.3%). Adventive species distribution showed higher adventive woody species percent in 2008 and 2009 (6.5%, 6.3%) compared to

2005 (4.4%), lower adventive forb percent in 2008 and 2009 (7.1%, 7.2%) than in 2005 (10.6%), with a similar percent of adventive graminoids in 2008 and 2009 (0.0%, 1.4%) to 2005 (0.9%).

The number of prairie fen indicator species was similar in 2008 and 2009 (7, 6) to that in 2005 (6) as well as the number of total prairie fen species in 2008 and 2009 (26, 25) with 2005 (25). There were fifteen *Cypripedium candidum* associates in 2008 with only eight reported in 2009; fifteen were counted in the 2005 report.

SUMMARY

The combined inventories in 2008 and 2009, which included the intact remnant areas, and the cleared and uncleared areas within and slightly outside the 1949 boundaries, had lower FQI indexes than in 2005. However the low- and mid-forty numbers indicate that the 1949 area continues to be an area with sufficient floristic quality to be at least of marginal quality area potential (Wilhelm and Masters 1995), a wetland of sufficient native character to be of rather profound environmental importance in terms of regional natural areas perspective (Wilhelm 1992), and an area which possess sufficient conservatism and richness that it is floristically important from a statewide perspective (Herman et al. 2005), and a wetland that cannot be realistically be replaced by mitigation (Wilhelm 1992; Wilhelm and Masters 1995). Similarly, the Mean C indexes for 2008 and 2009 were lower than in the remnant intact areas in 2005, but still suggest a high quality site with restoration potential as indicated by the FQI numbers. The FACW- wetness indicator is the same reported in 2005. The high-C percentages were lower than the intact site in 2005. Percent native species were similar to that reported in 2005 and native species distribution of the floral inventory was analogous to that in 2005. Prairie fen indicators and species were analogous to 2005. The *Cypripedium candidum* associates were the same for 2008 and 2005; however, six fewer species were counted in 2009. Except for the *C. candidum* associate count in 2009, the larger 1949 boundaries have lower but similar indices and percentages to those of 2005 and restoration of the larger site shows definite and indubitable progress toward achieving the desired results of a similar species composition as the Intact 2005 areas three years after the start of the project.

Table 4.4 – List of species in Kirk Fen 2008 including intact area, cleared areas, and uncleared areas.

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Acer negundo	0	-2	FACW-	Nt Tree
ALLIARIA PETIOLATA	0	0	FAC	Ad B-Forb
Allium cernuum	5	5	UPL	Nt P-Forb
Amphicarpaea bracteata	5	0	FAC	Nt A-Forb
Andropogon gerardii	5	1	FAC-	Nt P-Grass
Andropogon scoparius	5	3	FACU	Nt P-Grass
Anemone virginiana	3	5	UPL	Nt P-Forb
Arisaema triphyllum	5	-2	FACW-	Nt P-Forb
Asclepias incarnata	6	-5	OBL	Nt P-Forb
Aster firmus	4	-5	OBL	Nt P-Forb
Aster lanceolatus	2	-3	FACW	Nt P-Forb
Aster lateriflorus	2	-2	FACW-	Nt P-Forb
Aster novae-angliae	3	-3	FACW	Nt P-Forb
Aster umbellatus	5	-3	FACW	Nt P-Forb
Bidens frondosus	1	-3	FACW	Nt A-Forb
Carex blanda	1	0	FAC	Nt P-Sedge
Carex granularis	2	-4	FACW+	Nt P-Sedge
Carex hystericina	2	-5	OBL	Nt P-Sedge
Carex leptalea	5	-5	OBL	Nt P-Sedge

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Carex pellita	2	-5	OBL	Nt P-Sedge
Carex sterilis	10	-5	OBL	Nt P-Sedge
Carex tetanica	9	-3	FACW	Nt P-Sedge
Carpinus caroliniana	6	0	FAC	Nt Tree
Chelone glabra	7	-5	OBL	Nt P-Forb
CIRSIUM ARVENSE	0	3	FACU	Ad P-Forb
Cirsium muticum	6	-5	OBL	Nt B-Forb
CIRSIUM VULGARE	0	4	FACU-	Ad B-Forb
Clematis virginiana	4	0	FAC	Nt W-Vine
Cornus alternifolia	5	5	UPL	Nt Tree
Cornus amomum	2	-4	FACW+	Nt Shrub
Cornus foemina	1	-2	FACW-	Nt Shrub
Cornus stolonifera	2	-3	FACW	Nt Shrub
Corylus americana	5	4	FACU-	Nt Shrub
Cuscuta gronovii	3	-3	FACW	Nt A-Forb
ELAEAGNUS UMBELLATA	0	3	FACU	Ad Shrub
Epilobium coloratum	3	-5	OBL	Nt P-Forb
Equisetum arvense	0	0	FAC	Nt Fern Ally
Equisetum fluviatile	7	-5	OBL	Nt Fern Ally
Erechtites hieracifolia	2	3	FACU	Nt A-Forb
Erigeron annuus	0	1	FAC-	Nt B-Forb
Eupatorium maculatum	4	-5	OBL	Nt P-Forb
Eupatorium perfoliatum	4	-4	FACW+	Nt P-Forb
Eupatorium purpureum	5	0	FAC	Nt P-Forb
Euthamia graminifolia	3	-2	FACW-	Nt P-Forb
Fraxinus americana	5	3	FACU	Nt Tree
Galium aparine	0	3	FACU	Nt A-Forb
Galium boreale	3	0	FAC	Nt P-Forb
Galium concinnum	5	3	FACU	Nt P-Forb
Galium triflorum	4	2	FACU+	Nt P-Forb
Geum canadense	1	0	FAC	Nt P-Forb
Glyceria striata	4	-5	OBL	Nt P-Grass
Hackelia virginiana	1	1	FAC-	Nt P-Forb
Helianthus giganteus	5	-3	FACW	Nt P-Forb
HESPERIS MATRONALIS	0	5	UPL	Ad P-Forb
Hierochloe odorata	9	-3	FACW	Nt P-Grass
Impatiens capensis	2	-3	FACW	Nt A-Forb
Iris virginica	5	-5	OBL	Nt P-Forb
Juglans nigra	5	3	FACU	Nt Tree
Juncus brachycephalus	7	-5	OBL	Nt P-Forb
Juncus dudleyi	1	0	FAC	Nt P-Forb

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Juncus effusus	3	-5	OBL	Nt P-Forb
Juncus nodosus	5	-5	OBL	Nt P-Forb
Juniperus virginiana	3	3	FACU	Nt Tree
Larix laricina	5	-3	FACW	Nt Tree
Lathyrus palustris	7	-3	FACW	Nt P-Forb
LIGUSTRUM VULGARE	0	1	FAC-	Ad Shrub
Lobelia kalmii	10	-5	OBL	Nt P-Forb
Lobelia siphilitica	4	-4	FACW+	Nt P-Forb
LONICERA MAACKII	0	5	UPL	Ad Shrub
LONICERA TATARICA	0	3	FACU	Ad Shrub
LONICERA XBELLA	0	3	FACU	Ad Shrub
Lycopus americanus	2	-5	OBL	Nt P-Forb
Lysimachia quadriflora	10	-5	OBL	Nt P-Forb
LYTHRUM SALICARIA	0	-5	OBL	Ad P-Forb
MEDICAGO LUPULINA	0	1	FAC-	Ad A-Forb
Mentha arvensis	3	-3	FACW	Nt P-Forb
Muhlenbergia glomerata	10	-4	FACW+	Nt P-Grass
Onoclea sensibilis	2	-3	FACW	Nt Fern
Oxalis fontana	0	3	FACU	Nt P-Forb
Oxalis stricta	0	3	FACU	Nt P-Forb
Oxypolis rigidior	6	-5	OBL	Nt P-Forb
Parnassia glauca	8	-5	OBL	Nt P-Forb
Parthenocissus quinquefolia	5	1	FAC-	Nt W-Vine
Phalaris arundinacea	0	-4	FACW+	Nt P-Grass
Physocarpus opulifolius	4	-2	FACW-	Nt Shrub
Picea glauca	3	3	FACU	Nt Tree
Pilea fontana	5	-3	FACW	Nt A-Forb
POLYGONUM CONVOLVULUS	0	1	FAC-	Ad A-Forb
POLYGONUM CUSPIDATUM	0	3	FACU	Ad P-Forb
Potentilla fruticosa	10	-3	FACW	Nt Shrub
PRUNELLA VULGARIS	0	0	FAC	Nt P-Forb
Prunus serotina	2	3	FACU	Nt Tree
Pycnanthemum virginianum	5	-4	FACW+	Nt P-Forb
Quercus macrocarpa	5	1	FAC-	Nt Tree
Ranunculus hispidus	5	0	FAC	Nt P-Forb
Ranunculus recurvatus	5	-3	FACW	Nt A-Forb
Rhamnus alnifolia	8	-5	OBL	Nt Shrub
RHAMNUS CATHARTICA	0	3	FACU	Ad Tree
RHAMNUS FRANGULA	0	-1	FAC+	Ad Shrub
ROSA MULTIFLORA	0	3	FACU	Ad Shrub

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Rubus allegheniensis	1	2	FACU+	Nt Shrub
Rubus occidentalis	1	5	UPL	Nt Shrub
Rubus pubescens	4	-4	FACW+	Nt P-Forb
Rubus strigosus	2	-2	FACW-	Nt Shrub
Rudbeckia hirta	1	3	FACU	Nt P-Forb
Salix bebbiana	1	-4	FACW+	Nt Shrub
Salix petiolaris	1	-4	FACW+	Nt Shrub
Sanguinaria canadensis	5	4	FACU-	Nt P-Forb
Schoenoplectus acutus	5	-5	OBL	Nt P-Sedge
Scirpus atrovirens	3	-5	OBL	Nt P-Sedge
Senecio aureus	5	-3	FACW	Nt P-Forb
Smilacina stellata	5	1	FAC-	Nt P-Forb
SOLANUM DULCAMARA	0	0	FAC	Ad P-Forb
Solidago altissima	1	3	FACU	Nt P-Forb
Solidago canadensis	1	3	FACU	Nt P-Forb
Solidago nemoralis	2	5	UPL	Nt P-Forb
Solidago ohioensis	8	-5	OBL	Nt P-Forb
Solidago patula	6	-5	OBL	Nt P-Forb
Solidago riddellii	6	-5	OBL	Nt P-Forb
Solidago rugosa	3	-1	FAC+	Nt P-Forb
Solidago uliginosa	4	-5	OBL	Nt P-Forb
Symplocarpus foetidus	6	-5	OBL	Nt P-Forb
TARAXACUM OFFICINALE	0	3	FACU	Ad P-Forb
Thalictrum dasycarpum	3	-2	FACW-	Nt P-Forb
Thelypteris palustris	2	-4	FACW+	Nt Fern
Tilia americana	5	3	FACU	Nt Tree
Toxicodendron radicans	2	-1	FAC+	Nt W-Vine
Toxicodendron vernix	6	-5	OBL	Nt Shrub
Triglochin palustris	8	-5	OBL	Nt P-Forb
Typha latifolia	1	-5	OBL	Nt P-Forb
Ulmus americana	1	-2	FACW-	Nt Tree
Valeriana ciliata	10	-5	OBL	Nt P-Forb
Verbena urticifolia	4	-1	FAC+	Nt P-Forb
Viburnum lentago	4	-1	FAC+	Nt Shrub
VIBURNUM OPULUS	0	0	FAC	Ad Shrub
Viola cucullata	5	-5	OBL	Nt P-Forb
Vitis riparia	3	-2	FACW-	Nt W-Vine
Zizia aurea	6	-1	FAC+	Nt P-Forb

SPATIAL ANALYSIS OF INDIVIDUAL 2009 FLORAL INVENTORIES

Because the site was divided into smaller units (figure 3.2), these inventories will be examined for spatial patterns within the site and are reported on below. Summary tables of the data from the inventories as reported here can be found in Table 4.1 and comparison tables of FQI, Mean C and Mean W in Tables 4.5, 4.6 and 4.7.

FQI ranged from 12.8 to 31.2, with the highest found in Intact 1, H, and C and the lowest in K. None of the individual inventories had a FQI of 35 or greater; however, these areas are likely too small to rely on the FQI index for floristic quality (Goforth et al. 2001 cited by Herman et al. 2005) but do give us a view of the spatial comparison in the site.

A better indication of floristic quality (Taft et al. 2006) that is not as size dependent as the FQI (Wilhelm and Masters 2005) is the native Mean C. Its values ranged from 3.2 to 5.1, with the highest Mean C values found in Intact 1 (5.1), E (4.4), Intact 2 (4.3), and H (4.2), and the lowest in A, F, and J (all 3.2). All areas now are at or above the threshold of 3.5 indicating sufficient floristic quality to be at least of marginal quality area potential (Wilhelm and Masters 1995), a “critical” wetland (DuPage County Stormwater Management Committee cited by Herman et al. 2005), and irreplaceable by mitigation and unconscionable to do so (Wilhelm 1991, 1992, and 1993 cited by Wilhelm and Masters 1995).

Mean W indices ranged from -0.8 (FAC+) to -3.2 (FACW) with the lowest values (FAC+) found in J (the northernmost uncleared area) and A (the extreme northwest cleared area in the highest topological setting with soil transitioning to upland soil and with much of its areas outside the 1949 boundaries). All other areas reported FACW- to FACW. Six areas reported FACW: G (-2.5), Intact 2 (-2.5), E (-2.6), H (-2.9), Intact 1 (-3.1) and B (-3.2); all are contiguous and share topological gradients.

Associated low-, mid- and high-C percentages are analogous in distribution to the FQI and Mean C indexes reported above. The highest percentages of high-C species were found in Intact 1 (19%), Intact 2 (13%), E (12%), H (11%), and B (10%), while the lowest were found in J, K and L (all 0%).

Native species counts ranged from 16 to 52. Percent native species ranged from 76.2% to 90.2% with the highest percentages in E (90.2%), H (88.7%), Intact 2 (88.5%), and Intact 1 (88.4%). These areas ranking the highest are entirely within the 1949 boundaries and share the same topological gradients with Intact 1 and Intact 2. Note also that L, the lower most uncleared area reports at 87.5%; ranking this area fifth and higher than cleared areas A, C, D, F, and G. Their values ranged from 76-81% and they are located at the outer perimeter with some or most of their boundaries outside the 1949 boundaries.

Percent graminoid species ranged from 1.8% to 19.5%. The highest percent graminoid species were found in E (19.5%), H (17%), and Intact 2 (15.4%). The lowest percentage graminoid species were found in J (1.8%), D (4.8%), K (5.0%), L (6.2%), and A (9.6%). Of these areas J, K, and L are uncleared, and areas A and D are in the upper topological gradients and mostly outside the 1949 boundaries.

Percent adventive woody species ranged from 3.8% to 20% with the highest percentages found in J (10.7%), A (11.5%), and K (20%) of which J and K are uncleared. A is along the most upper topological gradient and mostly outside the 1949 boundaries. The lowest adventive woody species percentages are found in H (3.8%), Intact 2 (3.8%), and Intact 1 (4.6%).

Prairie fen species numbers had a wide variance ranging from 3 to 20 with the highest numbers found in contiguous areas Intact 2 (20), H (18), Intact 1 (17), and B (15) and lowest found in K (3), L (6), A (6), and J (7). No calcareous seep species were found in 2009 although *Parnassia glauca* and *Lobelia kalmii* were recorded in the 2008 inventories. The most dominant prairie fen zone in each area was represented by sedge meadow species ranging from two to thirteen species. The second most dominant was the wooded fen species with ranged from one to four species. Prairie fen indicator species ranged from zero to five with the most found in Intact 2 (5), H (5), Intact 1 (4), and B (4), which are contiguous and share topological gradients.

Cypripedium candidum associate species numbers ranged from 1 to 13 with the highest numbers counted in Intact 2 (13), Intact 1 (12), and H (11). The lowest numbers of *Cypripedium candidum* associates were found in K (1), J, (2) and A (2).

SUMMARY

None of the sites had an FQI of 35, however these areas are most likely too small to use the FQI reliably. Native Mean C, a floristic quality index not dependent on size, ranged from 3.2 to 5.1 with all but four of the areas at or above 3.5 indicating sufficient floristic quality to be at least of marginal quality area potential (Wilhelm and Masters 1995), a "critical" wetland (DuPage County Stormwater Management Committee cited by Herman et al. 2005), and irreplaceable by mitigation and unconscionable to do so (Wilhelm 1991, 1992, and 1993 cited by Wilhelm and Masters 1995). Wetland classifications ranged from FAC+ to FACW with all but two areas having wetland classifications at FACW- to FACW.

A general pattern within the site was seen with Intact 1, Intact 2, and H, usually having the highest values of FQI, Mean C, Mean W, percent native species, percent graminoid species, prairie fen species and indicators, and *Cypripedium candidum* associates with areas E and B also ranking high with many of the attributes. These areas all share the same topological gradient, are contiguous, and occupy the middle areas of the 1949 boundaries. J, K, and A consistently ranked lowest in values and indices.

The number of Prairie fen species ranged widely from 3 to 20 with the highest numbers found in the intact remnants and those areas contiguous with them. Overall, the sedge meadow species were the most represented with some representation of wooded fen and inundated fen species. No calcareous zone species were found. *Cypripedium candidum* associate species ranged from 1 to 13 with the highest counts found in the intact areas and the adjacent areas. Percent adventive woody species ranged from 3.8% to 20% indicating that more removal work is needed.

Table 4.5 – 2009 inventories ordered in decreasing FQI value.

inventory	FQI	Mean C	Mean W	Wet class
Intact 1 2009	31.2	5.1	-3.1	FACW
H 2009	29.0	4.2	-2.9	FACW
C 2009	28.7	4.0	-2.2	FACW-
Intact 2 2009	28.6	4.2	-2.6	FACW
B 2009	26.5	4.0	-3.2	FACW
E 2009	26.5	4.4	-2.6	FACW
G 2009	25.8	3.7	-2.5	FACW
D 2009	21.6	3.8	-2.2	FACW-
A 2009	20.8	3.2	-0.8	FAC+
J 2009 *[2]	20.7	3.2	-1.0	FAC+
F 2009	20.6	3.2	-2.1	FACW-
L 2009 *[2]	18.7	3.5	-2.1	FACW-
K 2009 *[2]	13.8	3.4	-1.7	FACW-

Table 4.6 – 2009 inventories ordered in decreasing Mean C value.

inventory	FQI	Mean C	Mean W	Wet class
Intact 1 2009	31.2	5.1	-3.1	FACW
E 2009	26.5	4.4	-2.6	FACW
H 2009	29.0	4.2	-2.9	FACW
Intact 2 2009	28.6	4.2	-2.6	FACW
C 2009	28.7	4.0	-2.2	FACW-
B 2009	26.5	4.0	-3.2	FACW
D 2009	21.6	3.8	-2.2	FACW-
G 2009	25.8	3.7	-2.5	FACW
L 2009 *[2]	18.7	3.5	-2.1	FACW-
K 2009 *[2]	13.8	3.4	-1.7	FACW-
A 2009	20.8	3.2	-0.8	FAC+
J 2009 *[2]	20.7	3.2	-1.0	FAC+
F 2009	20.6	3.2	-2.1	FACW-

Table 4.7 – 2009 inventories ordered in decreasing Mean W index.

inventory	FQI	Mean C	Mean W	Wet class
B 2009	26.5	4.0	-3.2	FACW
Intact 1 2009	31.2	5.1	-3.1	FACW
H 2009	29.0	4.2	-2.9	FACW
Intact 2 2009	28.6	4.2	-2.6	FACW
E 2009	26.5	4.4	-2.6	FACW
G 2009	25.8	3.7	-2.5	FACW-
C 2009	28.7	4.0	-2.2	FACW-
D 2009	21.6	3.8	-2.2	FACW-
F 2009	20.6	3.2	-2.1	FACW-
L 2009 *[2]	18.7	3.5	-2.1	FACW-
K 2009 *[2]	13.8	3.4	-1.7	FACW-
J 2009 *[2]	20.7	3.2	-1.0	FAC+
A 2009	20.8	3.2	-0.8	FAC+

Cypripedium candidum PILOT SURVEYS 2008 AND 2009

This section reports on the results from the *Cypripedium candidum* pilot surveys conducted in 2008 and 2009 and includes 1) ground water presence, 2) sun exposure, 3) graminoid presence and protection, 4) shrub threat, 5) forb competition, 6) *Cypripedium candidum* associate presence, and 7) a summary. For this survey, wetland sedges (*Carex* spp.) were reported as one entity. Summary of the information reported here can be found in Tables 4.8 and 4.9.

GROUND WATER PRESENCE

Ground water presence reports were more prevalent in 2009 as compared to 2008. In 2008, only the areas south and southeast of Intact 2 reported visible ground water, whereas in 2009, Intact 2 and eight other areas reported ground water and only the four northeastern most areas, Intact 1, A, B, and D, reported no ground water.

SUN EXPOSURE

Sun exposure was greater in 2009 than in 2008. In 2008, the site was characterized as full sun with local open shade with the areas south and southeast of Intact 2 having shade. In 2009 we see the site mostly open with full sun, with some areas having open shade, and only the three uncut areas J, K, and L as well as the cleared area D reporting shade.

GRAMINOID PRESENCE AND PROTECTION

Several areas in 2008 did not have data, however, we see the intact areas having only some graminoid presence and protection in 2008 whereas in 2009 these areas report having definite presence and protection. Also in 2009 we see that only the uncut areas of J, K, and L along with area F having no graminoid protection for *Cypripedium candidum*.

SHRUB THREAT

Shrub that pose ecological threats to the fen were less prevalent in the 2009 reports than in 2008. In 2008 we see heavy shrub threat in the two intact areas, while in 2009 shrub threat is reported as moderate. The cut phase 2 areas also report that in 2008 shrub threat was heavy while in 2009 the threat from shrubs was only moderate. Although there is missing information pertaining to the cut phase one areas, those with reports were light and moderate in 2008 and 2009.

FORB COMPETITION THREAT

While the reports for the intact areas in 2008 reported heavy threat by competitive forb species it appears that this declined in the 2009 survey to a moderate level. However, forb presence and threat were greater in the cut phase areas in 2008 than in 2009.

CYPRIPEDIUM CANDIDUM ASSOCIATE PRESENCE

Cypripedium candidum associate numbers remained the same in Intact 1 and were fewer by one species in Intact 2, while the cut phase 1 area had an additional species. The distribution of *C. candidum* associates is heaviest in the intact areas and areas in close proximity that share the same upper topological gradients as the intact areas: areas B, G and H. A total of sixteen *Cypripedium candidum* associates were reported from the surveys in 2008 while in 2009 only fourteen species were reported. *Carex* spp., *Eupatorium perfoliatum, Larix laricina, and Lysimachia quadriflora* were the dominant *C. candidum* associates both years. *Schoenoplectus acutus* gained presence from 2008 to 2009 while *Zizia aurea*, *Schizachyrium scoparium* and *Cornus sericea* lost presence. *Calamagrostis canadensis* was not reported either year. A complete summary of *Cypripedium candidum* associates can be found in Table 4.9. Spatial distribution of associates in 2008 was greatest in the intact areas, cut phase 1, and C areas while in 2009 we found the spatial distribution of *C. candidum* associates to favor the intact areas and the adjacent areas that share the upper topological gradients as the intact areas.

SUMMARY

The most notable observation from the surveys was that ground water presence was reported in more areas in 2009 than in 2008. Sun exposure was greater in 2009 than in 2008 but may be the result of subjective differences from one year to another. However, shrub threat shows considerable decline in the 2009survey, which would result in less shade and greater sun exposure for prairie fen species. Forb competition was less in 2009 in the intact areas but greater in the cut phase 1 areas. While *Cypripedium candidum* associate numbers were less with sixteen species reported in 2008 and fourteen species reported in 2009, spatial distribution of *C. candidum* associates were more widespread in 2009 from that reported in 2008 with *C. candidum* associates favoring the intact areas and the areas that share the same upper topological gradients as the intact areas.

Table 4.8 – *Cypripedium candidum* pilot survey summary table for 2008 and 2009.

AREA	VISGW	SUN	GRAM	SHBTHRT	FRBTHRT	CCNUM*[1]
intact 1 2008	no	full	some	heavy	heavy	13
intact 2 2008	almost	full, local shade	some	heavy	heavy	14
cut phs 1 2008	no	full, local open shade	no	light, edges heavy	light to moderate, local heavy	9
cut phs 1 A 08	no	full, local open shade	NO DATA	light	moderate	6
cut phs 1 B 08	no	full, local open shade	NO DATA	heavy	heavy	3
cut phs 1 C 08	no	full	NO DATA	NO DATA	light	7
cut phs 2 between 08	no	full	NO DATA	heavy (seedlings)	moderate	4
cut phs 2 SE of 2 08	yes	shade	no	heavy	light	8
cut phs 2 E of 2 08	no	full, local open shade	locally	heavy (seedlings)	heavy, light locally	2
uncleard S of 2 08	yes	shade, local open shade	no	heavy	moderate	2
intact 1 2009	no	full	yes	moderate	moderate	13
intact 2 2009	yes	full	yes	moderate	moderate	13
cut phs 1 2009	yes	full	DATA UNCERTAIN	light	heavy	10
A 2009	no	full	very little	moderate	heavy	2
B 2009	no	full	yes	light	moderate	9
C 2009	yes	full	locally	light	heavy	6
D 2009	no	shade, local open shade	DATA UNCERTAIN	heavy	heavy	5
E 2009	yes	full	yes	light	moderate	6
F 2009	yes	open shade	no	moderate	moderate	5
G 2009	yes	full	some	moderate (seedlings)	moderate	8
H 2009	yes	open shade	locally	heavy	light	12
J 2009	yes	shade	no	heavy	moderate	2
K 2009	yes	shade	no	heavy	light	1
L 2009	yes	shade	no	heavy	moderate	2

Table 4.8. Visible ground water (VISGW), sun exposure (SUN), graminoid presence and protection (GRAM), shrub threat (SHBTHRT), forb threat (FRBTHRT) and number of associates (CCNUM)

Table 4.9 – *Cypripedium candidum* associates found in Kirk Fen, 2008 and 2009.

CYP CAN ASSOCIATES 2008 SPECIES	NUMSUR
Carex sp.	10 (all)
Eupatorium perfoliatum	9
Larix laricina	8
Lysimachia quadriflora	8
Solidago ohioensis	8
Solidago riddelii	7
Thelypteris palustris	6
Andropogon gerardii	5
Zizia aurea	5
Potentilla fruticosa	4
Schoenoplectus acutus	3
Cornus sericea	2
Rhamnus alnifolia	2
Parnassia glauca	1
Schizachyrium scoparium	1
Campanula aparinoides	1
Calamagrostis canadensis	0

CYP CAN ASSOCIATES 2009 SPECIES	NUMSUR
Carex spp.	12 (all)
Eupatorium perfoliatum	12
Larix laricina	11
Lysimachia quadriflora	9
Schoenoplectus acutus	8
Solidago ohioensis	8
Solidago riddelii	7
Thelypteris palustris	6
Andropogon gerardii	5
Potentilla fruticosa	4
Rhamnus alnifolia	3
Zizia aurea	2
Parnassia glauca	1
Campanula aparinoides	0
Calamagrostis canadensis	0
Schizachyrium scoparium	0
Cornus sericea	0

FLORAL DOMINANCE PILOT SURVEYS 2008 AND 2009

This section reports on the portions of the pilot surveys that are biologically meaningful, sensitive to change and informative of the progress from restoration efforts. This report includes abundance and cover of 1) the three dominant highest-C species, 2) the three dominant species, and 3) dominance of all invasive species. Summary information reported here can be found in Tables 4.10 through 4.15 and will be referenced in the body of this section.

TWO DOMINANT HIGHEST-C SPECIES

The intact areas reported high-C species in the highest abundance and cover both years, however with slightly lower abundance and cover in 2009 than in 2008 directly tied to the fewer *Carex sterilis* (10) in 2008 (Tables 4.10). Intact

1 had the greater abundance and cover of the two high-C species reported in 2008, while in 2009 Intact 2 had the greater number of high-C species. Outside the intact areas High-C species were reported in many of the areas but not in all. Those areas outside the intact areas reporting high-C species were generally of low abundance and cover, with the exception of area H in 2009. Area H in 2009 had as much abundance and cover of two high-C species as Intact 1 in 2009, with more *Carex sterilis* (10) reported but fewer *Potentilla fruticosa* (10). Although *Carex sterilis* (10) had significantly less abundance and cover in the intact areas in 2009, we see a slightly greater frequency, abundance and cover in the other areas. Average abundance and cover of high-C species in the site 2008 was Common with 1-5% cover, while in 2009 abundance was Uncommon with 1-5% cover. Mid-C abundance and cover in the site both years was Uncommon and 1-5% cover (Table 4.11).

Table 4.10 – Highest-C species frequency, mean abundance and mean cover from pilot dominance surveys in Kirk Fen 2008 and 2009.

2008

Area		**Species**	**Abundance**	**% Cover**	**C**
intact 1	sp 1	*Carex sterilis*	D	51-75	10
	sp 2	*Potentilla fruticosa*	O	1-5	10
intact 2	sp 1	*Carex sterilis*	D	51-75	10
	sp 2	*Potentilla fruticosa*	C	1-5	10
cut phase 1	sp 1	*Lysamachia quadriflora*	U/O	<1	10
	sp 2	*Solidago ohioensis *1*	O(L)	1-5	8
cut phase 2 between intact areas	sp 1	*Cirsium muticum*	S	<1	6
	sp 2	*Juncus brachecephalis*	S	<1	7
cut phase 2, re-cut, E & SW of intact 2	sp 1	*Potentilla fruticosa*	C,L	<1	10
	sp 2				
cut phase 2, no re-cut, S & E of intact 2	sp 1	*Lysimachia quadriflora*	S	<1	10
	sp 2	*Potentilla fruticosa*	S	<1	10
uncut, S of intact 2	NO DATA CORRESPONDING WITH THE CYP CAN DATA SHEET				

cut phase 1 "A"	sp 1	*Lysimachia quadriflora*	U	<1	10
	sp 2	*none*			
cut phase 1 "B"	sp 1	*Solidago patula*	U	1-5	6
	sp 2	*Senecio aurea*	A	6-25	5
cut phase 1 "C"	sp 1	*Lysimachia quadriflora*	O	<1	10
	sp 2	*Solidago ohioensis*	O	1-5	8

*1 *Hierocholoe odorata (9)* was reported on floral inventory

2009

Area		**Species**	**Abundance**	**%Cover**	**C**
intact 1	sp 1	*Carex sterilis*	U	<1	10
	sp 2	*Potentilla fuiticosa*	C	6-25	10
intact 2	sp 1	*Potentilla fruticosa*	C	6-25	10
	sp 2	*Carex sterilis*	A	26-50	10
cleared phase	sp 1	*Solidago ohioensis*	U	<1	8
	sp 2	*Lysimachia quadriflora*	U	<1	10
A	sp 1	*Solidago patula*	U	1-5	6
	sp 2	none *5			
B	sp 1	*Carex sterilis*	O	1-5	10
	sp 2	*Potentilla fruticosa*	U(L)	<1	10
C	sp 1	*Carex sterilis*	O	1-5	10
	sp 2	none *1			
D	sp 1	*Solidago ohioensis*	R(L)	<1	8
	sp 2	*Lysimachia quadriflora*	R(L)	<1	10

Area		**Species**	**Abundance**	**Cover**	**C**
E	sp 1	*Lysimachia quadriflora*	O	<1	10
	sp 2	*Solidago ohioensis *2*	O	<1	8
F	sp 1	*Solidogo patula *3*	U	<1	6
	sp 2	*Heriochloe ordorata*	O	1-5	9
G	sp 1	*Carex sterilis*	R	<1	10
	sp 2	none *1			
H	sp 1	*Carex sterilis*	C	6-25	10
	sp 2	*Potentilla fruticosa*	U	<1	10
J	sp 1	*Senecio aureus*	C	26-50	5
	sp 2	*Carpinus caroliniana*	U	1-5	6
K	sp 1	*Larix laracina *4*	O	6-25	5
	sp 2	*Solidago patula*	R	<1	6
L	sp 1	none *5			
	sp 2	*Solidago patula*	O	1-5%	6

Table of highest-C species from pilot dominance survey 2009

*1 Lysimachia quadriflora was reported on floral inventory

*2 Carex sterilis and Eleocharis rostellata were reported on floral inventory

*3 Juncus brachycephalus was on floral inventory

*4 Symplocarpus foetidus was on floral inventory

Table 4.11. Summary table of two highest-C species in floral inventories, Kirk Fen 2008 and 2009.

Highest-C Species 2008	**frequency** 8 surveys	**abundance range in individual areas**	**mean abundance in individual areas**	**mean abundance in individual areas**	**cover range in individual areas**	**mean cover in individual areas**	**mean cover in individual areas**	**mean abundance in reported areas**	**mean abundance in reported areas**	**mean cover for all areas reportin g**	**mean cover for all areas reporting**
Potentilla fruticosa (10)	4	1 to 4	2.5	Occasional	1 to 2	1.5	1-5%				
Lysimachia quadriflora (10)	3	1 to 3	2	Uncommo n	1	1	<1%				
Carex sterilis (10)	2	6	6	Dominant	5	5	51-75%	C 8 to 10			
Solidago ohioensis (8)	1	3	3	Occasional	2	2	1-5%	3.4	Common	2.4	1-5%
Juncus brachycephalu s (7)	1	1	1	Scarce	1	1	<1%				
Circium muticum (6)	1	1	1	Scarce	1	1	<1%				
Solidago putula (6)	1	2	2	Uncommo n	2	2	1-5%	C <8			
Senecio areus (5)	1	5	5	Abundant	3	3	6-25%	2.3	Uncommon	1.8	1-5%

Highest-C Species 2009	13 surveys										
Carex sterilis (10)	6	1 to 5	3	Occasional	1 to 4	2.2	1-5%				
Potentilla fruticosa (10)	4	1 to 4	2.3	Uncommon	1 to 3	2	1-5%				
Solidago ohioensis (8)	2	0 to 3	1.5	Scarce	1	1	<1%				
Lysimachia quadriflora (10)	2	0 to 3	1.5	Scarce	1	1	<1%	C 8 to 10			
Hierocholoe odorata (9)	1	3	3	Occasional	2	2	1-5%	2.3	Uncommon	1.6	1-5%
*Solidago patula (6)**[3]	4	1 to 3	2	Uncommon	1 to 2	1.5	1-5%				
Carpinus carolinina (6)	1	2	2	Uncommon	2	2	1-5%	C <8			
*Larix laracina (5)**[3]	1	3	3	Occasional	3	3	6-25%	2.3	Uncommon	2.2	1-5%

Table * showing a summary Key speciesin order of frequency with abundance and cover ratingf from the 2008 and 2009 key species 2008 and 2009 surveys.

*[1] data missing on one survey

*[2] combining C. sterilis with C. spp when C. sterilis is the only Carex reported for cyp can asociate

*[3] higher species were on the inventory

THREE DOMINANT SPECIES

Intact 2 reported the highest-C species dominance both years by way of abundance and cover ratings (Tables 4.12 and 4.13). Intact 1 showed the next highest-C species dominance in 2008 but its lower species C values in 2009 were similar to that found in the cut areas. *Rhamnus frangula* was the most frequent and dominant species, followed by low-C and mid-C species both years. Three occurrences of high-C species as dominant species were reported both years. In 2008, high-C species *Carex sterilis* (10) was a dominant species in Intact 2 and *Solidago ohioensis* (8) was a dominant species in both Intact 1 and Intact 2. In 2009, *C. sterilis* (10) and *Solidago ohioensis* (8) were dominant species in Intact 2 and *Heriochloe odorata* (9) was a dominant species in Area F.

Table 4.12 – Dominant species frequency, abundance and cover from 2008 pilot dominance surveys in Kirk Fen.

Area	Sp.	Dominant spp.	Abundance	% Cover	C	ave. C
intact 1_2008	1	*Carex spp.*	D	>75	5	
	2	*Eupatorium perfoliatum*	D	51-75	4	
	3	*Solidago ohioensis*	D	26-50	8	
	4	*Rhamnus frangula*	C	26-50	0	4.3
intact 2_2008	1	*Carex sterilis*	D	51-75	10	
	2	*Rhamnus frangula*	A/D	26-50	0	
	3	*Solidago ohioensis*	A	6-25	8	6.0
cleared phase 1_2008	1	*Eupatorium perfoliatum*	D	26-50*	4	
	2	*Solidago canadensis*	D	51-75*	1	
	3	*Gyceria striata*	D/A	26-50	4	3.0
cleared phase 2 between intact areas_2008	1	*Cirsium arvense*	D	>75	0	
	2	*Rhamnus frangula*	A/D	51-75	0	
	3	*Senecio aurea*	O	51-75	5	1.7
cleared phase 2, recut, E, and SW of intact 2_2008	1	*Erectites hieracifolia*	D	26-50	2	
	2	*Rhamnus frangula*	D	6-25	0	
	3	*Cirsium arvense*	D	26-50	0	0.7
Cleared phase 2, no recut, S and E of intact 2_2008	1	*Rhamnus frangula*	D	>75	0	
	2	*Larix laracina*	C	26-50	5	2.5
	3					

uncleared, S of intact 2 2008	NO DATA CORRESPONDING WITH THE CYP CAN DATA SHEET					
cleared phase 1 "A" 2008	1	*Eupatorium perfoliatum*	D	51-75	4	
	2	*Solidago patula*	D	26-50	6	
	3	*Glyceria striata*	D	26-50	4	
	4	*Aster lateriflorus*	D	26-50	2	4.0
cleared phase 1 "B" 2008	1	*Solidago canadensis*	D	>75	1	
	2	*Cirsium arvense*	A; D(L)	26-50	0	
	3	*Senecio aureus*	A	6-25	5	
	4	*Rhamnus frangula*	A;D(L)	6-25	0	1.5
cleared phase 1 "C" 2008	1	*Sedges*	D	51-75	5	
	2	*Glyceria striata*	A	26-50	4	
	3	*Juncus brachycephalus*	A	26-50	7	5.3
Average Mean C					94	3

Table 4.11. Dominant species in 2008 inventories with abundance and cover ratings, C values for each species and average C value for each inventory. Average C dominance is not weighted by abundance or cover. Carex spp. C is estimated.

Dominant species frequency, abundance and cover from 2009 pilot dominance surveys in Kirk Fen

area	**Sp.**	**Dominant spp.**	**Abundance**	**%Cover**	**C**	**ave. C**
intact 1_2009	sp 1	*Carex stricta? (C. pellita)*	*A*	*51-75*	2	
	sp 2	*RHAMNUS FRANGULA*	*A*	*26-50*	0	
	sp 3	*Eupatorium perfoliatum*	*A*	*26-50*	4	2
intact 2_2009	sp 1	*Carex sterilis*	*A*	*26-50*	10	
	sp 2	*Solidago ohioensis*	*A*	*26-50*	8	
	sp 3	*RHAMNUS FRANGULA*	*A*	*26-50*	0	6
cleared phase 1_2009	sp 1	*Solidago altissima*	*A*	*26-50*	1	
	sp 2	*RHAMNUS FRANGULA*	*C*	*6-25*	0	
	sp 3	*Eupatorium maculatum*	*C*	*6-25*	4	
	sp 4	*Eupatorium perfoliatum*	*A*	*6-25*	4	2
A_2009	sp 1	*Solidago altissima*	*D*	*>75*	1	
	sp 2	*Senecio aureus*	*A*	*51-75*	5	
	sp 3	*Aster lateriflorus*	*A*	*26-50*	2	3
B_2009	sp 1	*Carex stricta? (C. pellita)*	*A*	*26-50*	2	
	sp 2	*Glyceria striata*	*A*	*26-50*	4	
	sp 3	*Eupatorium perfoliatum*	*C*	*26-50*	4	3
C_2009	sp 1	*Carex stricta? (C. pellita)*	*A*	*26-50*	2	
	sp 2	*Eupatorium peroliatum*	*A*	*6-25*	4	
	sp 3	*Eupatorium maculatum*	*A*	*6-25*	4	
	sp 4	*RHAMNUS FRANGULA*	*C*	*6-25*	0	3
D_2009	sp 1	*RHAMNUS FRANGULA*	*A[D(L)]*	*6-25*	0	
	sp 2	*Euthamia gramnifolia*	*A*	*6-25*	1	
	sp 3	*Solidago altisimma*	*C*	*1-5*	3	1
E_2009	sp 1	*Glyceria striata*	*D*	*>75*	4	
	sp 2	*RHAMNUS FRANGULA*	*C*	*26-50*	0	

	sp 3	*Euthamia graminifolia*	*C*	*6-25*	3	
	sp 4	*Schenoplectus acutus*	*A*	*6-25*	5	3
F_2009	sp 1	*Senecio aureus*	*A*	*6-25*	5	
	sp 2	*RHAMNUS FRANGULA*	*C*	*6-25*	0	
	sp 3	*Heriochloe ordorata*	*C*	*1-5*	9	4
G_2009	sp 1	*RHAMNUS FRANGULA*	*A*	*51-75*	0	
	sp 2	*Senecio aureus*	*A*	*26-50*	5	
	sp 3	*Glyceria striata*	*C*	*6-25*	4	2
H_2009	sp 1	*Carex stricta? (C. pellita)*	*A*	*26-50*	2	
	sp 2	*Glyceria striata*	*A*	*26-50*	4	
	sp 3	*RHAMNUS FRANGULA*	*A*	*26-50*	0	2
J_2009	sp 1	*RHAMNUS FRANGULA*	*A*	*26-50*	0	
	sp 2	*RHAMNUS CATHARTICA*	*A*	*26-50*	0	
	sp 3	*Senecio aureus*	*C*	*26-50*	5	
	sp 4	*CIRSIUM ARVENSE*	*A*	*6-25*	0	1
K_2009	sp 1	*Lonicera sp.*	*A*	*51-75*	0	
	sp 2	*RHAMNUS CATHARTICA*	*C*	*26-50*	0	
	sp 3	*RHAMNUS FRANGULA*	*A*	*6-25*	0	0
L_2009	sp 1	*RHAMNUS FRANGULA*	*A*	*26-50*	0	
	sp 2	*RHAMNUS CATHARTICA*	*O*	*26-50*	4	
	sp 3	*Clematis virginiana*	*C*	*6-25*	6	3
Average C of Dominant species						3

Table 4.12. Dominant species in 2009 inventories with abundance and cover ratings, C values for each species
and average C value for each inventory. Average C dominance is not weighted by abundance or cover. Carex
spp. C is estimated.

Table 4.13 – Dominant species summary of mean frequency, mean abundance and mean cover from pilot dominance surveys 2008 and 2009.

species	frequency	abundance range in individual areas	mean abundance in individual areas	mean abundance in individual areas	cover range in individual areas	mean cover in individual areas	mean cover in individual areas
DOMINANT SPECIES 2008	8 total surveys						
RHAMNUS FRANGULA (0)	6	4 to 6	5.3	Abundant	3 to 6	4.2	26-50%
CIRSIUM ARVENSE (0)	3	5 to 6	5.7	Dominant	4 to 6	4.7	51-75%
Carex spp	2	6	6	Dominant	5 to 6	5.5	>75%
Eupatorium perfoliatum (4)	2	6	6	Dominant	5	5	51-75%
Glyceria striata (4)	2	5 to 6	5.5	Dominant	4	4	26-50%
Senecio aureus (5)	2	5 to 6	5.5	Dominant	3 to 5	4	26-50%
Solidago ohioensis (8)	2	5 to 6	5.5	Dominant	3 to 4	3.5	26-50%
Solidago canadesis (C. altissima) (1)	1	6	6	Dominant	6	6	>75
Carex sterilis (10)	1	6	6	Dominant	6	6	>75%
Solidago patula (6)	1	6	6	Dominant	4	4	26-50%
Juncus brachycephalus (7)	1	5	5	Abundant	4	4	26-50%
Erictites hierachifolia (2)	1	6	6	Dominant	4	4	26-50%
Aster laterifolia (2)	1	6	6	Dominant	4	4	26-50%
Larix laracina (5)	1	4	4	Common	4	4	26-50%
DOMINANT SPECIES 2009	13 total surveys						
RHAMNUS FRANGULA (0)	11	4 to 5	4.6	Abundant	3 to 5	3.6	26-50%
Carex strict? (C. pellita) (2)	4	5	5	Abundant	4 to 5	4.3	26-50%
Glyceria striata (4)	4	5	5	Abundant	3 to 6	4.3	26-50%
Senecio aureus (5)	4	4 to 5	4.7	Abundant	3 to 5	4	26-50%
Eupatorium perfoliatum (4)	3	4 to 5	4.7	Abundant	3 to 4	3.7	26-50%
RHAMNUS CATHARTICA (0)	3	3 to 5	4	Common	4	4	26-50%

Solidago altissima (1)	2	3 to 6	5	Abundant	2 to 6	4	26-50%
Euthamia gramnifolia (3)	2	4 to 5	4.5	Dominant	4	4	26-50%
CIRSIUM ARVENSE (0)	1	5	5	Abundant	3	3	6-25%
Clematis virginica (6)	1	4	4	Common	3	3	6-25%
Hierochloe odorata (9)	1	4	4	Common	2	2	1-5%
Schenoplectus acutus (5)	1	5	5	Abundant	3	3	6-25%
LONICERA SP. (0)	1	5	5	Abundant	5.0	5	51-75%
Carex sterilis (10)	1	5	5	Abundant	4	4	26-50%
Solidago ohioensis (8)	1	5	5	Abundant	4	4	26-50%
Eupatorium maculatum (4)	1	5	5	Abundant	3	3	6-25%
Aster laterifolia (2)	1	5	5	Abundant	4	4	26-50%

DOMINANCE OF INVASIVE SPECIES

The lowest invasive abundance and cover was reported in the cut phase 1 areas both years, with the cut phase 2 areas reporting the highest in 2008 and uncut areas in 2009 (Table 4.14). The intact areas reported similar abundance and cover both years. As reported above, *Rhamnus frangula* was the dominant species of the site both years. Several notes and the author's recollection is that *R. frangula* seen in these years were seedlings and possibly some re-sprouts. The invasive dominance survey found six other invasive species throughout the site. Invasive species frequencies were higher in 2009 than 2008 for all invasive species except *Cirsium arvense*, which had lower frequencies. Average abundance of each species throughout the site was less in 2009 than in 2008 for *R. frangula*, *Lythrum salicaria*, and *Cirsium arvense*, however, average abundance was greater in 2009 for *R*. *cathartica*, *Phalaris arundinacae*, and *Lonicera* species (Table 4.15).

Table 4.14. Invasive species abundance and cover from 2008 pilot surveys in Kirk Fen.

Area		Invasive spp.	Abundance	%Cover
intact 1_2008	sp 1	*RHAMNUS CATHARTICA*	S	<1
	sp 2	*RHAMNUS FRANGULA*	D	26-50
	sp 3	*LYTHRUM SALICARA*	C	6-25
	sp 4	*CIRSIUM ARVENSE*	None *	
intact 2_2008	sp 1	*RHAMNUS FRANGULA*	A/D	26-50
	sp 2	*LYTHRUM SALICARIA*	O	1-5
	sp 3	*CIRSIUM ARVENSE*	A,L	1-5
	sp 4	*RHAMNUS CATHARTICA*	S	<1
cleared phase 1_2008	sp 1	*RHAMNUS FRANGULA*	C	6-25
	sp 2	*CIRSIUM ARVENSE*	D(L)	6-25
	sp 3	*LYTHRUM SALICARIA*	C(L)	1-5
	sp 4	*Phalaris arundinacea*	D(L)	<1
	sp 5	*LONICERA XBELLA*	S	<1
		RHAMNUS CATHARTICA	none	

cleared phase 2 between intact areas_2008	sp 1	*CIRSIUM ARVENSE*	D	>75
	sp 2	*RHAMNUS FRANGULA*	A/D	51-75
	sp 3	*LYTHRUM SALICARIA*	O	1-5
	sp 4	*RHAMNUS CATHARTICA*	none	
cleared phase 2, recut, E, and SW of intact 2_2008	sp 1	*CIRSIUM ARVENSE*	D	26-50
	sp 2	*RHAMNUS FRANGULA*	D	6-25
	sp 3	*LONICERA SP.*	O	1-5
	sp 4	*CIRSIUM VULGARIS*	S	<1
	sp 5	*RHAMNUS CATHARTICA*	NA	
	sp 6	*LYTHRUM SALICARA*		
Cleared phase 2, no recut, S and E of intact 2_2008	sp 1	*RHAMNUS FRANGULA*	D	>75
	sp 2	*RHAMNUS CATHARTICA*	O	1-5
uncleared, S of intact 2 2008	NO DATA CORRESPONDING WITH THE CYP CAN DATA SHEET			
cleared phase 1 "A" 2008	sp 1	*LYTHRUM SALICARIA*	C	6-25
	sp 2	*CIRSIUM ARVENSE*	D,L	6-25
	sp 3	*RHAMNUS FRANGULA*	C	1-5
	sp 4	*Phalaris arundinacea*	D,L	1-5
	sp 5	*LONICERA XBELLA*	S	<1
		RHAMNUS CATHARTICA	none	
cleared phase 1 "B" 2008	sp 1	*CIRCIUM ARVENSE*	A; D(L)	26-50
	sp 2	*RHAMNUS FRANGULA*	A; D(L)	6-25
	sp 3	*LONICERA SP.*	U	1-5
	sp 4	*RHAMNUS CATHARTICA*	none	
cleared phase 1 "C" 2008	sp 1	*RHAMNUS CATHARTICA*	none	
	sp 2	*RHAMNUS FRANGULA*	D(L)	6-25
	sp 3	*CIRSIUM ARVENSE*	O	1-5

* *Cirsium arvense* was in this area before herbicide treatments

Invasive species abundance and cover form 2009 pilot survey in Kirk Fen.

Area		**Invasive spp.**	**Abundance**	**% Cover**	
intact 1_2009	sp 1	*RHAMNUS FRANGULA*	A	26-50	
	sp 2	*LYTHRUM SALICARIA*	O	1-5	
	sp 3	*Phalaris arundinacea*	D(L)	<1	
	sp 4	*RHAMNUS CATHARTICA*	S	<1	
intact 2_2009	sp 1	*RHAMNUS FRANGULA*	A	26-50	Re-sprouts
	sp 2	*LYTHRUM SALICARIA*	U	<1	
	sp 3	*RHAMNUS CATHARTICA*	none	0	
	sp 4	none			

cleared phase 1_2009	sp 1	*RHAMNUS FRANGULA*	C	6-25	
	sp 2	*RHAMNUS CATHARTICA*	S	<1	
	sp 3	*Phalaris arundinacea*	A(L)	<1	
	sp 4	*LYTHRUM SALICARIA*	U	<1	
A_2009	sp 1	*LONICERA SP.*	O	6-25	
	sp 2	*RHAMNUS FRANGULA*	C	6-25	
	sp 3	*Phalaris arundinacea*	O	<1	
	sp 4	*RHAMNUS CATHARTICA*	S	<1	
B_2009	sp 1	*RHAMNUS FRANGULA*	C	6-25	
	sp 2	*RHAMNUS CATHARTICA*	S	<1	
	sp 3	*LYTHRUM SALICARIA*	S	<1	
	sp 4	*Phalaris arundinacea*	C(L)	<1	
C_2009	sp 1	*RHAMNUS FRANGULA*	C	6-25	mostly seedlings
	sp 2	*RHAMNUS CATHARTICA*	S	1-5	
	sp 3	*LONICERA SP.*	U	1-5	
	sp 4	*Phalaris arundinacea*	D(L)	<1	
D_2009	sp 1	*RHAMNUS FRANGULA*	A[D(L)]	6-25	mostly seedlings
	sp 2	*RHAMNUS CATHARTICA*	S	<1	
	sp 3	*LYTHRUM SALICARIA*	S	<1	
	sp 4	*LONICERA XBELLA*	U	1-5	
E_2009	sp 1	*RHAMNUS FRANGULA*	C	26-50	
	sp 2	*LYTHRUM SALICARIA*	U	<1	
	sp 3	*LONICERA XBELLA*	S	<1	
	sp 4	*RHAMNUS CATHARTICA*	none	0	
F_2009	sp 1	*RHAMNUS FRANGULA*	C	6-25	
	sp 2	*RHAMNUS CATHARTICA*	S	<1	
	sp 3	*Phalaris arundinacea*	S	<1	
	sp 4	none			
G_2009	sp 1	*RHAMNUS FRANGULA*	A	51-75	
	sp 2	*LYTHRUM SALICARIA*	O	1-5	
	sp 3	*LONICERA XBELLA*	U	1-5	
	sp 4	*RHAMNUS CATHARTICA*	S	<1	

H_2009	sp 1	*RHAMNUS FRANGULA*	A	26-50
	sp 2	*RHAMNUS CATHARTICA*	S	<1
	sp 3	*LYTHRUM SALICARIA*	U	<1
	sp 4	*Phalaris arundinacea*	A(L)	<1
J_2009	sp 1	*RHAMNUS CATHARTICA*	A	26-50
	sp 2	*RHAMNUS FRANGULA*	A	26-50
	sp 3	*CIRSIUM ARVENSE*	A	6-25
	sp 4	*Phalaris arundinacea*	D(L)	6-25
	sp 5	*LYTHRUM SALICARIA*	S	<1
	sp 6	*LONICERA SP.*	C	<1
K_2009	sp 1	*LONICERA SP.*	A	51-75
	sp 2	*RHAMNUS CATHARTICA*	C	26-50
	sp 3	*RHAMNUS FRANGULA*	C	6-25
	sp 4	*Phalaris arundinacea*	D(L)	<1
L_2009	sp 1	*RHAMNUS FRANGULA*	A	26-50
	sp 2	*RHAMNUS CATHARTICA*	O	26-50
	sp 3	*Phalaris arundinacea*	D/L	1-5
	sp 4	*none*		

Table 4.15. Summary table of invasive abundance and frequency in Kirk Fen. 2008 and 2009.

	frequency	abundance range in individual areas	mean abundance in individual areas	mean abundance in individual areas	cover range in individual areas	mean cover in individual areas	mean cover in individual areas	mean abundance in KF	mean abundance in KF	mean cover in KF	mean cover in KF
INVASIVE SPECIES 2008	8 total surveys										
RHAMNUS FRANGULA	8	4 to 6	5.4	Abundant	2 to 6	3.8	26-50%	5.4	Abundant	3.8	26-50%
RHAMNUS CATHARTICA	3	1 to 3	1.6	Uncommon	1 to 2	1.3	<1%	0.6	Scarce	0.5	<1%
Phalaris arundinacea	1	5	5	Abundant	1 to 2	1.5	<1%	0.6	Scarce	0.3	<1%
LYTHRUM SALICARIA	5*	3 to 4	2.8	Occasional	2 to 3	2	1-5%	1.8	Uncommon	1.3	<1%
LONICERA SP.	3	1 to 3	2	Uncommon	1 to 2	1.7	1-5%	0.8	Scarce	0.6	<1%
CIRSIUM ARVENSE	8	1 to 6	3.8	Common	1 to 6	2.8	6-25%	3.8	Common	2.8	6-25%
INVASIVE SPECIES 2009	13 total surveys										
RHAMNUS FRANGULA	13	4 to 5	4.5	Abundant	3 to 5	3.6	26-50%	4.5	Abundant	3.6	26-50%
RHAMNUS CATHARTICA	11	1 to 5	1.8	Uncommon	1 to 4	1.9	1-5%	1.5	Uncommon	1.6	1-5%
Phalaris arundinacea	9	1 to 5	4	Common	1 to 3	1.3	<1%	2.8	Occasional	0.9	<1%
LYTHRUM SALICARIA	8	1 to 3	1.9	Uncommon	1 to 2	1.3	<1%	1.2	Scarce	0.8	<1%
LONICERA SP.	7	1 to 5	2.7	Occasional	1 to 5	2.3	1-5%	1.5	Uncommon	1.2	<1%
CIRSIUM ARVENSE	1	5	5	Abundant	3	3	6-25%	0.4	Scarce	0.2	<1%

SUMMARY

High-C species were found in high abundance and cover in the intact areas, with mostly low abundance and cover in the surrounding areas with the exception of Area H in 2009. The intact areas in 2009 had lower High-C abundance and cover than in 2008 mostly due to fewer *Carex sterilis* (10) reported in 2009. Average abundance and cover of high-C species in the site both years were low. The most dominant species in the way of frequency, abundance, and cover was *Rhamnus frangula*, mostly in the form of seedlings and re-sprouts as well as some remaining uncut plants. Low-C and mid-C species were next to dominate the site, with exceptions of high-C species dominance in both intact areas in 2008 and in Intact 2 and area F in 2009. Other invasive species found were *Rhamnus cathartica, Phalaris arundinacea, Lythrum salicaria, Lonicera* spp. and *Cirsium arvense.* Although overall abundance and cover ratings of invasive species were less in 2009 than 2008, frequency ratings were greater in 2009 with the exception of *C. arvense*, which was lower. Average abundance of *R. frangula*, *Lythrum salicaria*, and *Cirsium arvense* throughout the site was less in 2009 than in 2008; however, average abundance was greater in 2009 for *R. cathartica*, *Phalaris arundinaea*, and *Lonicera* species.

LINE-INTERCEPT TRANSECT INVENTORY AND SPECIES RELATIVE COVER 2009

This section reports on the floral species recorded along five line-intercept transects conducted in Kirk Fen, July 2009. Reports will begin with the westernmost transect (transect five) and ends with the easternmost transect (transect four)[1]. For each transect a brief description of the position and orientation is followed by a report on the FQI, Mean C, Mean W, sequential Mean W, prairie fen species, *Cypripedium candidum* associates, and percent high-, mid-, and low-C species. Finally, a summary of vegetation patterns within the site based on the transect reports is made. Full FQA generated transect reports, modified to include summaries of prairie fen species, *Cypripedium candidum* associates, and invasive species are filed at the Botanical Gardens.

For this report the term quadrant is synonymous with the term section. For *C. candidum* associates counts, sedges are defined as wetland *Carex* spp. and were counted individually. For prairie fens species counts, wetland asters (*Aster* spp.) were also counted individually. Tables relevant to each line-intercept transect are interspersed throughout (Tables 4.16-4.50). Summary tables 4.51 – 4.60 can be found at the end of the summary section.

TRANSECT-FIVE

Line-intercept transect-five is the outermost west transect running from north to south, perpendicular to the contour lines at 20 degrees from north. It

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[1] Transect five was not originally planned and was conducted after the first four transects so that the numbering of the transects from west to east are not entirely sequential.

traverses the westernmost section of the cleared phase 1 area and outside and west of Intact 1 (figure 3.2).

FQI, Mean C, Floral inventory species composition, and Mean W

Native FQI is the fourth ranked of the five transects at 26.3, with native Mean C of 3.5 ranking last of the five transects. The floral inventory is predominantly low-C species (50.0%) and mid-C species (46.4%) with high-C species at 3.6% (the lowest of the five transects) (Summary Table 4.51). A little over eighty-one percent of the floral inventory is dominated by native species for a combined relative importance of 75.4%; second ranking of the five transects. Native perennial forbs made up 43.5% of the floral inventory with a relative importance of 44.8%. Although adventive shrubs make up only 4.3% of the floral inventory they have a relative importance at 13.7%. Native graminoids make up 8.7% of the floral inventory and have a relative importance of 7.6% (Table 4.16).

Table 4.16. Species type, number and percent recorded along line-intercept transect five.

	number species	percent of floral inventory			number species	percent of floral inventory
Native	**56**	**81.2%**		**Adventive**	**13**	**18.0&**
Tree	3	4.30%		Tree	1	1.40%
Shrub	7	10.10%		Shrub	3	4.30%
W-Vine	3	4.30%		W-Vine	0	0.00%
H-Vine	0	0.00%		H-Vine	0	0.00%
P-Forb	30	43.50%		P-Forb	6	8.70%
B-Forb	1	1.40%		B-Forb	1	1.40%
A-Forb	5	7.20%		A-Forb	1	1.40%
P-Grass	2	2.90%		P-Grass	1	1.40%
A-Grass	0	0.00%		A-Grass	0	0.00%
P-Sedge	4	5.80%		P-Sedge	0	0.00%
A-Sedge	0	0.00%		A-Sedge	0	0.00%
Fern	1	1.40%				

FQI ranged from 7.7 to 15.8 in individual sections for an average of 12.7 with a standard deviation of 2.8. The lowest indices were seen at the north sections at 7.7 and 8.6 with a rapid increase at sections three and four (15.3 and 15.8 respectively) and then decreasing at sections five through nine (13.6 to 13.0 respectively). Mean C for the individual sections ranged from 2.4 to 4.3 with an average Mean C of 3.5 with a standard deviation of 0.7. Mean C gradually increased from the north to the center with a slight decrease to the south with an increase at the end. The highest Mean C values for transect five were located in sections five (4.1) and nine (4.3). Mean W ranged from -0.1 (FAC) to -3.6 (FACW+) with the driest sections at the northernmost and southernmost sections and the wettest in the middle section five (Table 4.17)

Table 4.17. Floristic Quality summary table for each quadrant in line-intercept transect five Kirk Fen 2009.

TRANSECT 5
QUADRANT SUMMARY

QUAD	MC	W/Ad	FQI	W/Ad	MW	WET	NS	TS	MW SEQ	PF SP	CC SP	INV SP
1	2.6	1.9	7.7	6.6	-0.2	FAC	9	12	-0.1	0	0	3
2	2.4	1.5	8.6	6.9	-0.1	FAC	13	20	-0.5	1	1	2
3	3.7	3.0	15.3	13.7	-1.1	FAC+	17	21	-1.5	3	0	4
4	3.9	3.3	15.8	14.5	-3.4	FACW	16	19	-2.7	4	3	3
5	4.1	3.5	13.6	12.5	-3.6	FACW+	11	13	-3.3	2	3	2
6	3.3	2.9	13.6	12.8	-2.9	FACW	17	19	-2.9	3	3	2
7	3.5	2.9	13.7	12.5	-2.3	FACW-	15	18	-2.0	2	0	2
8	3.9	2.9	13.6	11.8	-0.9	FAC+	12	16	-1.3	3	1	3
9	4.3	3.3	13.0	11.3	-0.7	FAC+	9	12	-0.8	0	0	3
AVG	3.5	2.8	12.7	11.4	-1.7	FACW-	13.2	16.7				
STD	0.7	0.6	2.8	2.8	1.4		3.2	3.5				

Table 4.17. Mean coefficient of conservatism (MC), mean coefficient of conservatism with adventive species (W/Ad), floristic quality index (FQI), floristic quality index with adventives (W/Ad), mean wetness index (MW), wetness category (WET), number of native species (NS), number of total species (TS), sequential mean wetness (MW SEQ), number of prairie fen species (PF SP), number of *Cypripedium candidum* associates (CC SP) and number of invasive species (INV SP).

Dominant species and high-C species

The three dominant species by way of greatest relative importance were low-C species *Solidago altissima* (1), *Lonicera* x*bella* (0) and *Rhamnus frangula* (0), two of which are invasive species (*R. frangula*, *Lonicera* x*bella*) (Summary Table 4.53, Table 4.18)

Table 4.18. Dominant species found along line-intercept five transect in Kirk Fen 2009.

	SCIENTIFIC NAME	C	WETNESS	FRQ	COV	RFRQ	RCOV	RIV	QUADS
T5	Solidago altissima	1	FACU	7	773	4.7	12.9	8.8	2 to 8
	LONICERA XBELLA	0	FACU	4	760	2.7	12.7	7.7	1,2,4
	RHAMNUS FRANGULA	0	FAC+	7	397	4.7	6.6	5.6	2,4-9

Table 4.18. Coefficient of conservatism (C), wetness category, frequency (FRQ) cover (COV), relative frequency (RFRQ), relative cover (RCOV, relative importance (RIV) and the quadrants in which they were recorded.

High-C species *Hierochloe odorata* (9) and *Carex sterilis* (10) were found in quadrants four, five and eight for a combined relative importance of 1.5% the lowest value of the five transects (Summary Table 5.54, Table 4.19).

Table 4.19. Species with high coefficient of conservatism recorded along line-intercept transect five Kirk Fen 2009.

Transect	Quadrant(s)	species	Wetness	C	RFRQ	RCOV	RIV
T5	8	Hierochloe odorata	FACW	9	0.7	0.9	0.8
	4,5	Carex sterilis	OBL	10	1.3	0.1	0.7
		total			2	1	1.5

Table 4.19. Quadrants in which High-C species were recorded, wetness category, coefficient of conservatism (C), relative frequency (RFRQ), relative cover (RCOV and relative importance (RIV).

Prairie fen species

Prairie fen species ranged from zero to four within the individual quadrants, with the highest number of prairie fen species found in quadrant four (Table 4.17). Eight prairie fen species were tallied (the lowest count of the five transects), for a relative importance of 12.6%, the lowest ranking of the five transects (Summary Table 4.55). Seven sedge meadow species were found for a combined relative importance of 10.5% and one inundated flat species for a relative importance of 2.1%. No wooded fen or calcareous seep species were found along this transect (Table 4.20).

Table 4.20. Prairie fen species separated into MNFI prairie fen zones found along line-intercept transect five in Kirk Fen 2009.

TRANSECT 5 PRAIRIE FEN SPEICES						
SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Inundated Flat species						
Juncus brachycephalus	7	OBL	1.3	2.9	2.1	4,5
		total	1.3	2.9	2.1	
Sedge Meadow species						
Aster lanceolatus	2	FACW	2.7	2.3	2.5	3,4,7,8
Aster lateriflorus	2	FACW-	0.7	0.3	0.5	6
Carex sterilis	10	OBL	1.3	0.1	0.7	5
Cornus amomum	2	FACW+	1.3	0.8	1	2,3
Eupatorium maculatum	4	OBL	3.3	2.5	2.9	3,4,6,8
Eupatorium perfoliatum	4	FACW+	2	2.5	2.2	4,6,7
Thelypteris palustris	2	FACW+	0.7	0.7	0.7	8
		total	12	9.2	10.5	
Wooded fen		none				
Calcareous seep		none				
		total prairie fen sp	13.3	12.1	12.6	

Table 4.20. Species coefficient of conservatism (C), wetness category, total relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which species were found.

Cypripedium candidum associates

Cypripedium candidum associates in individual quadrants ranged from zero to four, with three species reported in each of quadrants four, five, and six and one species recorded on quadrants two and eight (Table 4.17). Five associate species were tallied for a relative importance of 6.3%, the lowest ranking of the five transects (Summary Table 4.56, Table 4.21).

Table 4.21. *Cypripedium candidum* associates found along line-intercept transect five in Kirk Fen 2009.

TRANSECT 5 CYPRIPEDIUM CANDIDUM ASSOCIATES						
SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Carex hystericina	2	OBL	1.3	0.1	0.7	4,6
Carex pellita	2	OBL	2.7	1.3	2	2,5,6
Carex sterilis	10	OBL	1.3	0.1	0.7	4,5
Eupatorium perfoliatum	4	FACW+	2	2.5	2.2	4,5,6
Thelypteris palustris	2	FACW+	0.7	0.7	0.7	8
		total cyp can assoc.	8	4.7	6.3	

Table 4.21. Species coefficient of conservatism (C), wetness category, relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Invasive species

Invasive species ranged from one to four in individual quadrants (Table 4.17) and were represented by nine species for a relative importance of 20.7%, sharing third rank with transect one in this regard (Summary Table 4.57). This is the only transect that *Rhamnus frangula* did not have the greatest relative importance of the non-native invasive species. *Lonicera* x*bella* had a relative importance of 7.7%, while *R. frangula* had a relative importance of 5.6% (Table 4.22).

Table 4.22. Invasive species found along line-intercept transect five in Kirk Fen 2009.

TRANSECT 5 INVASIVE SPECIES SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
LONICERA xbella	0	FACU	2.7	12.7	7.7	1,2,4,8
RHAMNUS FRANGULA	0	FAC+	4.7	6.6	5.6	2,4,7,8,9
CIRSIUM ARVENSE	0	FACU	2.7	1.4	2	6,7,8,9
RHAMNUS CATHARTICA	0	FACU	0.7	3.3	2	1
HESPERIS MATRONALIS	0	UPL	1.3	1.2	1.3	1,2
LYTHRUM SALICARIA	0	OBL	1.3	0.5	0.9	4,5
ALLIARIA PETIOLATA	0	FAC	1.3	0.3	0.8	1,2
LONICERA MAACKII	0	UPL	0.7	0.2	0.4	9
		total invasive spp	15.4	26.2	20.7	

Table 4.22. Species coefficient of conservatism (C), wetness category, (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

TRANSECT-ONE

Line-intercept transect-one is east and adjacent to transect-five, positioned perpendicular to the contour lines at nine degrees from north. Transect-one traverses the cleared phase 1 areas and Intact 1 (figure 3.2).

FQI, Mean C, floral inventory species composition, and Mean W

Native FQI is the second highest of the five transects at 30.3 with a native Mean C of 3.9; third ranking of the five transects. The floral inventory is dominated by mid-C species (47.5%) and low-C species (44.3%) with high-C species reported at 8.2%; fourth ranking of the five transects. A little over eighty-two percent of the floral inventory is represented by native species, for a relative importance of 67.1%; fourth ranking of the five transects (Summary Table 4.51). Native perennial forbs made up 43.25% of the floral inventory, for a relative importance of 38.8%. Although adventive shrubs made up only 4.1% of the floral inventory, they had a relative importance of 15.5%. Native graminoids made up 6.8% of the floral inventory, with relative importance of 4.0%; the lowest of the five transects (Table 4.23).

Table 4.23. Species type, number and percent recorded along line-intercept transect one.

	number species	percent of floral inventory		number species	percent of floral inventory
Native	**61**	**82.40%**	**Adventive**	**13**	**17.60%**
Tree	4	5.40%	Tree	1	1.40%
Shrub	8	10.80%	Shrub	3	4.10%
W-Vine	4	5.40%	W-Vine	0	0.00%
H-Vine	0	0.00%	H-Vine	0	0.00%
P-Forb	32	43.20%	P-Forb	6	8.10%
B-Forb	1	1.40%	B-Forb	2	2.70%
A-Forb	5	6.80%	A-Forb	1	1.40%
P-Grass	2	2.70%	P-Grass	0	0.00%
A-Grass	0	0.00%	A-Grass	0	0.00%
P-Sedge	3	4.10%	P-Sedge	0	0.00%
A-Sedge	0	0.00%	A-Sedge	0	0.00%
Fern	2	2.70%			

FQI ranged from 7.9 to 21.0 in individual quadrants, for an average of 13.3 with a standard deviation of 4.2. The lowest indices were seen at the northern two quadrants at 6.3 and 6.6, with a rapid increase to 21.0 at section five, dropping to 12.4 at quadrant seven, rising again to 16.8 at quadrant eight and dropping again to 11.3 at quadrant nine. Mean C ranged from 2.5 to 4.7, for an average Mean C of 3.8 with a standard deviation of 0.7. Mean C gradually increased from the north sections to a high of 4.7 in quadrant five, slightly decreasing to quadrant seven (3.6) then increasing at quadrant eight (3.8) and nine (4.0). Mean W ranged from 0.3 (FAC) to -3.4 (FACW), with the wettest area found in the transect's middle quadrants five, six, and seven (all FACW) (Table 4.24).

Table 4.24. Floristic Quality summary table for each quadrant in line-intercept transect one Kirk Fen 2009.

TRANSECT 1
QUDRANT SUMMARY

QUAD	MC	W/Ad	FQI	W/Ad	MW	WET	NS	TS	MW SEQ	PF SP	CC SP	INV SP
1	3.0	1.9	7.9	6.3	0.3	FAC	7	11	0.1	0	0	2
2	2.5	1.6	8.4	6.6	-0.1	FAC+	11	18	-0.6	0	0	4
3	3.5	2.2	11.8	9.2	-2.0	FACW-	11	18	-0.7	1	2	5
4	4.6	2.8	13.1	10.3	0.1	FAC	8	13	-1.8	2	1	5
5	4.7	4.3	21.0	20.0	-3.4	FACW	20	22	-2.2	8	7	3
6	4.2	3.7	16.8	15.8	-3.2	FACW	16	18	-3.1	10	7	3
7	3.6	2.9	12.4	11.1	-2.6	FACW	12	15	-2.3	4	3	3
8	3.8	3.1	16.8	15.3	-1.0	FAC+	20	24	-1.5	4	0	4
9	4.0	2.5	11.3	8.9	-0.9	FAC+	8	13	-1	0	0	5
AVG	3.8	2.8	13.3	11.5	-1.4	FAC+	12.6	16.9				
STD	0.7	0.9	4.2	4.6	1.4		5	4.3				

Table 4.24. Mean coefficient of conservatism (MC), mean coefficient of conservatism with adventive species (W/Ad), floristic quality index (FQI), floristic quality index with adventives (W/Ad), mean wetness index (MW), wetness category (WET), number of native species (NS), number of total species (TS), sequential mean wetness (MW SEQ), number of prairie fen species (PF SP), number of *Cypripedium candidum* associates (CC SP) and number of invasive species (INV SP).

Dominant species and high-C species

The three dominant species, by way of greatest relative importance, were non-native invasive species *Rhamnus frangula* (0), *Lonicera* spp. (0) and *Cirsium arvense* (0) This is the only transect where the three dominant species were all invasive ones (Summary Table 4.53, Table 4.25).

Table 4.25. Dominant species for line-intercept transect one in Kirk Fen 2009.

	SCIENTIFIC NAME	C	WETNESS	FRQ	COV	RFRQ	RCOV	RIV	QUADS
T1	RHAMNUS FRANGULA	0	FAC+	5	618	3.3	13.3	8.3	5 to 9
	LONICERA XBELLA	0	FACU	4	462	2.6	10.0	6.3	1,2,4, 9
	CIRSIUM ARVENSE	0	FACU	7	338	4.6	7.3	5.9	2-5, 7-9

Table 4.25. Coefficient of conservatism (C), wetness category, frequency (FRQ) cover (COV), relative frequency (RFRQ), relative cover (RCOV, relative importance (RIV) and the quadrants in which they were recorded.

High-C species were concentrated in quadrants five, six and seven, with the exception of *Aster nemoralis,* which was found in quadrant eight, but may have been misidentified and is likely *A. borealis*(9) . High-C species represented 8.2% of the floral inventory and a relative importance of 3.5%; the fourth ranking of the five transects (Summary Table 4.54, Table 4.26).

Table 4.26. Species with high coefficient of conservatism recorded along line-intercept transect one Kirk Fen 2009.

Transect	Quadrant(s)	species	W	C	RFRQ	RCOV	RIV
T1	5,6,7	Solidago ohioensis	OBL	8	2	0.6	1.3
	5,6	Hierochloe odorata	FACW	9	1.3	0.2	0.8
	8	Aster nemoralis*	OBL	10	0.7	0.3	0.5
	6	Potentilla fruticosa	FACW	10	0.7	0.4	0.5
	5	Lysimachia quadriflora	OBL	10	0.7	0.1	0.4
		total			5.4	1.6	3.5

Table 4.26. Quadrants in which High-C species were recorded, wetness category, coefficient of conservatism (C), relative frequency (RFRQ), relative cover (RCOV and relative importance (RIV). * likely *Aster. borealis* (9).

Prairie fen species

Prairie fen species ranged from zero to ten within the individual quadrants, with the highest number of species in quadrants five (9) and six (10). Transect one, with a total of seventeen species, had the highest number of the five transects, for a relative importance of 11.2%; the lowest of the five transects (Summary Table 4.55). Thirteen sedge meadow species were counted, for a relative importance of 10.1%; two inundated flat species, for a relative importance of 0.7%; and one wooded fen species, for a relative importance of 0.4%. No calcareous seep species were recorded for this transect (Table 4.27).

Table 4.27. Prairie fen species separated into MNFI prairie fen zones found along line-intercept transect one in Kirk Fen 2009.

TRANSECT 1 PRAIRIE FEN SPECIES						
SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Inundated Flat species						
Juncus brachycephalus	7	OBL	0.7	0	0.3	5
Schoenoplectus acutus	5	OBL	0.7	0.2	0.4	6
		total	1.4	0.2	0.7	5,6,7
Sedge Meadow species						
Aster puniceus	5	OBL	2.0	0.3	1.2	5,6,7
Aster lateriflorus	2	FACW-	1.3	0.1	0.7	5,6,7
Asters*	10	OBL	0.7	0.3	0.5	8
Carex stricta	4	OBL	1.3	0.3	0.8	5,6
Cornus amomum	2	FACW+	2.0	0.3	1.2	4,8
Eupatorium maculatum	4	OBL	2.6	2.6	2.6	4,5,6
Eupatorium perfoliatum	4	FACW+	2.0	3.0	2.5	3,5
Lysimachia quadriflora	10	OBL	0.7	0.1	0.4	5
Potentilla fruticosa	10	FACW	0.7	0.4	0.5	6
Pycnanthemum virginianum	5	FACW+	0.7	0.2	0.4	5
Rudbeckia hirta	1	FACU	0.7	0.1	0.4	6
Solidago ohioensis	8	OBL	2.0	0.6	1.3	5,6,7
Solidago riddellii	6	OBL	1.3	0.2	0.7	5,6
Thelypteris palustris	2	FACW+	0.7	0.2	0.4	6
		total	18.7	8.7	13.6	
Wooded fen species						
Cornus foemina	1	FACW-	0.7	0.2	0.4	8
		total	0.7	0.2	0.4	

Calcareous seep species	none					
		total prairie fen spp	20.8	9.1	14.7	

Table 4.27. Species coefficient of conservatism (C), wetness category, total relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which species were found. * Likely Aster borealis (9)

Cypripedium candidum associates

Cypripedium candidum associates in individual quadrants ranged from zero to seven with the greatest number reported in quadrants 5 and 6. Nine *C. candidum* associates were tallied, for a relative importance of 9.1%; the fourth ranking of the five transects (Summary Table 4.56, Table 4.28).

Table 4.28 *Cypripedium candidum* associates found along line-intercept transect one in Kirk Fen 2009.

TRANSECT 1 CPRIPEDIUM CANDIDUM ASSOCIATES **SCIENTIFIC NAME**	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Carex pellita	2	OBL	2	1.2	1.6	5,6,7
Carex stricta	4	OBL	1.3	0.3	0.8	5,6
Eupatorium perfoliatum	4	FACW+	2	3	2.5	4,5,6
Lysimachia quadriflora	10	OBL	0.7	0.1	0.4	5
Potentilla fruticosa	10	FACW	0.7	0.4	0.5	6
Schoenoplectus acutus	5	OBL	0.7	0.2	0.4	6
Solidago ohioensis	8	OBL	2	0.6	1.3	5,6,7
Solidago riddellii	6	OBL	1.3	0.2	0.7	5,6
Zizia aurea	6	FAC+	2	0.6	1.3	3,4,5
		total cyp can spp	12.7	6.6	9.1	

Table 4.28. Species coefficient of conservatism (C), wetness category, relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Invasive species

Invasive species ranged from two to five in individual quadrants and were represented by nine species, for a relative importance of 30.1%, the highest of the five transects (Summary Table 4.57, Table 4.29).

Table 4.29. Invasive species found along line-intercept transect one in Kirk Fen 2009.

TRANSECT 1 INVASIVE SPECIES SCIENTIFIC NAME	C	WETNESS	RFRQ	RCOV	RIV	QUADS
RHAMNUS FRANGULA	0	FAC+	3.3	13.3	8.3	5 to 9
LONICERA XBELLA	0	FACU	2.6	10.0	6.3	1,2,4,8
CIRSIUM ARVENSE	0	FACU	4.6	7.3	5.9	2 to 5,7,8,9
RHAMNUS CATHARTICA	0	FACU	2.6	7.0	4.8	2,3,4,9
HESPERIS MATRONALIS	0	UPL	2.6	2.0	2.3	1,2,3,4
ALLIARIA PETIOLATA	0	FAC	1.3	0.5	0.9	3,9
LONICERA MAACKII	0	UPL	0.7	1.1	0.9	9
LYTHRUM SALICARIA	0	OBL	0.7	0.6	0.7	6
		total invasive spp	18.4	41.8	30.1	

Table 4.29. Species coefficient of conservatism (C), wetness category, (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

TRANSECT-TWO

Line-intercept transect two is the middle transect perpendicular to the contour lines at 0.5 degree from north. It traverses the westernmost cleared phase 2 area and the east end of the 2003 Intact 1 area (figure 3.2).

FQI, Mean C, floral inventory species composition, and Mean W

Native FQI is third ranking of the five transects at 26.9, with the highest native Mean C of the five transects at 4.2. The floral inventory is dominated by mid-C species at 53.7%, with low-C species at 36.6% and high-C species representing 9.8%; the second ranking for the five transects (Summary Table 4.51). A little over eighty percent of the floral inventory is represented by native species, for a relative importance of 65.4%; the lowest ranking of the five transects. Native perennial forbs make up 45.1% of the floral inventory, for a relative importance of 35.8%. Although adventive shrubs made up only 3.9% of the floral inventory, they had the greatest relative importance of 18.5%. Native graminoids represent 2% of the floral inventory, with a relative importance of 8.4% (Summary Table 4.52, Table 4.30)

Table 4.30. Species type, number and percent recorded along line-intercept transect two.

	number species	percent of floral inventory			number species	percent of floral inventory
Native	**41**	**80.40%**		**Adventive**	**10**	**19.60%**
Tree	3	5.90%		Tree	1	2.00%
Shrub	2	3.90%		Shrub	2	3.90%
W-Vine	4	7.80%		W-Vine	0	0.00%
H-Vine	0	0.00%		H-Vine	0	0.00%
P-Forb	23	45.10%		P-Forb	6	11.80%
B-Forb	1	2.00%		B-Forb	0	0.00%
A-Forb	1	2.00%		A-Forb	1	2.00%
P-Grass	1	2.00%		P-Grass	0	0.00%
A-Grass	0	0.00%		A-Grass	0	0.00%
P-Sedge	5	9.80%		P-Sedge	0	0.00%
A-Sedge	0	0.00%		A-Sedge	0	0.00%
Fern	1	2.00%				

FQI ranged from 5.5 to 22.7 in individual quadrants. for an average of 12.9, with a standard deviation of 5.4. The 22.7 FQI was the highest recorded of the five transects. The lowest value was recorded at the northern first section at 5.5 with a gradual increase at quadrant five (12.3), a rapid increase to 21.1 at quadrant six, and rapidly decreasing to 15.8 and 13.0 at the last two quadrants. Mean C ranged from 2.8 to 5.2 (the second highest Mean C of the quadrants for the five transects) for an average Mean C of 3.9 with a standard deviation of 0.9. Mean W ranged from 1.8 (FACU+) to -3.8 (FACW+), with the wettest quadrants at five, six and seven (FACW, FACW+, and FACW respectively) (Summary Table 4.51, Table 4.31) .

Table 4.31. Floristic Quality summary table for each quadrant in line-intercept transect two Kirk Fen 2009.

TRANSECT 2
QUADRANT SUMMARY

QUAD	MC	W/Ad	FQI	W/Ad	MW	WET	W/Ad	NS	TS	MW SEQ	W/Ad	PF SP	CC SP	INV SP
1	2.8	1.4	5.5	3.9	1.8	FACU+	2.6	4	8	0.9	1.8	0	0	3
2	3.3	2.0	10.0	7.7	0.1	FAC	1.0	9	15	0.2	1.2	1	0	5
3	3.4	2.4	9.1	7.6	-1.1	FAC+	-0.1	7	10	-0.7	-0.1	1	0	4
4	3.4	2.6	10.8	9.4	-1.1	FAC+	-1.1	10	13	-1.9	-1.0	3	1	4
5	3.9	2.4	12.3	9.8	-3.4	FACW	-1.9	10	16	-2.8	-2.1	3	1	5
6	5.2	4.5	22.7	21.1	-3.8	FACW+	-3.2	19	22	-3.3	-2.4	9	10	2
7	5.2	4.4	17.2	15.8	-2.7	FACW	-2.2	11	13	-2.5	-2.1	4	5	2
8	4.1	3.9	15.5	15.0	-0.9	FAC+	-0.9	14	15	-1.8	-1.5	1	0	2
AVG	3.9	2.9	12.9	11.3	-1.4	FAC+	-0.7	10.5	14					
STD	0.9	1.2	5.4	5.6	1.9		1.9	4.5	4.2					

Table 4.31. Mean coefficient of conservatism (MC), mean coefficient of conservatism with adventive species (W/Ad), floristic quality index (FQI), floristic quality index with adventives (W/Ad), mean wetness index (MW), wetness category (WET), number of native species (NS), number of total species (TS), sequential mean wetness (MW SEQ), number of prairie fen species (PF SP), number of *Cypripedium candidum* associates (CC SP) and number of invasive species (INV SP).

Dominant species and high-C species

The three dominant species, by way of greatest relative importance, were *Rhamnus frangula* (0), *Solidago altissima* (1) and *Symplocarpus foetidus* (6). *R. frangula* relative importance was the second highest of the five transects (Table 4.31, Summary Table 4.53).

Table 4.32. Dominant species for line-intercept transect two in Kirk Fen 2009.

	SCIENTIFIC NAME	C	WETNESS	FRQ	COV	RFRQ	RCOV	RIV	QUADS
T 2	RHAMNUS FRANGULA	0	FAC+	7	1045	6.3	24.6	15.4	2 to 8
	Solidago altissima	1	FACU	7	183	6.3	4.3	5.3	2 to 8
	Symplocarpus foetidus	6	OBL	6	209	5.4	4.9	5.1	2,3,5 to 8

Table 4.31. Coefficient of conservatism (C), wetness category, frequency (FRQ) cover (COV), relative frequency (RFRQ), relative cover (RCOV, relative importance (RIV) and the quadrants in which they were recorded.

High-C species were concentrated in quadrants 6,7, and 8 and represented 9.8% of the floral inventory, with a relative importance of 7.4% (Table 4.33;, the second highest of the five transects (Summary Table 4.54).

Table 4.33. Species with high coefficient of conservatism recorded along line-intercept transect two Kirk Fen 2009.

Transect	Quadrant(s)	species	W	C	RFRQ	RCOV	RIV
T2	6,7	Carex sterilis	OBL	10	1.8	4.8	3.3
	6	Lysimachia quadriflora	FACU	10	0.9	4.1	2.5
	6	Solidago ohioensis	OBL	8	1.8	0.4	1.1
	8	Cercis canadensis	OBL	8	0.9	0.1	0.5
		total			5.4	9.4	7.4

Table 4.33. Quadrants in which they were recorded, wetness category, coefficient of conservatism (C), relative frequency (RFRQ), relative cover (RCOV), and relative importance (RIV).

Prairie fen species

Prairie fen species ranged from zero to nine within the individual quadrants, with the highest number in quadrant six (Table 4.31). A total of fourteen species were reported, for a total relative importance of 17.4%; the third highest of the five transects (Summary Table 4.55). Nine sedge meadow species were reported, for a relative importance of 16.4%, two inundated flat species for a relative importance of 1.0%, and two wooded fen species for a relative importance of 2.0%. No calcareous seep species were found (Table 4.34).

Table 4.34. Prairie fen species separated into MNFI prairie fen zones found along line-intercept transect two in Kirk Fen 2009.

TRANSECT 2 PRAIRIE FEN SPECIES SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Inundated Flat species						
Juncus brachycephalus	7	OBL	0.9	0.1	0.5	6
Schoenoplectus acutus	5	OBL	0.9	0	0.5	6
		total	1.8	0.1	1.0	
Sedge Meadow species						
Aster lateriflorus	2	FACW-	0.9	0.5	0.7	3
Aster puniceus	5	OBL	2.7	2.3	2.5	3,4,6
Aster umbellatus	5	FACW	0.9	0.5	0.7	7
Carex sterilis	10	OBL	1.8	4.8	3.3	6.7
Carex stricta	4	OBL	0.9	0.3	0.6	6
Eupatorium maculatum	4	OBL	2.7	1.2	1.9	3,4,8
Eupatorium perfoliatum	4	FACW+	3.6	5.5	4.5	3,4,6,7
Lysimachia quadriflora	10	OBL	0.9	0.1	0.5	6
Solidago ohioensis	8	OBL	1.8	0.4	1.1	6,7
Solidago riddellii	6	OBL	0.9	0.1	0.5	6
		total	17.1	15.7	16.3	
Wooded fen species						
Cornus foemina	1	FACW-	0.9	0.1	0.5	2
Physocarpus opulifolius	4	FACW-	0.9	2.2	1.5	8
		total	1.8	2.3	2.0	
Calcareous seep species						
none						
		total prairie fen spp	20.7	18.1	19.3	

Table 4.34. Species coefficient of conservatism (C), wetness category, total relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which species were found.

Cypripedium candidum associates

Cypripedium candidum associates in individual quadrants ranged from zero to ten, with associates concentrated in quadrant six (10) and quadrant seven

(5) and other quadrants reporting zero or one (Table 4.31). A total of ten associates were found, for a relative importance of 14.5%: the highest ranking of the five transects (Table 4.35, Summary Table 4.56).

Table 4.35. *Cypripedium candidum* associates found along line-intercept transect two in Kirk Fen 2009.

TRANSECT 2 CPRIPEDIUM CANDIDUM ASSOCIATES SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Carex hystericina	2	OBL	0.9	0.2	0.5	6
Carex pellita	2	OBL	1.8	1.2	1.5	6,7
Carex sterilis	10	OBL	1.8	4.8	3.3	6.7
Carex stricta	4	OBL	0.9	0.3	0.6	6
Eupatorium perfoliatum	4	FACW+	3.6	5.5	4.5	3,4,6,7
Lysimachia quadriflora	10	OBL	0.9	0.1	0.5	6
Schoenoplectus acutus	5	OBL	0.9	0	0.5	6
Solidago ohioensis	8	OBL	1.8	0.4	1.1	6,7
Solidago riddellii	6	OBL	0.9	0.1	0.5	6
Zizia aurea	6	FAC+	1.8	1.2	1.5	7
		total cyp can spp	15.3	13.8	14.5	

Table 4.35. Species coefficient of conservatism (C), wetness category, relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Invasive species

Invasive species ranged from two to five in individual quadrants (Table 4.31) and were represented by six species. for a relative importance of 29.4%; the second highest of the five transects (Table 4.36, Summary Table 4.57).

Table 4.36. Invasive species found along line-intercept transect two in Kirk Fen 2009.

TRANSECT 2 INVASIVE SPECIES SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
RHAMNUS FRANGULA	0	FAC+	6.3	24.6	15.4	2 to 8
HESPERIS MATRONALIS	0	UPL	2.7	4.8	3.7	1,2,3
CIRSIUM ARVENSE	0	FACU	4.5	1.9	3.2	2 to 6
LONICERA XBELLA	0	FACU	1.8	4.5	3.1	1,2
RHAMNUS CATHARTICA	0	FACU	2.7	2.9	2.8	1,2,5
LYTHRUM SALICARIA	0	OBL	1.8	0.6	1.2	5
		total invasive spp	19.8	39.3	29.4	

Table 4.36. Species coefficient of conservatism (C), wetness category, (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

TRANSECT-THREE

Line-intercept transect-three lies east of transect two perpendicular to contour lines at 1.5 degrees from north through the middle of the cut phase 2 area and Intact 2 (figure 3.2).

FQI, Mean C, floral inventory species composition, and Mean W

Native FQI is the highest ranking at 31.5, with a native Mean C of 4.0; the second ranking of the five transects. The floristic inventory has equal amounts of low- and mid-C species (44.3% each) with high-C species reported at 11.5%; the highest reported for the five transects (Summary Table 4.51). Percent native species and relative importance were 88.4% and 77.9% respectively; both the highest of the transects. Native forbs made up 53.5% of the inventory, for a relative importance of 47.5 and a relative cover of 42.0. Although adventive shrubs made up only 2.9% of the floral inventory, they had the second most relative importance at 11.5%. Native graminoid species represented 14.5% of the floral inventory and had a relative importance of 10.6% (Table 4.37, Summary Table 4.52).

Table 4.37. Species type, number and percent recorded along line-intercept transect two.

	number species	percent of floral inventory			number species	percent of floral inventory
Native	**61**	**88.40%**		**Adventive**	**8**	**11.60%**
Tree	1	1.40%		Tree	1	1.40%
Shrub	7	10.10%		Shrub	2	2.90%
W-Vine	4	5.80%		W-Vine	0	0.00%
H-Vine	0	0.00%		H-Vine	0	0.00%
P-Forb	31	44.90%		P-Forb	4	5.80%
B-Forb	1	1.40%		B-Forb	0	0.00%
A-Forb	5	7.20%		A-Forb	1	1.40%
P-Grass	2	2.90%		P-Grass	0	0.00%
A-Grass	0	0.00%		A-Grass	0	0.00%
P-Sedge	8	11.60%		P-Sedge	0	0.00%
A-Sedge	0	0.00%		A-Sedge	0	0.00%
Fern	2	2.90%				

FQI ranged from 7.9 to 22.2 in individual sections, with the highest average of the five transects at 14.5, with a standard deviation of 4.1. The lowest value was seen at the second quadrant at 6.3, with a steady increase to 22.2 at quadrant seven, followed by a decrease to 11.3 and a slight increase to 13.7 in the last two quadrants. Mean C ranged from 2.8 to 5.9 (the highest of the five transects) for an average Mean C of 3.9, with a standard deviation of 0.9. Mean W ranged from -0.6 (FAC+) to -3.6 (FACW+), with the wettest area at quadrant seven (Table 4.38).

Table 4.38. Floristic Quality summary table for each quadrant in line-intercept transect three Kirk Fen 2009.

TRANSECT 3
QUDRANT SUMMARY
TRANSECT 3

QUAD	MC	W/Ad	FQI	W/Ad	MW	WET	NS	TS	MW SEQ	PF SP	CC SP	INV SP
1	3.1	2.2	12.3	10.4	-1.1	FAC+	16	22	-0.8	2	0	5
2	3.0	1.9	7.9	6.3	-0.6	FAC+	7	11	-1.2	1	0	3
3	2.8	2.3	12.2	11.1	-2.0	FACW-	19	23	-1.6	1	2	4
4	3.5	3.1	13.4	12.6	-2.1	FACW-	15	17	-2.1	6	4	2
5	4.5	3.9	16.8	15.8	-2.3	FACW-	14	16	-2.4	5	3	2
6	4.2	4.0	19.2	18.8	-2.8	FACW	21	22	-2.9	10	8	1
7	5.9	5.5	22.2	21.4	-3.6	FACW+	14	15	-2.6	5	5	1
8	3.7	3.2	16.1	14.9	-1.4	FAC+	19	22	-2.8	6	5	3
9	3.8	3.1	11.3	10.3	-3.3	FACW	9	11	-2.4	3	2	2
10	4.6	3.7	13.7	12.4	-2.6	FACW	9	11	-2.9	3	1	2
AVG	3.9	3.3	14.5	13.4	-2.2	FACW	14.3	17				
STD	0.9	1.1	4.1	4.4	1.0		4.7	5				

Table 4.38. Mean coefficient of conservatism (MC), mean coefficient of conservatism with adventive species (W/Ad), floristic quality index (FQI), floristic quality index with adventives (W/Ad), mean wetness index (MW), wetness category (WET), number of native species (NS), number of total species (TS), sequential mean wetness (MW SEQ), number of prairie fen species (PF SP), number of *Cypripedium candidum* associates (CC SP) and number of invasive species (INV SP).

Dominant species and high-C species

The three dominant species by way of greatest relative importance, were low-C species *Rhamnus frangula* (0), *Aster lateriflorus* (2), and *Cirsium arvense* (0). The *R. frangula* relative importance was the second lowest of the five transects (Table 4.39, Summary Table 4.53).

Table 4.39. Dominant species for line-intercept transect three in Kirk Fen 2009.

	SCIENTIFIC NAME	C	WETNESS	FRQ	COV	RFRQ	RCOV	RIV	QUADS
T3	RHAMNUS FRANGULA	0	FAC+	9	560	5.3	10.0	7.6	1-5, 7-10
	Aster lateriflorus	2	FACW-	9	355	5.3	6.3	5.8	1, 3-10
	CIRSIUM ARVENSE	0	FACU	6	410	3.5	7.3	5.4	1-5,8

Table 4.39. Coefficient of conservatism (C), wetness category, frequency (FRQ) cover (COV), relative frequency (RFRQ), relative cover (RCOV, relative importance (RIV) and the quadrants in which they were recorded.

High-C species were concentrated in quadrants five, six, and seven and represented 11.5% of the floral inventory, for a total relative importance of 9.3%; the highest relative importance of high-C species of the five transects (Table 4.40, Summary Table 4.54).

Table 4.40 Species with high coefficient of conservatism recorded along line-intercept transect three in Kirk Fen 2009.

Transect	Quadrant(s)	species	W	C	RFRQ	RCOV	RIV
T3	4 to 8,10	Solidago ohioensis	OBL	8	3.5	5.0	4.2
	5,7	Carex sterilis	OBL	10	1.8	1.4	1.6
	6	Carex tetanica	FACW	9	0.6	2.1	1.4
	7	Potentilla fruticosa	FACW	10	0.6	0.9	0.7
	6,7	Heirochloe odorata	FACW	9	1.2	0.1	0.7
	6	Aster borealis	OBL	10	0.6	0.2	0.4
	7	Rhamnus alnifolia	OBL	8	0.6	0.1	0.3
		Total high-C spp.			8.9	9.8	9.3

Table 4.40. Quadrants in which High-C species were recorded, wetness category, coefficient of conservatism (C), relative frequency (RFRQ), relative cover (RCOV and relative importance (RIV).

Prairie fen species

Prairie fen species ranged from zero to ten within the individual quadrants, with the highest number in quadrant 6 (Table 4.38). A total of fifteen species were reported, for a relative importance of 26.4%; the highest of the five transects. Eleven sedge meadow species were reported, for a relative importance of 22.5%; two inundated flat species, for a relative importance of 1.4%; and two wooded fen species, for a relative importance of 2.5%. No calcareous seep species were found (Table 4.41, Summary Table 4.55).

Table 4.41. Prairie fen species separated into MNFI prairie fen zones found along line-intercept transect three in Kirk Fen 2009.

TRANSECT 3 PRAIRIE FEN SPECIES SCIENTIFIC NAME Inundated flat	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Juncus brachycephalus	7	OBL	0.6	0.2	0.4	5
Schoenoplectus acutus	5	OBL	0.6	1.3	1	6
		total	1.2	1.5	1.4	
Sedge meadow						
Aster borealis	9	OBL	0.6	0.2	0.4	6
Aster lanceolatus	2	FACW	2.9	1.4	2.2	2-6
Aster lateriflorus	2	FACW-	5.3	6.3	5.8	all
Carex leptalea	5	OBL	1.2	0.1	0.6	
Carex sterilis	10	OBL	1.8	1.4	1.6	7,8
Carex stricta	4	OBL	0.6	0.1	0.3	7
Cornus amomum	2	FACW+	1.8	0.3	1	4,8
Eupatorium maculatum	4	OBL	2.4	1.6	2	3,4,6,9
Eupatorium perfoliatum	4	FACW+	2.9	4.4	3.7	4,5,6,8,9
Potentilla fruticosa	10	FACW	0.6	0.9	0.7	7
Solidago ohioensis	8	OBL	3.5	5	4.2	4-8,10
		total	23.6	21.7	22.5	
Calcareous seep		none				
Wooded fen						
Cornus foemina	1	FACW-	1.2	3.1	2.1	1,6
Cornus sericea	2	FACW	0.6	0.2	0.4	6
		total	1.8	3.3	2.5	
		total prairie fen sp.	26.6	26.5	26.4	

Table 4.41. Species coefficient of conservatism (C), wetness category, total relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which species were found.

Cypripedium candidum associates

Cypripedium candidum associates in individual quadrants ranged from zero to eight, with the highest number of associates reported in quadrant eight (Table 4.38). A total of nine associates were reported, for a relative importance of 12.0%; the second highest ranking of the five transects (Table 4.42, Summary Table 4.56).

Table 4.42. *Cypripedium candidum* associates found along line-intercept transect three in Kirk Fen 2009.

TRANSECT 3 CYPRIPEDIUM CANDIDUM ASSOCIATES SCIENTIFIC NAME	C	WETNESS	RFRQ	RCOV	RIV	QUADS
Carex hystericina	2	OBL	0.6	0	0.3	6
Carex leptalea	5	OBL	1.2	0.1	0.6	6,7
Carex pellita	2	OBL	2.4	1.5	1.9	3,6,7,8
Carex sterilis	10	OBL	1.8	1.4	1.6	7,8
Carex stricta	4	OBL	0.6	0.1	0.3	7
Carex tetanica	9	FACW	0.6	2.1	1.4	6
Potentilla fruticosa	10	FACW	0.6	0.9	0.7	7
Schoenoplectus acutus	5	OBL	0.6	1.3	1	6
Solidago ohioensis	8	OBL	3.5	5	4.2	4-8,10
		total	11.9	12.4	12	

Table 4.42. Species coefficient of conservatism (C), wetness category, relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Invasive species

Invasive species ranged from one to five in individual quadrants (Table 4.38) and were represented by six species, for a relative importance of 21.2%; fourth ranking of the five transects (Table 4.43, Summary Table 4.57).

Table 4.43. Invasive species found along line-intercept transect three in Kirk Fen 2009.

TRANSECT 3 INVASIVE SPECIES SCIENTIFIC NAME	C	WETNESS	RFRQ	RCOV	RIV	QUADS
RHAMNUS FRANGULA	0	FAC+	5.3	10	7.6	all but 6
CIRSIUM ARVENSE	0	FACU	3.5	7.3	5.4	1 to 5, 8
LONICERA XBELLA	0	FACU	1.8	6	3.9	1,2,3
RHAMNUS CATHARTICA	0	FACU	1.8	2.4	2.1	1,9,10
HESPERIS MATRONALIS	0	UPL	1.2	1.9	1.5	1,3

LYTHRUM SALICARIA	0	OBL	1.2	0.1	0.7	8
		total invasive sp.	14.8	27.7	21.2	

Table 4.43. Species coefficient of conservatism (C), wetness category, (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

TRANSECT- FOUR

Line-intercept transect-four is the easternmost transect running from north to south, perpendicular to the contour lines at -10 degrees from north and traverses the easternmost section of the cut phase 2 area and the historic 1949 fen (figure 3.2).

FQI, Mean C, floral inventory species composition, and Mean W

Native FQI is lowest reported of the five transects at 21.8, with a native Mean C of 3.6, fourth ranking of the five transects (Summary Table 4.51). The floristic inventory is dominated by low-C species (52.8%), followed by mid-C species (38.9%), with high-C species reported at 8.3%; the third ranking of the five transects. Eighty percent of the floral inventory is represented by native species with a relative importance of 68.0%. Native forbs made up 40% of the floral inventory, for a relative importance of 30.7%. Although adventive shrubs make up only 6.7% of the floral inventory, they had a relative importance of 24.3%; the highest ranking of the five transects. Native graminoids represented 10.2% of the floral inventory, with a relative importance of 10.3%, (Table 4.44, Summary Table 4.52) most of which is *Carex pellita*[2].

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[2] Consult FQA reports at the Botanical Gardens for full report of species. This was a non-flowering sedge that is assumed to be *Carex pellita*.

Table 4.44. Species type, number and percent recorded along line-intercept transect four.

	number species	percent of floral inventory			number species	percent of floral inventory
Native	**36**	**80.00%**		**Adventive**	**9**	**20.00%**
Tree	2	4.40%		Tree	0	0.00%
Shrub	4	8.90%		Shrub	3	6.70%
W-Vine	4	8.90%		W-Vine	0	0.00%
H-Vine	0	0.00%		H-Vine	0	0.00%
P-Forb	17	37.80%		P-Forb	4	8.90%
B-Forb	1	2.20%		B-Forb	1	2.20%
A-Forb	1	2.20%		A-Forb	1	2.20%
P-Grass	2	4.40%		P-Grass	0	0.00%
A-Grass	0	0.00%		A-Grass	0	0.00%
P-Sedge	3	6.70%		P-Sedge	0	0.00%
A-Sedge	0	0.00%		A-Sedge	0	0.00%
Fern	2	4.40%				

FQI ranged from 9.5 to 12.8 in individual sections, with a standard deviation of 1.2 and the lowest average of the five transects at 11.4. Mean C ranged from 2.8 to 4.7, for an average Mean C of 3.6, with a standard deviation of 0.9. Mean W ranged from -0.4 (FAC) to -2.9 (FACW), with the wettest section at quadrant four (Table 4.45).

Table 4.45. Floristic Quality summary table for each quadrant in line-intercept transect four Kirk Fen 2009.

TRANSECT 4
QUDRANT SUMMARY

QUAD	MC	W/Ad	FQI	W/Ad	MW	WETINX	W/Ad	NS	TS	MW SEQ	W/Ad	PF SP	CC SP	INV SP
1	2.8	2.1	9.5	8.3	-0.4	FAC	0.3	12	16	-1.1	0.1	1	0	3
2	4.7	2.3	11.4	8.1	-1.8	FACW-	-0.1	6	12	-1.4	-0.3	0	0	3
3	3.5	2.8	11.8	10.4	-2.0	FACW-	-1.2	11	14	-2.2	-1.3	1	0	2
4	3.4	3.2	12.8	12.4	-2.9	FACW	-2.7	14	15	-2.5	-2.0	3	4	1
5	3.7	3.1	12.7	11.8	-2.5	FACW	-2.0	12	14	-2.5	-2.0	6	4	2
6	3.9	2.8	11.0	9.3	-2.1	FACW-	-1.4	8	11	-2.3	-1.9	3	0	2
7	3.0	2.8	9.9	9.5	-2.4	FACW-	-2.2	11	12	-1.8	-1.5	5	1	1
8	3.9	3.3	12.3	11.3	-1.0	FAC+	-0.9	10	12	-1.7	-1.6	3	0	1
AVG	3.6	2.8	11.4	10.1	-1.9	FACW-	-1.3	10.5	13.3					
STD	0.6	0.4	1.2	1.6	0.8		1	2.5	1.8					

Table 4.45. Mean coefficient of conservatism (MC), mean coefficient of conservatism with adventive species (W/Ad), floristic quality index (FQI), floristic quality index with adventives (W/Ad), mean wetness index (MW), wetness category (WET), number of native species (NS), number of total species (TS), sequential mean wetness (MW SEQ), number of prairie fen species (PF SP), number of *Cypripedium candidum* associates (CC SP) and number of invasive species (INV SP).

Dominant species and high-C species

The three dominant species, by way of greatest relative importance, were *Rhamnus frangula* (0), *Clematis virginiana* (4), *and Carex pellita* (2). *R. frangula* relative importance is the highest ranking of the transects, at 21.0% (Table 4.46, Summary Table 4.53).

Table 4.46. Dominant species for line-intercept transect four in Kirk Fen 2009.

	SCIENTIFIC NAME	C	WET	FRQ	COV	RFRQ	RCOV	RIV	QUADS
T4	RHAMNUS FRANGULA	0	FAC+	8	1456	7.5	34.4	21.0	all
	Clematis virginiana	4	FAC	6	304	5.7	7.2	6.4	1-4,6,8
	Carex pellita	2	OBL	3	404	2.8	9.5	6.2	3,4,5

Table 4.46. Coefficient of conservatism (C), wetness category, frequency (FRQ) cover (COV), relative frequency (RFRQ), relative cover (RCOV, relative importance (RIV) and the quadrants in which they were recorded.

High-C species were located individually in quadrants 4,5 and 8 and represented 8.3% of the transect floral inventory, for a total relative importance of 2.3%; the fourth ranking of the five transects (Table 4.47, Summary Table 4.54).

Table 4.47 Species with high coefficient of conservatism recorded along line-intercept transect four in Kirk Fen 2009.

Transect	Quadrant(s)	species	W	C	RFRQ	RCOV	RIV
T4	4	Carex sterilis	OBL	10	0.9	0.8	0.9
	5	Potentilla fruticosa	FACW	10	0.9	0.8	0.9
	8	Aster nemoralis*	OBL	10	0.9	0.1	0.5
		total			2.7	1.7	2.3

Table 4.47. Quadrants in which they were recorded, wetness category, coefficient of conservatism (C), relative frequency (RFRQ), relative cover (RCOV and relative importance (RIV). Likely *Aster borealis* (9)

Prairie fen species

Prairie fen species ranged from zero to six within the individual quadrants. The highest numbers of prairie fen species were found in quadrants five (6) and seven (5) (Table 4.45). Eleven prairie species were recorded in all, for a total relative importance of 17.7%, the second highest of the transects (Summary Table

4.55). Nine sedge meadow species were reported, for a relative importance of 13.5%, and two wooded fen species, for a relative importance of 4.2%. No inundated fen or calcareous seep species were found (Table 4.48).

Table 4.48. Prairie fen species separated into MNFI prairie fen zones found along line-intercept transect four in Kirk Fen 2009.

TRANSECT 4 PRAIRIE FEN SPECIES SCIENTIFIC NAME	**C**	**WETNESS**	**RFRQ**	**RCOV**	**RIV**	**QUADS**
Inundated flat		none				
Sedge meadow sp.						
Aster lanceolatus	2	FACW	5.7	3.6	4.6	3-8
Aster nemoralis*	10	OBL	0.9	0.1	0.5	8
Carex sterilis	10	OBL	0.9	0.8	0.9	4
Cornus amomum	2	FACW+	1.9	1.6	1.7	5
Eupatorium maculatum	4	OBL	2.8	0.9	1.9	6,7,8
Eupatorium perfoliatum	4	FACW+	1.9	0.3	1.1	5,7
Potentilla fruticosa	10	FACW	0.9	0.8	0.9	5
Solidago riddellii	6	OBL	1.9	0.5	1.2	4,5
Thelypteris palustris	2	FACW+	0.9	0.5	0.7	5
		total	17.8	9.1	13.5	
Calcareous seep sp.		none				
Wooded fen sp.						
Cornus foemina	1	FACW-	4.7	1.3	3	1,6,7
Physocarpus opulifolius	4	FACW-	0.9	1.4	1.2	7
		total	5.6	2.7	4.2	
		total prairie fen sp.	23.4	11.8	17.7	

Table 4.48. Species coefficient of conservatism (C), wetness category, total relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which species were found. *Likely *A. borealis* (9)

Cypripedium candidum associates

Cypripedium candidum associates ranged from zero to four in individual quadrants. The highest numbers were found in quadrants four and five (Table 4.45). Seven *Cypripedium candidum* associates were reported, for a relative importance at 11.5%; the third ranking of the five transects (Table 4.49, Summary Table 4.56).

Table 4.49. *Cypripedium candidum* associates found along line-intercept transect four in Kirk Fen 2009.

TRANSECT 4 CYPRIPEDIUM CANDIDUM ASSOCIATES SCIENTIFIC NAME	C	WETNESS	RFRQ	RCOV	RIV	QUADS
Carex pellita	2	OBL	2.8	9.5	6.2	3,4,5
Solidago riddellii	6	OBL	1.9	0.5	1.2	4,5
Eupatorium perfoliatum	4	FACW+	1.9	0.3	1.1	5,7
Carex sterilis	10	OBL	0.9	0.8	0.9	4
Potentilla fruticosa	10	FACW	0.9	0.8	0.9	5
Thelypteris palustris	2	FACW+	0.9	0.5	0.7	5
Carex hystericina	2	OBL	0.9	0.1	0.5	4
		total cyp can assoc.	10.2	12.5	11.5	

Table 4.49. Species coefficient of conservatism (C), wetness category, relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Invasive species

Invasive species ranged from one to three in individual quadrants (Table 4.45) and were represented by four species, for a relative importance of 26.7%; third ranking of the five transects (Table 4.50, Summary Table 4.57). The upper quadrants have the most invasive species and the highest relative importance. Both the range of invasive species in quadrants and total species were the lowest for the five transects.

Table 4.50. Invasive species found along line-intercept transect four in Kirk Fen 2009.

TRANSECT 4 INVASIVE SPECIES SCIENTIFIC NAME	C	WETNESS	RFRQ	RCOV	RIV	QUADS
RHAMNUS FRANGULA	0	FAC+	7.5	34.4	21	all
CIRSIUM ARVENSE	0	FACU	3.8	2.7	3.2	1,2,5,6
LONICERA XBELLA	0	FACU	1.9	1.8	1.9	2,3
HESPERIS MATRONALIS	0	UPL	0.9	0.3	0.6	1
		total invasive spp.	14.1	39.2	26.7	

Table 4.50. Species coefficient of conservatism (C), wetness category, (RFRQ), relative cover (RCOV), relative importance (RIV) and the quadrants in which they were found.

Table 4.51. Summary transect floristic quality information for five line-intercept transects in Kirk Fen 2009.

	FQI	MC	MW	wetness category	0 to 3	4 to 7	8 to 10	NS	TS	%NS
transect 5	26.3	3.5	-1.5	FACW-	50.00%	46.40%	3.60%	56	69	81.20%
transect 1	30.3	3.9	-1.5	FACW-	44.30%	47.50%	8.20%	61	74	82.40%
transect 2	26.9	4.2	-2.3	FACW-	36.60%	53.70%	9.80%	41	51	80.40%
transect 3	31.5	4.0	-2.0	FACW-	44.30%	44.30%	11.50%	61	69	88.40%
transect 4	21.8	3.6	-1.7	FACW-	52.80%	38.90%	8.30%	36	45	80.00%

Table 4.51. Floristic Quality Index (FQI), Mean C (MC), Mean wetness (MW), Mean wetness category, low conservative species (0-3), mid-conservative species (4-7), high conservative species (8-10), native species (NS), total species (TS), and percent native species (%NS).

Table 4.52. Physiognomy summary charts for five line-intercept transects in Kirk Fen 2009.

transect 5	**%**
PHYSIOGNOMY	**RIV**
Nt P-Forb	44.8
Ad Shrub	13.7
Ad P-Forb	6.4
Nt Shrub	6.2
Nt W-Vine	6.0
Nt A-Forb	4.9
Nt Tree	4.6
Nt P-Sedge	3.9
Nt P-Grass	3.7
Ad Tree	2.0
Ad P-Grass	1.1
Ad B-Forb	0.8
Nt Fern	0.7
Nt B-Forb	0.6
Ad A-Forb	0.5
total native	**75.4**

transect 1	**%**
PHYSIOGNOMY	**RIV**
Nt P-Forb	38.8
Ad Shrub	15.5
Ad P-Forb	12.7
Nt W-Vine	7.0
Nt Shrub	6.2
Nt Tree	5.9
Ad Tree	4.8
Nt P-Sedge	2.8
Nt A-Forb	1.9
Ad B-Forb	1.4
Nt P-Grass	1.2
Nt B-Forb	0.5
Ad A-Forb	0.4
Nt Fern	0.4
Nt Fern Ally	0.4
total native	**67.1**

transect 2	**%**
PHYSIOGNOMY	**RIV**
Nt P-Forb	35.8
Ad Shrub	18.5
Ad P-Forb	12.1
Nt W-Vine	9.9
Nt P-Sedge	6.3
Nt Tree	4.3
Ad Tree	2.8
Nt B-Forb	2.7
Nt P-Grass	2.1
Nt Shrub	2.0
Nt Fern Ally	1.6
Ad A-Forb	1.1
Nt A-Forb	0.7
total native	**65.4**

transect 3	**%**
PHYSIOGNOMY	**RIV**
Nt P-Forb	47.5
Ad Shrub	11.5
Ad P-Forb	8.1
Nt W-Vine	7.9
Nt P-Sedge	7.8
Nt Shrub	7.1
Nt A-Forb	2.9
Nt P-Grass	2.8
Ad Tree	2.1
Nt B-Forb	0.8
Nt Fern Ally	0.6
Nt Tree	0.5
Ad A-Forb	0.4
total native	**77.9**

transect 4	**%**
PHYSIOGNOMY	**RIV**
Nt P-Forb	30.7
Ad Shrub	24.3
Nt W-Vine	13.0
Nt P-Sedge	7.6
Nt Shrub	6.8
Ad P-Forb	6.2
Nt P-Grass	2.7
Nt A-Forb	2.3
Nt Tree	1.9
Nt B-Forb	1.2
Nt Fern Ally	1.1
Ad B-Forb	0.8
Ad A-Forb	0.8
Nt Fern	0.7
total native	**68.0**

Table 4.52. Relative importance (RIV).

Table 4.53. Summary of percent relative importance of dominant species along five line-intercept transects in Kirk Fen 2009.

	dom sp 1	RIV	dom sp. 2	RIV	dom sp. 3	RIV
transect 5	*Solidago altissima*	8.8	*Lonicera sp.*	7.7	*Rhamnus frangula*	5.6
transect 1	*Rhamnus frangula*	8.3	*Lonicera sp.*	6.3	*Cirsium arvense*	5.9
transect 2	*Rhamnus frangula*	15.4	*Solidago altissima*	5.3	*Symplocarpus foetidus*	5.1
transect 3	*Rhamnus frangula*	7.6	*Aster lateriflorus*	5.8	*Cirsium arvense*	5.4
transect 4	*Rhamnus frangula*	21.0	*Clematis virginiana*	6.4	*Carex pellita*	6.2

Table 4.53. Relative importance (RIV).

Table 4.54 Summary of relative importance of high conservative species along five line-intercept transects in Kirk Fen 2009.

	sp 1	RIV	sp 2	RIV	sp 3	RIV	sp 4	RIV	sp 5	RIV	sp 6	RIV	sp 7	RIV	total RIV
T 5	*Hierochloe odorata (9)*	0.8	*Carex sterilis (10)*	0.7											**1.5**
T 1	*Solidago ohioensis (8)*	1.3	*Hierochloe odorata (9)*	0.8	*Aster nemoralis * (10)*	0.5	*Potentilla fruticosa (10)*	0.5	*Lysimachia quadriflora (10)*	0.4					**3.5**
T 2	*Carex sterilis (10)*	3.3	*Cercis canadensis (8)*	2.5	*Solidago ohioensis (8)*	1.1	*Lysimachia quadriflora (10)*	0.5							**7.4**
T 3	*Solidago ohioensis (8)*	4.2	*Carex sterilis (10)*	1.6	*Carex tetanica (9)*	1.4	*Potentilla fruticosa (10)*	0.7	*Heirochloe ordorata (9)*	0.7	*Aster borealis (9)*	0.4	*Rhamnus alnifolia (8)*	0.3	**9.3**
T 4	*Potentilla fruticosa (10)*	0.9	*Carex sterilis (10)*	0.9	*Aster nemoralis* (10)*	0.5									**2.3**

Table 4.54. Relative importance (RIV). **Aster nemoralis* is possibly misidentified and likely *Aster borealis*.

Table 4.55. Summary of prairie fen species found along five line-intercept transects in Kirk Fen 2009.

PRAIRIE FEN SPP

	#PF	PFH#	FRQ	COV	RFRQ	RCOV	RIV	IF	IFRIV	SM	SMRIV	WF	WFRIV	CS
T5	8	4	20	729	13.3	12.1	**12.6**	1	2.1	7	10.5	0	0.0	0
T1	17	10	32	456	21.5	9.7	**15.3**	2	0.7	14	14.2	1	0.4	0
T2	14	9	23	764	20.7	18.1	**19.3**	2	1.0	10	16.3	2	2.0	0
T3	15	10	45	1486	26.6	26.5	**26.4**	2	1.4	11	22.5	2	2.5	0
T4	11	6	25	507	23.4	11.8	**17.7**	0	0.0	9	13.5	2	4.2	0

Table 4.55Number prairie fen species (#PF), highest number of prairie fen species found in a quadrant (PFH#), frequency (FRQ), cover (COV), relative frequency (RFRQ), relative cover (RCOV), relative importance (RIV), number inundated fen species (IF), inundated fen species relative importance (IFRIV), sedge meadow fen species (SM), sedge meadow species relative importance (SMRIV); wooded fen species (WF), wooded fen species relative importance (WFRIV), calcareous fen species (CS) found in five line-intercept transects in Kirk Fen 2009. Wetland asters counted individually.

Table 4.56. Summary of *Cypripedium candidum* associates found along five line-intercept transects in Kirk Fen 2009.

CYP CAN ASSOCIATES

	#CC	CCH#	FRQ	COV	RFRQ	RCOV	RIV
T5	5	2	12	290	8.0	4.7	**6.3**
T1	9	7	19	303	12.7	6.6	**9.1**
T2	10	10	17	584	15.3	13.8	**14.5**
T3	9	8	20	691	11.9	12.4	**12.0**
T4	7	4	11	532	10.2	12.5	**11.5**

Table 4.56. Number of *Cypripedium candidum* associates species (#CC), highest number *Cypripedium candidum* associate species found in a quadrant (CCH#), Frequency (FRQ), cover (COV), relative frequency (RFRQ), relative cover (RCOV), and relative importance (RIV) Wetland *Carex species* counted individually.

Table 4.57. Summary of invasive species found along five line-intercept transects in Kirk Fen 2009.

INVASIVE SPP

	#INV	INVH#	FRQ	COV	RFRQ	RCOV	RIV
T5	9	4	23	1571	15.4	26.2	**20.7**
T1	9	5	28	1940	18.4	41.8	**30.1**
T2	6	4	22	1671	19.8	39.3	**29.4**
T3	6	5	25	1556	14.8	27.7	**21.2**
T4	4	3	15	1660	14.1	39.2	**26.7**

Table 4.57. Number of invasive species (#INV), highest number of invasive species found in a quadrant (INVH#), frequency (FRQ), cover, relative frequency (COV), relative cover (RCOV), and
relative importance (RIV).

SUMMARY

The middle transects (one, two, and three) had the highest FQI and Mean C values reported of the five transects. These transects also typically had the highest FQI, Mean C, prairie fen species, and *Cypripedium candidum* associates and relative importance reported in individual quadrants; these generally reported in the middle quadrants. The middle and east (two, three, and four) transects had the higher percent graminoid representation on the floral inventory, as well as higher relative importance of graminoids. Mean W ranged from -1.5 to -2.3, with all transects reporting a mean wetness index of FACW- (Table 4.51), with highest wetness generally found in the middle quadrants of each transect.

Forbs dominated the physiognomy, with relative importance from 30.7% to 47.5%, with shrub next to dominate with relative importance from 11.5% to 24.3% (Table 4.52).

Percent native species ranged from 80.0% to 88.4%, with the lowest reported for transect four and the highest reported for transect three. Relative importance of native species ranged from 65% to 77.9%, with the lowest reported for transect two and the highest reported for transect three. Native forbs dominated the floral inventory and had the greatest floral physiognomy relative importance in all transects (Table 4.51).

The transect inventories were dominated by low-and mid-C species, with mid-C species dominating transects one and two, low-C species dominating transects five and four, and low-C and mid-C equally represented in transect three. The three species having the highest relative importance for each transect were low-C species, except in transect two, which had *Symplocarpus foetidus* (6) with high relative importance (5.1%) (Table 4.53 and 4.58).

Table 4.58. Dominant species in order of combined relative importance and the transects in which they were found.

Dominant species	C	RIV	Transects
RHAMNUS FRANGULA	0	57.9	all
Solidago altissima	1	14.1	5,2
LONICERA SP.	0	14.0	5,1
CIRSIUM ARVENSE	0	11.3	1,3
Clematis virginiana	4	6.4	4
Carex pellita	2	6.2	4
Aster lateriflorus	2	5.8	3
Symplocarpus foetidus	6	5.1	2

Relative importance (RIV)

Rhamnus frangula was the dominant species throughout the site, with a combined relative importance of 57.9%. Nearly all transects had *R. frangula* with the highest relative importance, the exception being transect-five where *Solidago altissima* (1) was listed as having the highest relative importance. *S. altissima* and was found in two transects as one of the three dominant species, for a relative combined importance of 14.1%. Other dominant species in order of relative importance were *Lonicera* spp. (0, 14.0%), *Cirsium arvense* (0, 11.3%), *Clematis virginiana* (4, 6.4%), a non-flowering sedge that was assumed to be *Carex pellita* (2, 6.2%), *Aster lateriflorus* (2, 5.8%), and *Symplocarpus foetidus* (6, 5.1%) (Table 4.53 and 4.58).

High-C species made up from 3.6% to 11.5% of the floral inventory, for a relative importance ranging from 1.5% to 7.9%. Transect-three had the highest percent high-C species reported in the floral inventory and the highest relative importance (7.9%) of the five transects. Transect-two ranked second for percent high-C species in the floral inventory (9.8%) and relative importance (7.4%). High-C species, in order of relative importance were, *Solidago ohioensis* (8, 6.6%), *Carex sterilis* (10, 6.5%), *Cercis canadensis* (8, 2.5%), *Hierochloe odorata* (9, 2.3%), *Potentilla fruticosa* (10, 2.1%), *Carex tetanica* (10, 5.1%), *Aster nemoralis* (10, 1.0%) (possibly misidentified and likely A. borealis), *Lysimachia quadriflora* (10, 0.9%), *Aster borealis* (10, 0.4%), and *Rhamnus alnifolia* (8, 0.3%) (Table 4.54 and 4.59).

Table 4.59. High coefficient of conservatism in order of combined relative importance and the transects in which they were found.

High-C species	RIV	Transects
Solidago ohioensis (8)	6.6	1,2,3
Carex sterilis (10)	6.5	5,2,3,4
Cercis canadensis (8)	2.5	2
Hierochloe odorata (9)	2.3	5,1,3
Potentilla fruticosa (10)	2.1	1,2,4
Carex tetanica (10)	1.4	3
Aster nemoralis (10)*	1.0	1,4
Lysimachia quadriflora (10)	0.9	1,2
Aster borealis (9)	0.4	3
Rhamnus alnifolia (8)	0.3	3

Table 4.59. Relative importance (RIV). *Likely *Aster borealis* (9).

Prairie fen species ranged from eight to seventeen and were found with the highest numbers on the middle transects one, two, and three. For all transects, the highest number of prairie fen species were found at the middle quadrants. Prairie fen relative importance ranged from 12.6% to 26.4%, with the higher relative importance of prairie fen species found in the middle and east transects two, three, and four. Prairie fen species were dominated by sedge meadow species. No calcareous zone species were reported for the five transects (Table 4.55).

Cypripedium candidum associates ranged from 5 to 10 and were found with the highest numbers in the middle quadrants of transect two. Relative importance of *C. candidum* associates ranged from 6.3% to 14.5% with the greatest along transects-two and –three (Table 4.56).

Invasive species ranged from four to nine, with the west transects five and one each reporting nine species. Invasive relative importance ranged from 20.7% to 30.1%, with the highest relative importance of invasive species found along transect-one. *Rhamnus frangula* (57.9%) was the most prominent species, by way of relative importance, and ubiquitous, as mentioned in the paragraph on dominant species. Other invasive species, in order of relative importance, were *Cirsium arvense* (19.7%), *Rhamnus cathartica* (11.7%), *Hesperis matronalis* (9.4%), *Lonicera* spp. (9.3%), *Lythrum salicaria* (3.5%) and *Alliaria petiolata* (1.7%) (Table 4.57 and 4.60). In upland quadrants, *R. cathartica* assumed highest relative importance, along with other upland invasive species *Lonicera* spp., *Hesperis matronalis* and *Alliaria petiolata*. *Lythrum salicaria* was found in the middle wetter quadrants.

Table 4.60. Invasive species in order of combined relative importance and the transect in which they were found.

Invasive species	RIV	Transects
RHAMNUS FRANGULA	57.9	all
CIRSIUM ARVENSE	19.7	all
RHAMNUS CATHARTICA	11.7	5,1,2,3
HESPERIS MATRONALIS	9.4	all
LONICERA SPP.	9.3	all
LYTHRUM SALICARIA	3.5	5,1,2,3
ALLIARIA PETIOLATA	1.7	5,1

Relative importance (RIV)

Transect-three, which runs through the middle of the cut phase 2 area and Intact 2, has the greatest portion of quadrants within the 1949 boundaries and ranked the highest for FQI, Mean C, Mean W, prairie fen species relative importance, percent native species, native species relative importance, and percent graminoids and relative importance. It shared the highest number of native species (61) with transect-one, shared second rank for *Cypripedium candidum* associate numbers and ranked second for *C. candidum* associate relative importance. Transect-three also had the highest number and relative importance of high-C species, and although three low-C species were dominant, their relative importance was the lowest of the five transects. Additionally, transect-three had the second lowest relative importance of *Rhamnus frangula* and the second lowest combined relative importance of invasive species. Furthermore, transect-three quadrants had greater total and native species, the highest average total and native species, and although it shared with transect one the highest number of prairie fen species in a quadrant, transect three had a higher prairie fen species mean. Additionally, transect-three *Cypripedium candidum* associate numbers for individual quadrants were not the highest but the average shared highest ranking. Transect-three by all measures rated overall the highest of the five transects.

In comparison, transect-one, which runs through the middle of the cut phase 1 area and Intact 1, had some important high qualities: FQI and Mean C similar to transect three; higher species diversity; and distribution of low-C, mid-C, and high-C show mid-C dominance. However, transect-one had lower high-C percentage, low percent and relative importance of graminoids, and ranked fourth and third for relative importance of total native species, high-C species, prairie fen, and *Cypripedium candidum* associates. Additionally, transect-one has the highest relative importance of invasive species. However, transect-one had the highest number of prairie fen species reported for a quadrant, with the highest average prairie fen species, the third highest number reported for *Cypripedium candidum* associates and had an average *C. candidum* associate similar to that of transect three. Therefore, although the floral inventory attributes show high quality, the relative importance of species demonstrate low site quality. The reports of prairie fen species and *C. candidum* associates are promising and with further restoration this transect should increase in quality.

Transect-two, which runs between the intact areas, has the highest Mean C, is strongly mid-C dominated in the floral inventor,; has the highest relative importance of *Cypripedium candidum* associates, the second highest relative importance of high-C species, prairie fen species and percent graminoid species; and shares second rank for number of *C. candidum* associates. However, it ranks third and fourth for FQI, percent and relative importance of native species and graminoids, and has the second highest relative importance of invasive species. Ttransect one shows a mixture of qualities and shows promise to be of high quality with further restoration efforts to decrease woody invasive species.

Transect-five, which runs through the westernmost section and only has a portion of its transect within the 1949 boundary, has mixed qualities like transect-two but is generally lower in rankings. Results for transect-two showed it ranking second in relative importance of native species; third for percent native species; fourth for FQI and Mean C; and fifth for high-C relative importance, prairie fen species number and importance, *Cypripedium candidum* number and relative importance; and it had the second highest low-C dominance of the five transects.

However, transect-five also had the lowest relative importance of invasive species.

Transect-four, which runs through the easternmost section of the cleared phase 2 section and borders the non-cleared section, ranked the lowest in FQI, fourth for Mean C and relative importance of high-C species, third for native species relative importance and *Cypripedium candidum* associate, had the highest percent low-C species and the highest relative importance of *Rhamnus frangula*; was third overall for invasive species relative importance and had the lowest total and native species diversity. Although this is the lowest ranking transect, the supposition is that because it runs along the un-cleared section, attributes are low. Because it runs through the easternmost section of the 1949 boundaries, further restoration should improve floristic quality.

COMPARING TRANSECT DATA TO FLORISTIC INVENTORIES, DOMINANCE SURVEYS, AND *CYPRIPEDIUM CANDIDUM* SURVEYS

Generally speaking the data generated from the floristic inventory and dominance survey, and to some degree the *Cypripedium candidum* survey, produced a similar site impression of relative floristic quality, response to restoration and floral patterns as the line-intercept transect data. Quadrants in the middle sections of the transects had the highest attributes of Mean C, native species numbers, prairie fen species, *Cypripedium candidum* associates, and showed the wettest indexes and categories; the same as what was reported from the results of the floristic survey and dominance surveys. What the transect report supplied that the other means of surveillance did not was the relative importance of all species and complexes of species. However, the dominance survey does give us an indication of the relevance of high-C species, by way of frequency and dominance, but only for the three most prevalent species, with the supposition that the other high-C species were lower in frequency and dominance. And, the dominance survey does give invasive species relative importance through the frequency and cover data of all invasive species, whereas the transect method missed some species. Additionally, though the transect method identifies wetness to a more precise degree, the *C. candidum* site survey and floral inventories of the areas do give a strong indication of wetness. Furthermore, although the line-intercept transect method recorded some species that the area inventories did not record, the number of species recorded on the inventories not recorded on the transects were four times greater and included some important high-C, prairie fen, and *Cypripedium candidum* associates that were not accounted for in the transect inventories (Table 4.61 and 4.62).

Table 4.61 – Species recorded on 2009 line-intercept transects but not on 2008/2009 inventories in Kirk Fen.

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Aster borealis	9	-5	OBL	Nt P-Forb
Aster laevis	5	5	UPL	Nt P-Forb
Carex stricta	4	-5	OBL	Nt P-Sedge
Circaea alpina	4	-3	FACW	Nt P-Forb
Circaea lutetiana	2	3	FACU	Nt P-Forb
CONVOLVULUS ARVENSIS	0	5	UPL	Ad P-Forb
Fraxinus nigra	6	-4	FACW+	Nt Tree
Galium aparine	0	3	FACU	Nt A-Forb
Galium palustre	3	-5	OBL	Nt P-Forb
Geranium maculatum	4	3	FACU	Nt P-Forb
OXALIS CORNICULATA	0	3	FACU	Ad P-Forb
Phryma leptostachya	4	5	UPL	Nt P-Forb
Pilea pumila	5	-3	FACW	Nt A-Forb
POLYGONUM PERSICARIA	0	-3	FACW	Ad A-Forb
Potentilla norvegica	0	0	FAC	Nt A-Forb
Prunus virginiana	2	1	FAC-	Nt Shrub
Rubus hispidus	4	-3	FACW	Nt Shrub
RUMEX CRISPUS	0	-1	FAC+	Ad P-Forb
Salix amygdaloides	3	-3	FACW	Nt Tree
Smilacina racemosa	5	3	FACU	Nt P-Forb
SONCHUS OLERACEUS	0	3	FACU	Ad A-Forb

Table 4.62 – Species missed on 2009 line-intercept transects but recorded on 2008/2009 inventories in Kirk Fen

SCIENTIFIC NAME	C	W	WETNESS	PHYSIOGNOMY
Acer saccharum	5	3	FACU	Nt Tree
Agropyron trachycaulum	8	0	FAC	Nt P-Grass
Andropogon gerardii	5	1	FAC-	Nt P-Grass
Andropogon scoparius	5	3	FACU	Nt P-Grass
Anemone virginiana	3	5	UPL	Nt P-Forb
Asclepias incarnata	6	-5	OBL	Nt P-Forb
Aster ericoides	3	4	FACU-	Nt P-Forb
Aster firmus	4	-5	OBL	Nt P-Forb
Aster pilosus	1	2	FACU+	Nt P-Forb
Carex granularis	2	-4	FACW+	Nt P-Sedge
Cuscuta gronovii	3	-3	FACW	Nt A-Forb
DACTYLIS GLOMERATA	0	3	FACU	Ad P-Grass
ELAEAGNUS UMBELLATA	0	3	FACU	Ad Shrub
Eleocharis rostellata	10	-5	OBL	Nt P-Sedge
EUONYMUS ALATA	0	5	UPL	Ad Shrub
Eupatorium perfoliatum	4	-4	FACW+	Nt P-Forb
Fraxinus nigra	6	-4	FACW+	Nt Tree
Gentianopsis crinita	8	-4	FACW+	Nt A-Forb
Helianthus giganteus	5	-3	FACW	Nt P-Forb
Iris virginica	5	-5	OBL	Nt P-Forb
Juglans nigra	5	3	FACU	Nt Tree
Juncus dudleyi	1	0	FAC	Nt P-Forb
Juncus effusus	3	-5	OBL	Nt P-Forb
Lobelia kalmii	10	-5	OBL	Nt P-Forb
LONICERA TATARICA	0	3	FACU	Ad Shrub
MEDICAGO LUPULINA	0	1	FAC-	Ad A-Forb
Mentha arvensis	3	-3	FACW	Nt P-Forb
Muhlenbergia glomerata	10	-4	FACW+	Nt P-Grass
Oenothera biennis	2	3	FACU	Nt B-Forb
Oxypolis rigidior	6	-5	OBL	Nt P-Forb
Parnassia glauca	8	-5	OBL	Nt P-Forb
PRUNELLA VULGARIS	0	0	FAC	Nt P-Forb
Prunus serotina	2	3	FACU	Nt Tree
Quercus macrocarpa	5	1	FAC-	Nt Tree
Ranunculus hispidus	5	0	FAC	Nt P-Forb
Ranunculus recurvatus	5	-3	FACW	Nt A-Forb
Ribes cynosbati	4	5	UPL	Nt Shrub
ROSA MULTIFLORA	0	3	FACU	Ad Shrub
Salix bebbiana	1	-4	FACW+	Nt Shrub
Salix pedicellaris	8	-5	OBL	Nt Shrub
Salix petiolaris	1	-4	FACW+	Nt Shrub
Sambucus canadensis	3	-2	FACW-	Nt Shrub
Sanguinaria canadensis	5	4	FACU-	Nt P-Forb
Scirpus atrovirens	3	-5	OBL	Nt P-Sedge
Sium suave	5	-5	OBL	Nt P-Forb

SONCHUS ASPER	0	0	FAC	Ad A-Forb
Tilia americana	5	3	FACU	Nt Tree
Toxicodendron vernix	6	-5	OBL	Nt Shrub
Triglochin palustris	8	-5	OBL	Nt P-Forb
TYPHA ANGUSTIFOLIA	0	-5	OBL	Ad P-Forb
Typha latifolia	1	-5	OBL	Nt P-Forb
Ulmus americana	1	-2	FACW-	Nt Tree
Valeriana ciliata	10	-5	OBL	Nt P-Forb
Verbena urticifolia	4	-1	FAC+	Nt P-Forb
Vitis aestivalis	6	3	FACU	Nt W-Vine

QUESTIONS THIS STUDY RAISES

The concern of a greater response of common fen species over rare and state threatened species after woody species removal needs to be examined. Early succession response of herbaceous weed stage has been reported (Schwartz and Whitson 1987) and 66.7% of "climax" fen species had re-vegetated an exposed fen substrate after 8 years (Bowles et al 1996 reporting on Zimmerman 1983), however, some important questions need further examination so response of vegetation in this and related situations can be fully understodd.

1) Is the difference of recovery of species just an indication of asynchronous response to changes in ground water levels (Large et al 2007)?
2) Did the rapid decomposition of woody underground root structure alter the nutritional load or mycorrhizal population, impacting floral response (Shefferson et al. 2005, Wardle et al. 2004, Zobel et al. 1997, Smith et al. 1999, Callaway et al 2003, Castelli and Casper 2003)?
3) Is there a disruption of a soil community feedback on the plant community (Bever 2003)?
4) Is the soil degraded from evapo-transpirational loss, and if so to what degree, how long will it take to return to historic structure and composition, and how will this effect long-term succession in Kirk Fen?
5) Is the 3.8% to 20% presence of invasive woody species contributing to the lack of recovery of high-C and state threatened floral species?

6) Has the *Cypripedium candidum* population disappeared and/or have been in dormancy too long to re-emerge ((Nicole' et al (2005) and Shefferson et al 2003)?
7) Was the seed bank of conservative species or compromised?
8) Have adjacent septic systems in the upper topography affected nutrient load (van der Hoek & Sykora 2006, Amon et al 2002, Bedford and Godwin 2003)?
9) Have the banks of Kirk Brook incised to a point where drainage rate has increased effecting peat decomposition and mineralization and consequent eutrophication, resulting in a shift in species composition (van der Hoek & Sykora 2006, Amon et al 2002, Bowles et al 2005)?
10) Has the ground water recharge interruption from the recent (last 25 years) commercial and residential development affected Kirk Fen's hydrologic character (Bowles et al 2005, Amon el al 2002, van der Hoek & Sykora 2006, Amon et al 2002)?
11) Could the impact on the remaining intact portion of the fen and the rare species therein have been lessened by doing the restoration in smaller increments?
12) Is deer browse deterring some species return?

RESTORATION PRACTICES IN PRAIRIE FENS BASED ON THIS STUDY

Taking in consideration the response to the restoration management in Kirk Fen and the above questions, I wonder if the haste in which this area was cleared of woody species and the disturbance from clearing in such a short period may have set back the recovery and negatively affected higher conservative coefficient species. For future restoration projects, in such a sensitive setting as a prairie fen, I would suggest a slower and more methodical approach. Perhaps the original intent of clearing the intact areas and outward should have been more closely adhered to and administered more slowly. The response of the area of the second clearing may be due to inherently higher quality site characteristics or due to the two-step process in which woody species were cleared, a less invasive approach . For the future clearing of the areas within the 1949 boundaries and the areas surrounding (refer the chapter five), I suggest less cutting per year and the two-step approach of cutting one dormant season and returning a second dormant season to re-cut and herbicide. This may allow seeds to respond to the added light of the initial cutting and seedlings to grow for a season before soil dynamics are disrupted from decomposition. Even though clearing took place in winter when the soil was mostly frozen, some disturbance from foot traffic may have resulted. By clearing a lesser amount, the disturbance from foot traffic may be reduced.

V. Call for Future Activities in Kirk Fen

This chapter addresses the opportunity for future activities and has four sections: 1) literature review, 2) call for future monitoring activities, 3) call for future restoration activities, 4) call for Kirk Brook Catchment mitigation and protection, Kirk Brook re-sedimentation, and ground water monitoring, and 5) call for public access and prairie fen education.

Literature Review

This literature review covers a) site isolation and uniqueness of individual fens, b) short-term and long-term succession in fire-dependent ecosystems, c) ground water influences on succession and trajectory, d) monitoring and long-term research, e) fire management, and e) impact of white-tailed deer in ecosystems related to prairie fens and Cypripedium species and the use of exclosures.

Site isolation and uniqueness of individual fens

Because of the bio-geomorphic context in which fens occur (landscape setting, substrate genesis, hydrologic regime, chemical parameters of water and soil, and vegetative characteristic) each fen is unique and it may not be possible to describe the expected plant community for an individual fen (Amon et al. 2002). Even with meeting all the structural and functional goals of restoration, the restored site may not reflect the model system or idealized fen (van Diggelen and

Marrs 2003). Immigration of species from adjacent sites is often inefficient under natural conditions due to the fragmented nature of the landscape (Nekola 1999; Van Diggelen and Marrs 2003).

Diversity of plant communities varies conversely with isolation and community composition is strongly influenced by proximity of source; geographically isolated fens are likely to have lower species richness than those that are close together (Nekola 1999; Bedford and Godwin 2003). Climate further contributes to floristic uniqueness (Large et al. 2007). Therefore, a direct correlation of unique floral characteristics with increased distance between similar wetland systems is to be expected. Because of the isolated pockets of unique geo-morphological and hydrological conditions that make fen habitats possible, it is likely that fens have always had unique flora within a larger matrix of typical fen species (Large et al. 2007). Contemporary fragmentation increases the distinctive floral component found in fens (Nekola 1999) and rare and endangered species may not be present when expected (Amon et al. 2002). Furthermore, Nekola states that immigration rates cannot be maintained at pre-settlement levels and that the probability that species will be able to reestablish themselves following local extinction is low, with the ultimate effect of severely decreased number of species. Additionally, although there is a strong positive relationship between species richness and habitat size, it is reported that only 6.3% of the variance in fens species richness is accounted for by the size of the habitat (Nekola 1999).

SHORT- AND LONG-TERM SUCCESSION IN FIRE DEPENDENT ECOSYSTEMS

It has been reported that a flush of native species appears in a fire-suppressed fen two seasons after a prescribed burn (Middleton et al. 2006). Significant temporal changes occurred throughout a fen after six years of fire management that paralleled the known fire effects on grassland (Bowles et al. 2003). Successional change in a reconstructed prairie in Iowa showed three developmental phases: a three-year herbaceous weed stage, a five-year perennial grassland stage, and an early prairie stage (Schwartz and Whitson 1987). It was also reported that that 66.7% of “climax” fen species had re-vegetated an exposed fen substrate after eight years (Zimmerman 1983 cited by Bowles et al. 1996). Although the Kirk Fen restoration project is based on relieving stresses to a rudimentary yet intact site, knowing this pattern of weedy to early prairie succession in a reconstruction project may help management to respond, rather than reac,t to resulting weedy successional species.

GROUND WATER INFLUENCES ON SUCCESSION AND TRAJECTORY

Fens are ground water-driven systems and their structure and function within the landscape are strongly influenced by the amount and content of ground water discharge to the plant root zone. Continuous ground water input stabilizes water levels, maintains saturation in the root zone, is essential for the anoxia driven accumulation of organic material, and moderates soil temperature (Amon el al. 2002; Bowles et al. 2005). Changes in water levels can lead to significant changes in vegetation. The extent of the shift in species composition depends primarily on the drainage intensity and secondarily on micro-topography (van der Hoek and Sykora 2006). Changes to ground water levels can occur from impediment of ground water recharge and/or drainage of the system (Amon et al. 2002).

Drainage or reduced input rates may result in peat decomposition and mineralization and consequent eutrophication, resulting in a shift in species composition (Amon et al. 2002; Bowles et al. 2005; van der Hoek and Sykora 2006). An alternative scenario under these conditions is for a site to become more oligotrophic as acidification and leaching from rainwater plus the drying out of peat soils from the lowered water table eventually produce a non-fen successional environment (Amon et al. 2002). Drained fens in some areas have shifted to fen meadows (Middleton et al. 2006) and therefore species found in the resulting area may be largely those of the sedge meadow zone complex. In Michigan, lowered ground water levels in fen systems are reported to result in shrub-carr ecosystem (Spieles et al. 2010) when fires are suppressed. Sedge meadows within a calcareous fen are characterized by subsurface ground water table, high organic content and cation exchange capacity, low magnesium and sodium levels, high total calcium, low species richness, and greater vegetation height with lower light transmittance (Amon et al. 2002).

It is characteristic of fens to have a continuous input of low nutrient water, providing adequate but not superfluous nutrient supply over the growing season (Amon et al. 2002). Along with mineral-rich water, the low availability of nitrogen and phosphorous determines distinctive floral characteristics (Bedford and Godwin 2003). Therefore, cultural eutrophication threatens the structural and functional integrity of fens. Although it is suggested that phosphorous limitation (due to adsorption) would control the increased fertility from additional nitrogen concentration in ground water discharge (Boyer and Wheeler 1989), caution is given for any agricultural and septic leakage to fen systems (Amon et al. 2002; Bedford and Godwin 2003). Nutrient addition from leaking septic tanks and drain fields is suspected of contributing to the dominance of invasive species such as *Typha angustifolia* (narrow-leaved cat tail), *Phragmites australis* (reed canary grass), and *Lythrum salicaria* (purple loosestrife) (Panno et al. 1999 cited in Spieles et al. 2010).

MONITORING AND LONG-TERM RESEARCH

Although monitoring may be interpreted to be strictly driven by management goals, there are many calls for long-term monitoring and data collection in order to gain a more thorough knowledge of the interrelated components of fen systems and an integrated understanding of the structure and function of wetland habitats (Amon et al. 2002; Bowles et al. 2005; Large et al. 2007; Spieles et al. 2010). Goal-directed monitoring can be useful to guide management decisions and directly measure success of actions taken. Surveillance of site changes and observation of trends over time can have a significant impact on fens restoration greater understanding. Long-term monitoring, especially of hydrological dynamics and vegetative response over ecologically significant time scales, is very important (Large et al. 2007). Such research would give a greater understanding to plant community trajectories, while also supplying the natural areas manager information to develop ecologically appropriate strategies for the site. Furthermore, there is a tendency to rely on floral inventories alone to assess success or failure without a total understanding of the underlying factors that influence plant assemblages. Some species may exhibit substantial inertia to regime change and these responses can be species-specific and therefore floristic response may not by synchronous with change in water level, and, individual species relationships to moisture are not always easily identifiable (Large et al. 2007). Additionally individual fens may contain rare indicator species that may be useful on a local basis but not over the whole region, and absence of these should not be used to define the absence of a fen (Amon et al. 2002). Soil chemistry, soil water chemistry, ground water levels both from a fixed datum as well from the true datum (soil level), ground water flow rates, recharge, and discharge will all help develop a clearer picture of the dynamics of the ecosystem (Amon et al. 2002; Large et al. 2007).

FIRE MANAGEMENT

This part of the literature review looks at a) prairie fens as fire-dependent ecosystems historically, b) effects of fire frequency on succession and ecosystem trajectory, c) the effect of timing and scale of prescribed burns on vegetation and fauna, and d) conclusions.

Prairie fens as historically fire-dependent ecosystems

North American Indians increased the fire incidence in many ecosystems by adding regularly occurring fires to natural lightning fires (Saur 1944 and Stewart 1951 and 1956 cited by Vogl 1969). Fire has long been accepted as a natural disturbance in prairie fens. Moran (1981) states that because dominant fen grasses were contiguous with prairie grasses on the uplands, it seems reasonable to assume that before European settlement, these fens burned, as did the surrounding prairies and savannas. Early settlers also burned areas to keep vegetation fresh for grazing domestic stock and for hunting game. He further quotes Curtis (1959) as stating, “fire is a natural agent maintaining fens”. Therefore fire in North-American fens can be considered a natural disturbance (Middleton 2006) and should play an important role in both the preservation and evolution of wetland ecosystems (Choen 1994, Kushland 1990, and Wade et al. 1980 all cited by Smith et al. 2001).

Due to fire suppression, the contemporary structure for prairie fens reflects a system without fire and the resulting vegetation is influenced primarily by hydrology (Spieles et al. 2010). The available research literature cites many benefits regarding fires in fens, sedge meadows, and prairies. Periodic fires retard and reverse succession of fens toward a shrub-carr ecosystem (Spieles et al. 2010). Establishment and growth of prairie species are stimulated when fire removes litter and creates patch disturbances through varying fire intensities across a site (Hulbert 1969 and 1988, Biondini et al. 1989, Collins 1989, and Evens et al. 1989 all cited by Bowles et al. 2003). Fire can give fire-adapted native species a competitive advantage over many exotics that have not adapted to fire (Blumenthal et al. 2005 and Suding and Gross 2006 cited by Middleton et al. 2010). Fire has been suggested as being particularly important for maintaining herbaceous species and species richness patterns in sedge meadows and fens (Bowles et al. 1996, Kost and De Steven 2000, and Clark and Wilson 2001, all cited by Middleton 2002). Without fire, fens begin to lose biodiversity. *Cypripedium candidum* is known to be stimulated by fire (Swink and Wilhelm 1994 cited by Bowles 1996). Fire, too, can be valuable tool for increasing suitable habitat for some fauna (MWPARC 2009), including the state- threatened eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) (Lee and Legge 2000) and the Michell's satyr (*Neonympha mitchellii mitchellii*), a federally and state endangered butterfly that seems to be restricted to calcareous wetlands including prairie fens and sedge meadows (Lee 2000). Although van Diggelen et al. (2006) caution us that there are still many uncertainties about the role of fire in managing fens and floodplains, they suggest that most fens and floodplains may not capable of surviving without regular human intervention and that abandonment can lead to shrub invasion (Jensen 1998 cited by van Diggelen et al. 2006).

Effect of fire frequency on succession and ecosystem trajectory

Adding fire to fens is certain to change both the pattern of species within a site as well as the site's trajectory over time. The changes within a site from fire management are principally due to frequency and timing of fires. Species richness and patterns are influenced by fire frequency so that fire may be particularly important for maintaining herbaceous species in sedge meadows and fens (Bowles et al. 1996; Kost and De Steven 2000; Clark and Wilson 2001).

Impacts of frequent fires may include vegetation shift to that of greater graminoid cover, less forb frequency within the site, and overall lower diversity after eight consecutive dormant-season prescribed burns (Bowles et al. 1996). Lower frequency of prescribed burns is likely to regulate graminoid dominance by keeping forbs within the greater vegetation matrix (Bowles et al. 1996). However, "typical" forb fen species, because of their transient or short-term persistent seed, may not contribute to the seed bank as much as the persistent seed of *Carex* species, therefore, even with lower frequency of fire, a graminoid dominant community may result until subsequent migration can occur from intact sites within the fen (Large et al. 2007). Temporal changes in a fen after six years of fire management included loss of alien species and gain of prevalent fen species with a cumulative effect of changes in cover rather than species frequency.

The effect of timing and scale of burns on vegetation and fauna

Timing of fires can have a profound impact on vegetation and herpetofauna. Early spring burns are reported to stimulate seed germination and aid in the establishment and development of forbs (Isselstein et al. 2002), control *Phalaris arundinacea* (reed canary grass) in a wet mesic sandy loam habitat (Howe 2000), reduce the abundance of alien cool season grasses in prairies (Svedarsky et al. 1986, Abrams and Hulbert 1987, and Henderson 1992, all cited by Bowles et al. 2003), and favor C4 grasses (Howe 1994b, Hulbert 1986 and 1988, Steuter 1987, Anderson 1990 all cited by Howe 2000,) including *Andropogon gerardii* (big blue stem grass) and *Sorghastrum nutans* (Indian grass) in a tall grass prairie (Town and Kemp 2008). One prairie, after a spring burn, was two times more productive than August-burned and unburned plots in a wet-mesic sandy loam prairie (Howe 2000). However, another report stated that spring burns did not significantly increase species richness and diversity or increase sedges in a tall grass prairie (Towne and Kemp 2008). Yet another report states that spring burns may temporarily delay sedge growth (Warners 1997). Late spring burns should be done cautiously, in that they were reported to negatively impact early flowering forbs (Towne and Ownesby 1984 cited by Bowles et al. 2003). Additionally, since the massasauga comes out of hibernation and is active from April to late October in Michigan (Lee and Legge 2000), caution is given to avoid burns after the first of April to avoid mortality of this threatened species (Lee and Legge 2000; MWPARC 2009).

Growing season burns tend to be more variable in intensity and "patchy," (Howe 2000) increasing diversity as a result. They have been proposed as a potential tool to increase species heterogeneity (Town and Kemp 2008), temporarily suppress dominant vegetation and increase biodiversity in prairies (Howe 1999 and 2000), help control woody species (Anderson 1990 cited by Kost and De Steven 2000; Bowles et al. 1996), and selectively remove undesirable species in native grasslands (Grace et al. 2001, Emery and Gross 2005, both cited by Simmons et al. 2007). They have been reported to increase *Andropogon* *gerardii* and *Sorghastrum nutans* in a tall grass prairie in Kansas (Town and Kemp 2008) and may bolster perennial forb abundance (Warners 1997; Kost and De Steven 2000). Howe (2000) reported that mid-summer fires were found to favor C3 grasses, with a net result of a mix of C3 and C4 grasses in experimentally sown plots. This result supports Town and Kemp (2008) who stated that growing season burns did not suppress warm season grasses. Additionally, Town and Kemp (2008) reported that although growing season burns increased asters and sedges, most perennials were neutral in response and did not preferentially encourage spring blooming plants. Late season burns controlled *Phalaris arundinacea* in experimentally sown wet mesic, sandy loam plots (Howe 2000). Because fires through the green growth tend to be slower, such fires may allow refugia for herpetofauna (MWPARC 2009). It was suggested that infrequent growing-season burns, especially under drought conditions, might especially provide the disturbance necessary to reduce the importance of vigorous graminoid species and promote colonization by forbs, enhancing community diversity and richness (Bowles et al. 1996). However, a growing season burn in an oak savanna in the Indiana Dunes National Lakeshore had a significant negative effect on the number of flowering stems and total number of flowers of forbs (Pavlovic et al. 2010). Two publications had cautionary reports concerning growing season burns. Simmons et al. (2007) reported that the abundance of *Solidago canadensis* increased after late growing season fires in two Texas prairies (Simmons et al 2007) and suggest that intense growing season burns may promote invasion of alien species.

The dormant season have been the most typical time of prescribed fire but it is also the most controversial. Although a single dormant season fire in a sedge meadow in southern Wisconsin stimulated flowering and seed set of herbaceous species, significantly increased biomass and cover of perennials forbs, and stimulated the appearance of species that had not been observed in twenty years, alien species showed a slight increase (Middleton 2002). In contrast, after four burns in six years, Bowles et al. (1996) reported that increased frequencies of graminoid species, decrease of forb species, and a loss of alien species occurred. Clark and Wilson (2001) also reported a loss in cover of non-native species as well as an increase in native species cover from two fall burns. Additionally, Bowles et al. (1996) demonstrated an increase of *Andropogon gerardii* and gain of prevalent fen species, while also reporting that some late-successional graminoid fen species had not yet appeared in the disturbed graminoid fen, *Typha latifolia* (broadleaf cattail) increased, *Solidago ohioensis* (Ohio goldenrod) mean percent cover decreased and total species richness decreased from 33 to 16 species.

For woody species control, further differences among dormant season burns exist. Middleton (2002) reported no control on *Cornus sericea* (*C. sericea*) after one dormant season burn. Bowles et al. (1996) reported four consecutive dormant season burns did not control *Cornus racemosa* and that dormant season burns may be less successful in controlling woody vegetation. Van Diggelen et al. also reported that shrubs were not controlled in fens. Conversely, Clark and Wilson (2001) reported that although the few studies they reviewed in wetland prairies show inconsistent responses by woody species to fire (Acker 1991, Streatfeild 1995, Pendergrass 1996, Clark and Wilson 1998, all cited by Clark and Wilson 2001), reduction of woody species cover was noted in a wetland prairie after one October burn followed by a September burn two years later. Additionally, they reported significantly fewer shrubs survived after the first burn. An October burn successfully controlled buckthorn seedlings as large as 7/8" tall in a wet mesic location at the University of Michigan Botanical Gardens (personal observation).

For herpetofauna, dormant season burns are preferred, given that eastern massasauga rattlesnakes are less vulnerable to fire between November 1 and March 1 while they are hibernating underground (Lee and Legge 2000; MWPARC 2009).

For dormant season burns, it seems apparent that the frequency of burns may a key factor. Although dormant season burns may be useful tools to use as part of a mix burns targeting seedling woody species, such burns may also stimulate certain species, especially graminoid species. Accordingly, they should not be used too frequently, or solely, as loss of important species and the stimulus of some invasive species may result.

Additional to the consideration of timing is that of the scale of prescribed burns. Because certain fauna, such as the Mitchell's satyr and the eastern massasauga rattlesnake, are restricted to calcareous wetlands and the probability of repopulation decreases with increased distance (Nekola 1999), the temporary destruction of large portions of their habitat through a prescribed fire can have profoundly detrimental effects. It is therefore suggested that the scale of burning be limited to only a portion of the site during any one season in order to avoid risk to these species (Lee 2000; MWPARC 2009).

IMPACT OF WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) IN ECOSYSTEMS RELATED TO PRAIRIE FENS AND *CYPRIPEDIUM* SPECIES AND THE USE OF EXCLOSURES

Matthaei Botanical Gardens is known to have large populations of white-tailed deer *(Odocoileus virginianus*) that have impacted many woody and herbaceous species across the property. One possible explanation for the demise of the *Cypripedium candidum* population in Kirk Fen is that it may be in part due to the stress of deer browse. Remaining stands of *C. candidum* in Kirk Fen were found only in open areas among the twigs of *Rhamnus alnifolia* and low-lying *Pinus strobus* branches, suggesting the possibility that their survival had been due to the protection of these woody plants (informal conversation with Ellen Elliot Weatherbee).

Although there are numerous studies of the effect of white-tailed browse on forest ecosystems and woody plants, there are few that verify the damaging effects of deer browse on fen ecosystems and *Cypripedium* species. A literature review and telephone survey of professional botanists, endangered species scientists, natural area managers, and U.S. National Park Service resource managers, revealed that ninety-eight species of threatened or endangered plants were disturbed by deer and of the disturbed species, 38.7% belong to families

Liliaceae and Orchidaceae (Miller et al. 1992). Gregg (2004) showed that 65-95% of the stems of *Cypripedium reginae* were browsed during three years of severe deer browse in one site. Rentch et al. (2008) called for deer control after studying vegetation in a poor fen in West Virginia, and Pellerin et al. (2006) found that overall, white-tailed deer could be harmful for the long-term conservation of plant diversity in peatlands. Illinois Department of Natural Resources staff (Ludwig and Nelson 2006) drafted a deer management program for the Adeline Jay Geo-Karis Illinois Beach State Park (IBSP) after monitoring deer browse on vegetation in a wet prairie swale, dry mesic prairie, and a wet mesic prairie. Although only nine of the nineteen indicator species showed more than 30% stem browse, they suspect those showing lower percent browse are negatively impacted as well. Casual observances of negative effects of deer on plant populations in IBSP include stunted plant growth, loss of plant species, reduced plant reproduction, and reduction and decline in population size. They also cite several authors that conclude that ecosystem and habitat destruction occurs from high-density deer trampling (Szafoni 1991; Alverson et al. 1988; Anderson et al. 2001; Frankland and Nelson 2003; Jones 2004 and 2005). Although there is no definable healthy threshold of deer density in ecosystems, McShea et al. (1997) is cited (Russell et al. 2001) as stating that deer populations have exceeded pre-settlement levels and that rare plant communities are particularly vulnerable, especially in forage-poor areas. Their literature review of deer impact on plants and ecosystems further cite Augustine and Frelick (1998) as having suggested that deer browse can significantly reduce the growth rate of herbs and other authors as suggesting there is reduction of reproductive plants (Rooney 1997; Augustine and Frelich 1998) and the number of reproductive structures produced per plant. Anderson et al. (2001) states that because deer were not found to browse significantly on graminoids outside deer exclosures, that deer are likely to cause a shift in favor of grasses over forbs in prairies and reduce prairie plant diversity. In a later article (Anderson et al. 2005), it was concluded that intermediate browse created an intermediate disturbance and diversity was maximized.

Although exclosures have been built as long ago as 1936 to exclude sheep and cows from areas, and later to create visual evidence of the impact of deer browse, it is only recently that they have been used of late to protect rare plants (DeerFacts.org 2009). Based on the fact that deer can jump vertically up to 9 feet (DeerFacts.org 2009), 10’ x 10’ exclosures are typically built to be at least 8 feet tall, however, exclosures up to seven square meters were proven effective when just 5 feet tall. It is also suggested that 8-foot exclosures may benefit from the addition of two single strands at nine and ten feet, especially if they are excluding areas larger than 10’ square. The suggestion of additional wire atop an eight-foot fence is thought to confuse deer’s perception as to the height and safety of jumping in. Fencing that slants outward of the enclosed site area is also stated to confuse deer as and keep them from jumping over (DeerFacts.org 2009).

CONCLUSIONS

Prairie fens have zones of vegetation as a result of their response to the underlying hydrology and ground water chemistry. Finding a trajectory or model template for prairie fen restoration from other studies should not be relied on too heavily because of the unique bio-geomorphic context in which each fen is found, as well as their historical isolation and contemporary fragmentation. The MNFI prairie fen abstract (Spieles et al. 2010) presents a general summary of species composition, indicator plants, and zone descriptions that reflect a contemporary fire-suppressed fen community. It is perhaps the most applicable model for the Kirk Fen site, keeping in mind that some species of this model may disappear due to fire susceptibility. Trajectory projection based on the model system (Radrick Fen) or idealized fen may not be obtained due to a) inherent hydrogeological differences, b) distance affecting low seed migration and c) and low seed viability in the newly cleared areas. Although botanists distinguish fens by their vegetation, particularly the presence of certain indicator species, when anticipating future trajectories and specific floral species, it is important to acknowledge the uniqueness of individual fens and to realize that the lack of a particular species may be due to site isolation rather than an indication of ecosystem function. Therefore, caution is given not to base the absence or presence of individual indicatory species as a measure of success but rather by evaluate and measure the system as a whole.

Short-term succession for each area cleared within Kirk Fen and the site at large, will likely continue to be weedy during the first years, later developing into early successional prairie fen species. Heterogeneity of prairie fen plant associations within the site, due to patterns of hydrological differences across the site, may be established within ten years.

Ground water effects should be considered when evaluating results. Kirk Brook, the stream that runs along the south boundary of the fen, has become seriously degraded in recent years because of increased storm water inputs from upstream sources. The base channel of the stream has been dramatically undercut in sections and may be leaching ground water from the entire fen system. If this degradation of Kirk Brook is reducing the ground water in the fen, this will have a significant role on species composition and the trajectory of this fen by selecting out wetland obligate species and favoring facultative species, as well as enhancing decomposition and increasing mineralization. In this scenario, higher available nutrients from soil mineralization will likely shift the species composition to reflect a more eutrophic condition, or, with rainwater playing a greater role in the root zone, an oligotrophic condition may occur. Septic system leakage is another concern, in that nutrient enriched ground water may also alter the trajectory to a eutrophic system.

To measure the success of this restoration project and to make ecologically sound management decisions, monitoring with clear objectives can be useful to determine management success and to help in determining if intervention is needed. However, there is an opportunity and a responsibility to put in place long-term surveillance and research at this site to document and convey the ecosystem response to management decisions. Floristic surveys, as well as documentation of treatment areas, ground water hydrology, chemistry, and periodic soil surface surveys will aid in understanding the system as a whole.

Fire is expected to change the composition of the fen, both within the intact sites, as well as the cleared sites once a graminoid base is established to administer a prescribed burn. Varying the season of burns will be useful for a variety of goals. Early spring burns may aid in stimulating *Cypripedium candidum*, stimulating seed germination and promoting forb establishment and development, controlling *Phalaris arundinacea* and other alien cool season grasses, stimulating *Andropogon gerardii* (big blue stem grass) and *Sorghastrum nutans* (Indian grass), and increasing overall productivity. However, caution is given to avoid late spring burns because eastern massasauga rattlesnakes are active after April 1 and late spring burns may also negatively impact early flowering forbs. Growing season burns may aid in stimulating biodiversity and controlling the dominance of warm season grasses, but doing this at a large scale across the site would likely greatly impact massasauga populations. While dormant season burns may aid in the control of woody seedlings and re-sprouts, such fires may also increase graminoid dominance and lower species richness if these are too frequent . A lower frequency of prescribed burns could increase the overall forb component of the vegetation matrix. By dividing the Kirk Fen area into smaller units, greater biodiversity may be achieved while giving refugia to herpetofauna and other fauna. Therefore, prescribed burning for the fen should be approached by dividing the area up into units, each unit receiving different seasonal burns throughout a period of time in which all units have had at least one spring, one dormant season and one growing season burn, and the site in its entirety should be given time to rest before another but less frequent series of burns are administered.

There is growing evidence that deer are destructive in ecosystems related to prairie fens, rare plants, Orchidaceae, and particularly to *Cypripedium* species. Damage is principally due to their browsing but may also result from trampling. Deer may also create a shift to grass dominance.

Call for Future Monitoring Activities in Kirk Fen

This section includes a) proximate and distal expectations and project success defined for Kirk Fen and b) additional considerations. Two timetables are suggested, with and without the use of transect data and can be found in Tables 5.1 and 5.2.

Proximate and Distal Expectations and Project Success Defined for Kirk Fen

This section defines the short term and long term expectations for project success for Kirk Fen. It is important to have clear expectations in which to set monitoring objectives. The following expectations are based on the literature review and the baseline surveillances conducted by Ruhfel (2005) and for this practicum, are structure oriented rather than species specific or model ecosystem specific, and will be used to set proximate and distal monitoring objectives for Kirk Fen.

Early succession of Kirk Fen after restoration will likely be an early weedy stage, followed by a perennial grassland and an early prairie fen stage, followed by a stable fire-dependent community with the following characteristics:

- Graminoid dominant community
- Calcareous dominant community
- Full complement of fire-dependent prairie fen species – dominated by sedge meadow species but with an increase of calcareous zone species
- Increased species diversity to that of 2004/2005 report or greater, however with probably loss of fire-sensitive species
- Loss of non-native species and gain of native species
- Return of rare, endangered, and high-C species reported in 2004/2005
- Increased diversity and relative importance of mid-C and high-C species with concurrent decrease of relative importance of low-C species
- Mean C of 4.5 or greater for the site within the 1949 boundaries
- FQI 50 or greater for the site within the 1949 boundaries, indicating an extremely rare area and a significant component of Michigan's native biodiversity and natural landscapes (Herman et al. 2005) and of paramount importance in Illinois (Wilhelm 1992)
- Graminoids and forb protection for *Cypripedium candidum* without forb competition within most of the 1949 boundary
- Vegetation continuum with surrounding landscape

Tables 5.1 and 5.2 give timetables for two scenarios: a) one based on three to four years intervals using line-intercept transect data along with area inventories, dominance surveys, *Cypripedium candidum* site surveys, and photo-point monitoring, and b) another based on five year intervals using only inventories, dominance surveys, *Cypripedium candidum* site surveys, and photo-point monitoring without the benefit of line-intercept transects.

Table 5.1 – Project success parameters time table through the year 2030 including sub-area floral inventories, dominance surveys, *Cypripedium candidum* surveys and line-intercept transect inventories for Kirk Fen.

2015	Native FQI 45 or greater for site wide inventory
	Mean C 4.5 or greater for the site wide inventory
	Mean C 4.0 or greater within cleared phase 1 and 2 areas
	Mean C 3.5 or greater in east (presently un-cleared areas)
	Mean C 4.5 or greater within the intact areas
	percent native species at 90% or greater for site wide inventory
	low-C, mid-C, high-C at 40% or lower, 50%, and 10% or higher
	non-native invasive species frequency Uncommon and cover at 5% or less
	native graminoid cover frequency at Abundant and cover at 30% or greater
	native graminoid diversity increased, especially *Carex sp.*
	rare and high-C species missing from 2004/2005 inventory spontaneously established within the intact areas 1
	prairie fen species numbers stable or increased in sedge meadow, inundated fen and calcareous seep species
	site inventory shows full sun with infrequent local shade from native woody species in all areas within the 1949 boundaries
	Cypripedium candidum associates diversity at 15 or greater in intact areas and area H and at 10 or greater in areas B,E,G inventories
	photo-point documentation shows 80% decrease in shrubs and 50% increase in graminoid

2018	Native FQI 48 or greater for site wide inventory
	transect inventories show Mean C at 4.0 or greater in sections outside the middle quadrants
	transect inventories show percent native species at 89% or greater
	transect inventories show high-C RIV at 10% or greater
	transect inventories show mid-C inventory percent at 60% or greater
	transect inventories show invasive RIV at 5% or less
	transect inventories show *Rhamnus frangula* RIV at 5% or less
	transect inventories show three most dominant species mid-C or high-C (by way of RIV)

	transect inventories show graminoid RIV at 40% or greater
	transect inventories show prairie fen species RIV at 40% or greater
	transect inventories show increase of sedge meadow diversity to 18 or greater
	transect inventories show increase in *Cypripedium candidum* diversity and RIV at or greater than 10% in middle quadrants

2022	Mean C 4.8 or greater in intact areas
	Mean C 4.5 or greater within cleared phase 1 and 2 areas
	Mean C 4.0 or greater within east (presently un-cleared areas)
	percent native species at 95% or greater in all area inventories and site wide inventory
	low-C, mid-C, high-C at 30% or lower, 60%, and 10% or higher
	non-native invasive species frequency Scarce and cover <1%
	graminoid cover frequency at Dominant and cover at 50% or greater
	site inventory shows protection of graminoids for *Cypripedium candidum* in all areas within the 1949 boundary
	photo-point documentation shows an additional 15% decrease in non-native shrub population and a graminoid dominated ecosystem and indication of the return of high-C and conservative species, prairie fen species, and *Cypripedium candidum* and its associates

2026	transect inventory invasive RIV at <1% or less
	transect inventory shows prairie fen species RIV at 60% or greater
	transect inventory shows Mean C at 5.0 or greater for all quadrants inside the 1949 boundary
	rare and high-C species spontaneously established outside the intact areas within the topological gradients in which they are expected
	calcareous seep species established within the areas of visible ground water
	rare and high-C population mature, flowering and sustainable (seedling regeneration visible) within the hydrogeological gradients in which they are expected.
	photo-point documentation shows no non-native species, a graminoid dominated ecosystem, increased indication and populations of high-C, conservative species, prominent prairie fen species, and *Cypripedium candidum* and its associates evident

2030	FQI 50 or greater for site wide inventory
	Mean C 5.0 or greater for intact areas and cleared phase 1 and 2 areas
	Mean C 4.5 or greater within the east (presently un-cleared areas)
	low-C, mid-C, high-C dominance 25% or less, 65%, and 20% or greater
	calcareous seep species cover increased in the hydrogeological gradients in which they are expected
	vegetation continuum with surround landscape in place

	photo-point documentation shows a graminoid dominated ecosystem with diversity of fobs and return of important high-C and conservative species, prairie fen species, and a thriving population of *Cypripedium candidum* and its associates

1 *Cypripedium candidum, Hypoxis hirsuta, Salix candida, Valeriana ciliata, Valeriana uliginosa*.

Note: the area within the 1949 boundary site is assumed unless an areas is specifically stated

Table 5.2. Project success parameters time table through the year 2030 including sub-area floral inventories, dominance surveys, and site surveys, (without line-intercept transects).

2015	Native FQI 45 or greater for site wide inventory
	Mean C 4.5 or greater for the site wide inventory
	Mean C 4.0 or greater within cleared phase 1 and 2 areas
	Mean C 3.5 or greater in east (presently un-cleared areas)
	Mean C 4.5 or greater within the intact areas
	percentage native species at 90% or greater for site wide inventory
	low-C, mid-C, high-C at 40% or lower, 50%, and 10% or higher
	non-native invasive species frequency Common or less and cover at 6-25% or less
	native graminoid cover frequency at Abundant and cover at 30% or greater
	native graminoid diversity increased, especially *Carex* sp.
	rare and high-C species missing from 2004/2005 inventory spontaneously established within the intact areas 1
	prairie fen species numbers stable or increased in sedge meadow, inundated fen and calcareous seep species
	site inventory shows full sun with infrequent local shade from native woody species in all areas within the 1949 boundaries
	Cypripedium candidum associates diversity at 15 or greater in intact areas and at 10 or greater in areas B, E, and H inventories

2020	Native FQI 48 or greater for site wide inventory
	Mean C at 4.0 for areas bordering the 1949 boundary
	top three High-C dominance at Common or greater
	low-C, Mid-C, high-C at 30% or lower, 60% and 10% or higher
	rare and high-C species missing from 2004/2005 inventory stable or increasing within the intact areas 1
	Cypripedium candidum associates diversity at 15 or greater in intact areas and areas B,E,G, H, 10 or greater in all areas within the 1949 boundaries
	non-native invasive species frequency Scarce and cover <1%

2025	Mean C 4.8 or greater in intact areas
	Mean C 4.5 or greater within cleared phase 1 and 2 areas

	Mean C 4.0 or greater within east (presently uncleared areas)
	Low-C, mid-C, high-C at 35% or lower, 60% and 15% or higher
	percent native species at 95% or greater in all area inventories and site wide inventory
	rare and high-C population mature, flowering and sustainable (seedling regeneration visible) within the hydrogeological gradients in which they are expected.
	calcareous seep species established within the areas of visible ground water
	graminoid cover frequency at Dominant and cover at 50% or greater
	site inventory shows protection of graminoids for *Cypripedium candidum* in all areas within the 1949 boundary

2030	FQI 50 or greater for site wide inventory
	Mean C 5.0 or greater for intact areas and cleared phase 1 and 2 areas
	Mean C 4.5 or greater within the east (presently uncleared areas)
	low-C, mid-C, high-C dominance 25% or less, 65%, and 20% or greater
	calcareous seep species cover increased in the hydrogeological gradients in which they are expected
	vegetation continuum with surround landscape in place

1 *Cypripedium candidum, Hypoxis hirsuta, Salix candida, Valeriana ciliata, Valeriana uliginosa*

Note: the area within the 1949 boundary site is assumed unless an areas is specifically stated

ADDITIONAL CONSIDERATIONS

Vegetation structure can affect plant and animal community processes, resource use, trophic levels, and animal species population levels. These factors have important consequences for natural areas and should be important components of natural areas monitoring and management (Bowles et al. 2005). Although this practicum is limited to the prairie fen plant community, important rare and endangered animal species within a prairie fen should be understood, articulated, and incorporated into the expectations and project success timetable. Additionally, natural areas managers should keep in mind that structure, rather than specific species, may be more important to fauna, especially herpetofauna like the eastern massasauga rattlesnake (MWPARC 2009). If the structure of the fen is such that it supports rare and threatened fauna, even if certain species or a specie complex is not present, a change in the expectations could be made and the resulting trajectory of the site can be articulated and the project still considered a success.

CALL FOR FUTURE RESTORATION ACTIVITIES IN KIRK FEN

This section includes a) fire management, b) continued invasive woody species removal, c) continued invasive forb control, d) deer exclusion.

FIRE MANAGEMENT

This section concentrates on a) site specific goals and b) timetable for prescription fire in Kirk Fen.

Site-specific goals for prescription fire in Kirk Fen

Prescribed burns in Kirk Fen are based on the following site-specific goals:

1) Decrease woody seedlings and re-sprouts
2) Control non-native forbs
3) Promote floral diversity and species richness
4) Increase the small white lady slipper populations
5) Promote habitat for the eastern massasauga rattlesnake

Taking in account the varied effects that fire periodicity has on plant succession, fauna, floral communities, and the information generated from baseline inventories and site surveys, a proactive fire strategy based on the above objectives for Kirk Fen is written below. It first targets the higher quality areas and hopes to stimulate dormant *Cypripedium candidum* populations. Then it addresses the existing problem of buckthorn seedlings and re-sprouts with early spring and late fall burns. Once these urgent goals are achieved, dormant season burns can be incorporated into the timetable to encourage biodiversity and heterogeneity within the site. To sustain heterogeneity in structure, prescription burns should be continued in perpetuity by seasonably varied timing and allowing the site to go without burns occasionally.

Suggested timeline for prescription fire in Kirk Fen:

- Early spring 2011 – Burn to decrease thatch, stimulate *Cypripedium candidum* in the areas where they were last seen, and stimulate native grasses for future fire fuel. Additionally, an early spring burn will also stimulate seed germination and promote forb establishment and development, help control *Phalaris arundinacea* and cool season alien grasses, and increase overall productivity. *C. candidum* were last seen in and around the northeast edge of intact 2 in 2006 and in intact 1 in 2005. Spring burns, following MWPARC recommendations, should occur no later than April 1 if late March weather has been warm.
- October 2011 – Burn in the cleared phase 1 areas (without burn piles) if enough fuel is evident to target buckthorn seedlings and re-sprouts.
- Winter 2011 – Burn the branch piles left in the cut phase 2 areas. Branch piles are numerous and are shading out viable *Cypripedium candidum* habitat. It is important to carefully disassemble and burn the piles of branch debris to avoid disrupting animals using the piles for winter shelter (informal conversation with Jeff, Plakke, MBGNA Natural Areas Manager). If, upon dissembling, animals are found inhabiting the piles, one should discontinue working on that pile. It is also important to avoid one large fire in order to avoid soil sterilization and to purposefully leave some piles for fauna refuge.

- Spring 2012 – Target areas not burned Spring 2011 that have *Phalaris arundinacea*.
- October 2012 – Target the rest of the cleared phase 2 area,s if enough fuel is evident.
- Spring 2013 – Target the areas closest to the intact 2 area where branch piles were removed ,to decrease thatch and stimulate *Cypripedium candidum* populations and grasses.
- October 2013 – Target the easternmost areas if fuel is evident after clearing (hopefully Winter of 2011 – see call for further shrub removal section)
- After October 2013 – Once all units have had spring and October burns, and woody species are controlled, growing season (July/August) burns are suggested if dominant grasses are of concern and if increased diversity is desired. Watch *Solidago altissima* and *Solidago canadensis*, as *S. canadensis* was shown to increase after an August burn. MWPARC recommends burning during high humidity and cool temperature conditions for a slow moving fire. This will allow snakes to seek shelter and the burn to be patchy. For either mid or late season burns, snakes are not hibernating and can be herded away from the burn area[1]. Also, burn breaks around piles of branch debris and downed logs are recommended to create refuge for snakes.
- For sustained diversity and heterogeneity, vary the season of burns. Varying the burn season between spring, growing season, and early

dormant (October) season will add diversity and allow short-lived perennials and annuals to reestablish their seed banks. Additionally, alternating burn areas and seasons most closely mimics natural and historic Aboriginal burn regimes (conversation with University of Michigan Botanical Gardens and Arboretum Natural Areas staff), may potentially offer relief to herpetofauna populations and may be beneficial to a variety of grassland species (MWPARC).

- Allowing the entire site to rest for a year will avoid preventing burning too frequently.

FURTHER INVASIVE WOODY SPECIES CLEARING

The original goal for clearing to the 1949 boundaries was not met; therefore, further clearing is encouraged to the original intended extent as well as beyond to promote gradual transitions to nearby oak savanna areas as well as other habitats along Fleming Brook.

Recommended approach

For the clearing of woody species, 41% glyphosate mixed with a certified wetland surfactant and dye, applied within five minutes to freshly cut stumps of six inches or less is recommended. A Stewardship Network broadcast (12/14/2005) reported 1:1 concentration of Glyphosate on cut stumps at 6 inches or less gave 99% kill and that the herbicide should be applied in five minutes or less. The phase 1 area was treated this way (25% to 41% Glyphosate) and was casually observed to have had good effects. The author believes the 5-minute-or-less guideline of applying herbicide to fresh cut stumps as well as re-cutting the stumps at six inches or less compensates for lower glyphosate concentrations. Because of observed lower tamarack loss and faster high quality species rebound in the areas that were re-cut and treated with herbicide a year after the first cut, it is recommended that this delayed re-cut and herbicide approach be considered for the duration of the restoration project.

Areas to target

Below are several areas suggested for further clearing of woody species. It is recommended to target only adventive species and leave the woody native species undisturbed. The diversity of native woody species will enhance the ecosystem heterogeneity and the amount of transpirational loss of the few remaining trees and shrubs is likely to be minimal. It is also recommended that progress for clearing be incremental and over several years avoid impact to species of high conservatism and soil degradation.

The northeast and southeast sections within the 1949 boundary still remain to be cleared. It is recommended to continue the restoration process of clearing at these locations. The northeast section has an intact open wet area and some ground water upwelling. The recently cleared area adjacent to this location is already showing species of high quality only one year after clearing. Also, the topological contour lines suggest that this area may correspond hydrologically, and therefore potentially florally, to the intact 1 and 2 sites and adjacent northern areas. The smaller southeast section also has ground water upwelling and it is adjacent to the last recorded population of *Cypripedium candidum*.

Outside the 1949 boundary, a dense and nearly continuous stand of glossy buckthorn and other adventive woody species exists. The ability and rapidity of woody species to invade the fen is a real and imminent threat. This threat must be addressed in order to secure the sustainable future of the site. If fire management is administered within the fen boundaries, the threat of woody species establishment will be less impending; however, the evapotranspirational loss of soil moisture of this woody stand may indeed have a significant effect on the overall soil water balance of the fen proper.

Two specific areas outside the 1949 boundary are recommended to be cleared and managed. Outside and south of the 1949 boundary toward the junction of Kirk Brook and Fleming Creek, is a high quality woody ecosystem with notable tree and shrub prairie fen indicator species such as *Larix laricina*, *Physocarpus opulifolius*, *Toxicodendron vernix* and *Cornus amomum* in addition to *Corylus americana*, *Juglans nigra*, *Ulmus americana*, and *Viburnum lentago*. This area already has a Mean C of 3.6. The uniqueness to the Botanical Gardens property, the woody species, and Mean C all give merit to clearing of adventive species in this area. A small portion of this area has already been cleared. Also, it is recommended to continue the clearing process clearing along the path to Kirk Fen from the Brook to the cleared 1 area. This is a unique ecotone between upland and wetland with such notable species of *Carex tetanica*, a mature natural birch hybrid between *Betula alleghaniensis* and *B. pumila*, as well as a sizable stand of

Corylus americana and some very old *Carpinus caroliniana*. Caution is given to avoid too quick an approach, as was done with the phase 1 clearing, as the loss of the mature *Betula* hybrid may result. Additionally, concurrent clearing of the area adjacent and southwest of intact 1 is suggested. This would facilitate a fire-dependent continuum from the Marilyn K. Bland Prairie (North American demonstration prairie) and Kirk Woods (a remnant oak savanna woods) with Kirk Fen, allowing the genetic flow of grasses and forbs with the prairie. It would also enhance habitat for the eastern massasauga rattlesnake as gravid females traverse this area to upland areas to bare their live young. Additionally, it would provide visitors with an impressive and comprehensive vista of three unique, landscape-related, fire-dependent ecosystems. Clearing the woody invasive species farther to the east would help establish a higher quality contiguous landscape, with the open water wetland to the southeast of Kirk Fen and the open sedge meadow near Cherry Hill. See map (figure 5.1) for recommended areas to be cleared.

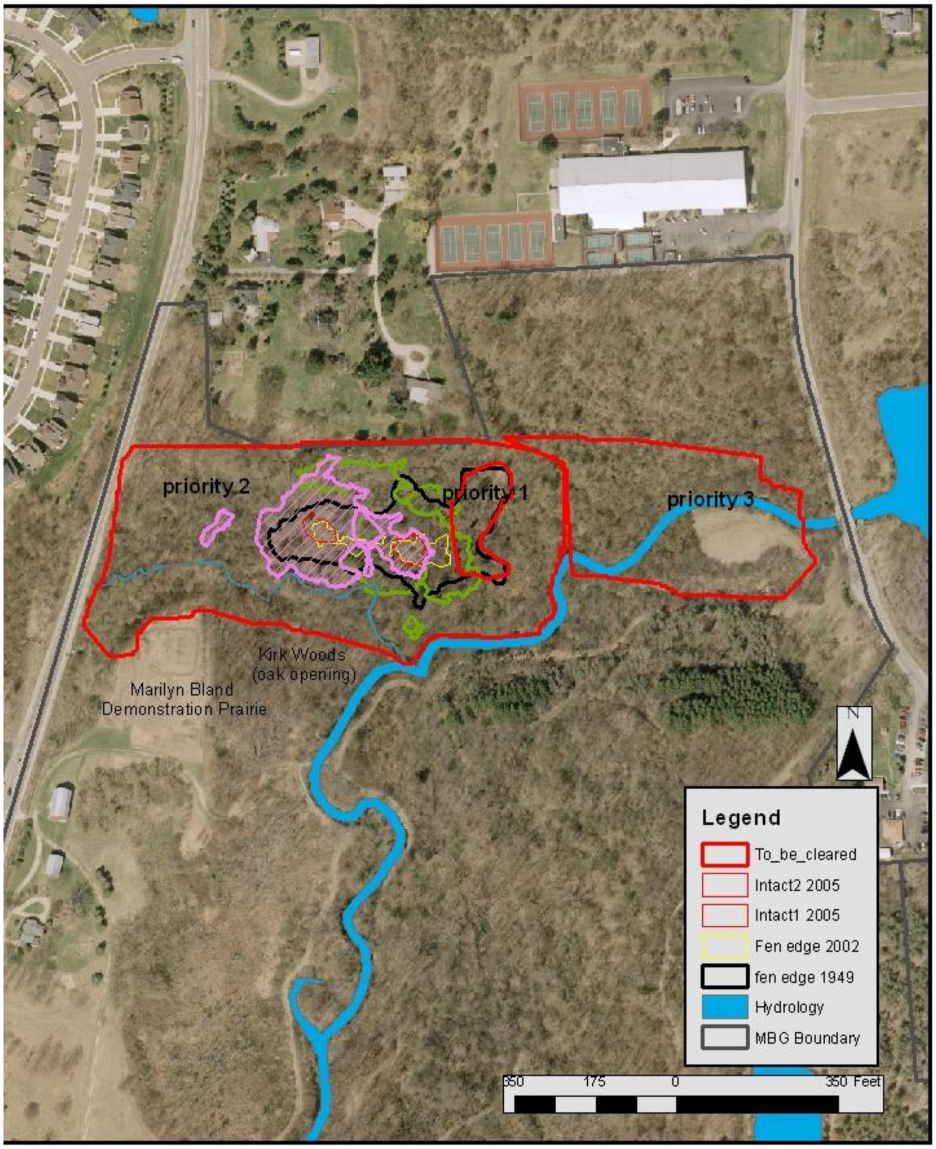

Figure 5.1. – Map showing areas in red for further non-native invasive woody species clearing with priorities.

FURTHER INVASIVE FORB CONTROL

The Japanese knotweed (*Polygonum cuspidatum*) population along the fence at the north boundary of the property needs to be addressed. A proven approach[*1] is to cut the stems low to the ground and treat the cut stems with 30% glyphosate (Czarapata 2005) mixed with certified wetland surfactant and dye. Repeated control is recommended throughout the growing season by addressing re-growth before it is knee high. As many as five or more years will be necessary for complete eradication. Four to five applications are likely necessary the first year. With each successive year, the number of treatments will decrease, until only one treatment will be necessary the last years. If at any time the stems are allowed to reach a greater than knee height during the growing season, progress will be impeded.

The canary reed grass (*Phalaris arundinacea*) stands have been set back with earlier control treatments but not entirely eradicated. Although early spring and August burns have been shown to have positive control effects on *P. arundinacea*, existing stands should to be monitored each year and treated with herbicide. Spraying early spring growth with 3% glyphosate mixed with a wetland certified surfactant and dye is recommended, or alternatively, cutting mature stems low to the ground and treating the cut stems with 30% glyphosate (Czarapata 2005) mixed with a wetland certified surfactant and dye.

The original garlic mustard (*Alliaria petiolata*) population along the north boundary has not returned to its original breadth or density. However, it is

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[*1] The author has had favorable success using this approach on an area at the Gardens being prepared for a native orchid garden.

recommended to revisit the upland areas in mid-May annually to pull the existing second-year plants along the shaded and drier north region. To avoid foot traffic in the fen, this area might be approached by way of the property to the north, if permission is sought. Garlic mustard also threatens the entrance path from populations in the adjacent wooded areas. Keeping this path free from garlic mustard is important to avoid further seed dispersal from foot and deer traffic. The wooded area immediately to the south of the intact 2 site should be monitored for outlying plants each year. Ideally the areas across the Brook should be managed given the evidence of deer crossing from that side to Kirk Fen.

DEER EXCLUSION

Because of the concern for the small white lady slipper (*Cypripedium candidum*) and the growing evidence of deer destruction on orchids and rare plants populations (Miller et al. 1992; Russell et al. 2001;Gregg 2004; Ludwig and Nelson 2006; Rentch et al. 2008) deer exclosures should be considered for parts of Kirk Fen where populations of *C. candidum* might repopulate. Wire fencing is preferred since prescribed burns are likely to continue. Although exclosures as large as 7-meters square have been demonstrated to be effective with only five foot fencing, typically exclosures are ten-foot square and these are built with at least eight foot fencing and should be constructed. Plans for 10-foot square exclosures at DeerFacts.org (2009) have estimated costs for three types of metal fencing ranging from $1,070.00 to $2,200.00.

CALL FOR KIRK BROOK CATCHMENT MITIGATION AND PROTECTION, KIRK BROOK RE-SEDIMENTATION, AND KIRK FEN GROUND WATER DYNAMICS AND CHEMISTRY MONITORING

KIRK BROOK CATCHMENT MITIGATION AND PROTECTION

Much of the following information and the maps are taken directly from a student team project (Crancer et al. 2010), of which the author was a participant. Kirk Brook Catchment is located to the west and northwest of Kirk Fen. The Kirk Brook Catchment drains approximately 310 acres of land of which approximately 140 acres are made up of highly erodible soils of Boyer loamy sand, Miami loam, and Fox sandy loam, as well as moderately erodible soils Houghton Muck and Sloan silt (figure 5.2). The most prominent land feature in the catchment is the valley ravine that runs nearly its entire length and is flanked by steep grades varying from 18 to 40% (figure 5.2). Outside the ravine are slopes of 6-18%, progressing to 0-6% at the boundaries of the catchment. The catchment has pockets of commercial and industrial areas and high-density housing. Because of the steepness of the ravine and the drainage from the impervious pavement of nearby high-density housing, part of the U-M East Medical Center, and part of Dominos Farm, the current velocity of water in Kirk Brook is presumed to be greater than historical rates. At present 50% of the catchment is shrub or forest (figure 5.3). Those woody vegetated areas have no present erosion problems. However, if these soils are further developed two possible concerns may result: erosion from soil disturbance and faster drainage of storm water runoff into the valley bottom. At present, the lower part of the catchment shows signs of significant erosion and a need exists to mitigate run off velocity, in order to prevent further erosion and to allow sediment build. A design mitigating current erosion and protection from parking lot contaminants has been proposed by a student team. The design is a “treatment train” within the brookshed, with two constructed wetlands – one located in the northern extent of the catchment and one located in the southern extent of the catchment, with two different purposes and foci. The north wetland is meant to remove contaminants from parking lot runoff, to slow erosive flows, and store floodwaters. The south wetland would store water and drop sediment to correct present erosion. The north section is adjacent to an Ann Arbor Parks and Recreation property and the privately owned portion is presently too sloped for housing. The south section currently is owned by the city and a sewer line currently runs at the valley floor to Plymouth Road. The location of Kirk Brook catchment and the construction of these wetlands as designed, with public access and pathways, would not only offer possible catchment mitigation but would utilize currently undevelopable land and would offer a logical greenbelt pathway from the Botanical Gardens site to Marshall Nature Area (part of the Ann Arbor Parks system) at the corner of Dixboro and Plymouth Roads, and The Horner-McLaughlin Natural Area (owned by the University and managed by MBGNA) found farther out on Dixboro Road.

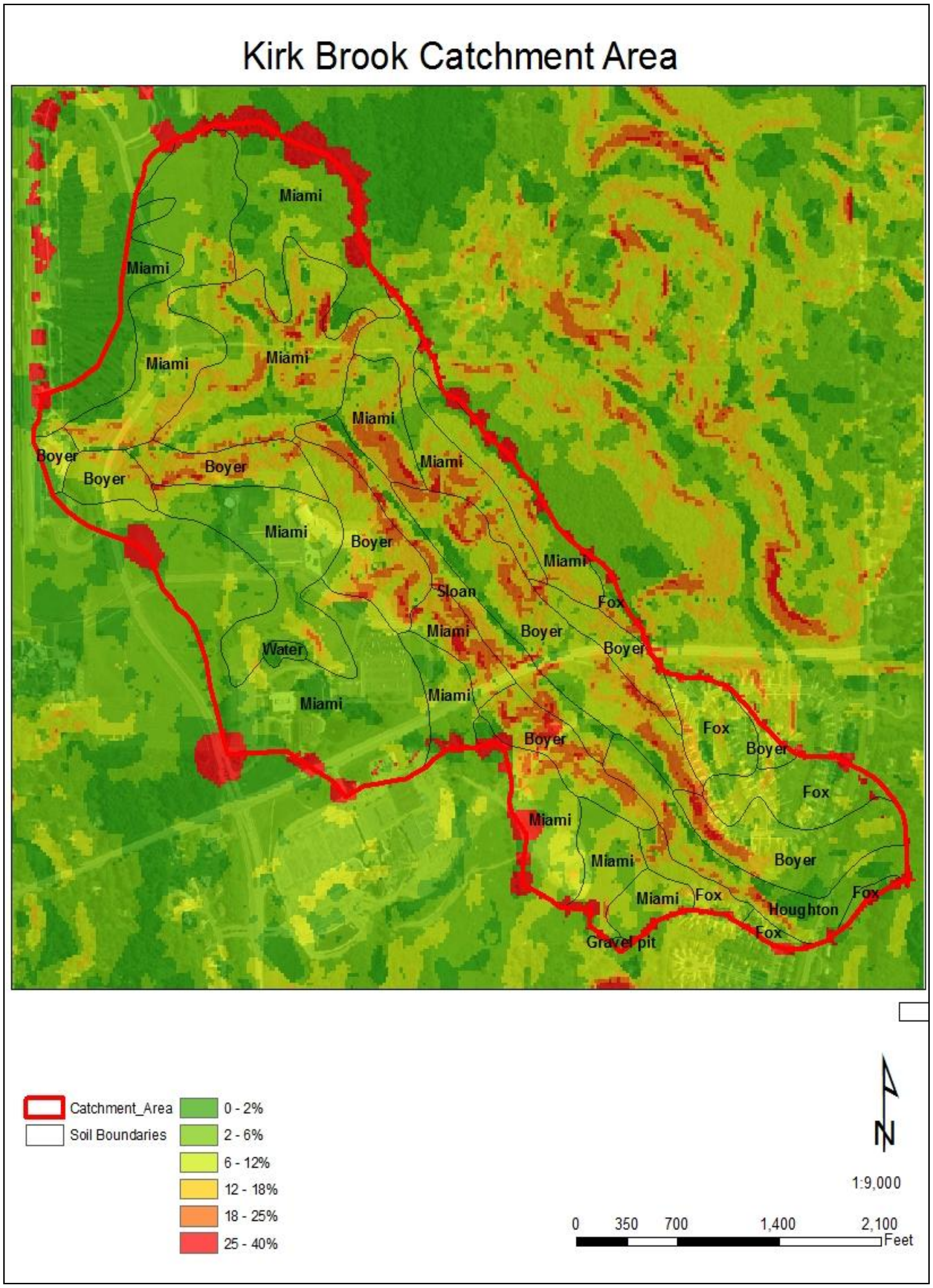

Figure 5.2. Slope and soils of Kirk Brook Catchment (Crancer et al 2010).

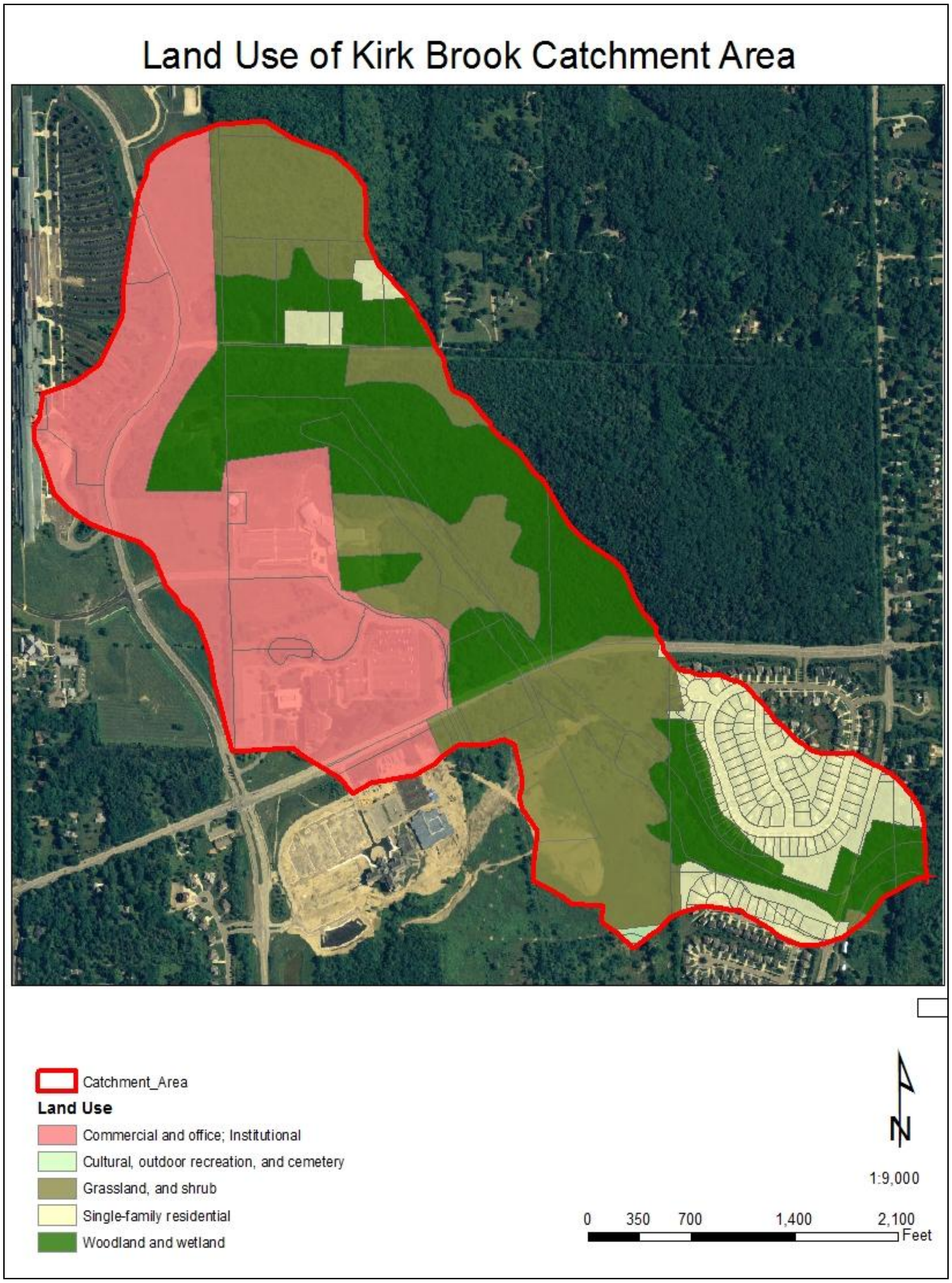

Figure 5.3. Land use of Kirk Broom Catchment (Crancer et al. 2010).

KIRK BROOK RE-SEDIMENTATION

Kirk Brook runs past the lower topography of Kirk Fen and currently shows channel bank erosion (figure 5.4). This lowering of the Brook bottom can potentially drain Kirk Fen faster than that prior to human impact and thus alters the historic hydrology that Kirk Fen originally developed upon. Altered hydrology of increased drainage will cause floristic and ecosystem changes such that Kirk Fen may more realistically be on a future trajectory as a sedge meadow rather than a functioning fen.

In addition to the Kirk Brook Catchment mitigation plan, a re-sediment plan should be explored to raise the brook floor up to historical heights. Raising the floor will slow the rate of drainage of Kirk Fen to historical rates. Ground water wells, as described above, should be completed before re-sedimentation so baselines measurements are made and compared to after re-sediment measurements.

Figure 5.4 – Kirk Brook bank cut (Crancer et al. 2010)

KIRK FEN GROUND WATER DYNAMICS AND CHEMISTRY MONITORING

Further soil tests similar to those Ruhfel conducted should be done to discover if ground water levels increased due to the interruption of evaporative transpirational loss from buckthorn and other woody vegetation. However, the use of a ream rod and measuring from soil level to ground water level lacks a permanent datum point to determine if the soil decreased or if the water table actually increased. In addition, there are no records of ground water level testing prior to the construction of the high-density housing or the low density housing to the north with which to compare. However, to gain a clearer picture of current hydrological dynamics in Kirk Fen, ground water wells that will test ground water level, discharge, and recharge will be a valuable tool in interpreting floristic rebound and evaluating the trajectory of Kirk Fen.

A ground water monitoring strategy, including three nested wells, was researched by a student intern. The project included two piezometers to measure ground water up-welling and down-welling (soil recharge and discharge); a third well for measuring ground water level based on a single datum point was partially installed but not completed. In the summer and fall of 2007, twelve one-inch piezometers made from PVC were placed along the transects utilized by Ruhfel (2005) in Kirk Fen. These were designed to monitor upwelling. Upwelling is monitored by placing a PVC with the lower below-ground portion drilled with tiny holes or fitted with fine screen. The next step of these nested wells would be to install piezometers to measure de-welling (with perforation or screen in the upper half of the PVC). Along with these two piezometers, another PVC pipe is needed to measure ground water level, with perforation along the entire below-soil portion of the pipe. This project was documented and reported on, and a folder of this information stored along with other research reports at the Botanical Gardens. Installation of ground water wells in the fen soils is very challenging, and the process was meticulously investigated by consulting water-monitoring professionals and by publication research.

The neighborhood directly north of the fen has septic fields, so it is suggested that natural areas management sample and monitor ground water chemistry in Kirk Fen for the following reasons: a) it is the ground water–surface water interactions and chemistry that occur in these settings that are most relevant to the functioning of fens in the landscape, b) it is known that fens typically have low phosphorous and nitrogen and additional nitrogen in particular can have a profound effect on vegetation, c) nutrient addition from leaking septic tanks and drain fields is suspected of contributing to the dominance of invasive species such as *Typha angustifolia* (narrow-leaved cat tail), *Phragmites australis* (reed canary grass), and *Lythrum salicaria* (purple loosestrife). The ground water monitoring wells addressed above give natural areas management an avenue to sample ground water chemistry for pH, nitrogen, and phosphorous.

CALL FOR PUBLIC ACCESS AND PRAIRIE FEN EDUCATION

Support for ecological restoration projects benefit from and are more successful with a strong education program. As development increases and encroaches on the few remaining natural lands, natural areas management and institutions dedicated to public outreach opportunities need to look for opportunities to utilize their natural areas in order to bring awareness about unique restoration projects, the region's natural heritage, and the value of restoring natural communities. MBGNA is such an institution and has a unique and varied visitor base that includes students from U-M and other educational institutions, MBGNA membership, non-member visitors, mission-related clubs, and public officials.

Public access to restoration sites and written material on eco-restoration serve to bring public awareness about eco-restoration approaches and processes and how such projects increase biological diversity and benefit wildlife. As Kirk Fen goes through a dynamic process of change, establishment, and maturity, an exciting and excellent opportunity presents itself for MBGNA to demonstrate to its visitors how the forces of nature, under skilled management, can restore a unique and highly valuable natural area to its historical roots.

In particular to this topic and to consider:

- Develop informational brochures to provide background information on the goals and processes of the site.
- Construct a boardwalk with interpretive signs at strategic locations to bring awareness to unique species of plants and wildlife found in Kirk Fen.

APPENDIX 3.1 – MONITORING TERMS DEFINED

It is important for the context of this written opus to define terms that often are misunderstood and often used interchangeably as they relate to botanical fieldwork.

Most of the following terms are borrowed from the Bureau of Land Management (BLM) Technical Reference Bulletin 1730-1 (Elzinga et al. 1998) and are included to add clarity and specificity to this report. These are listed in order from simplest rigor and least time consuming to the greater of each (Elzinga et al. 1998; Owen and Rosentreter 1992; Palmer 1986).

An *inventory* is a point-in-time measurement of the location and/or condition of a community, population, or specific species such as rare or endangered species. It can be simply a list of species making up a plant community and typically when the term inventory is used, it is in this reference. Or, it can be an assessment of existing and potential threats to a community or population. Additionally, one can conduct a rare plant inventory by locating all populations, determining the number of individuals, locating all rare species within a project area or within a habitat type, or assessing and describing the habita, including associate species, soils, aspect, and elevation. Inventories are a depiction of current conditions and have no reference to management objectives; however, an inventory may serve as a baseline or first measurement for further surveillance and is useful for developing a monitoring program. *Survey* is synonymous to inventory in this opus, especially as it pertains to an inventory sheet.

A *baseline study* is a collection of data to assess the existing conditions of a site and is sometimes termed "inventory monitoring." If a commitment to reschedule the measurements is made, then it may serve as a pilot surveillance or studies or monitoring.

Surveillance is measuring change over time in the absence of management objectives. It is a *study* that measures the change of a plant community, population or specific species with the intended commitment to re-visit the site and re-measure the same parameters at the same location. *Trend studies and long-term ecological studies* are types of surveillance. They often attempt to maximize the number of characteristics to be measured because those most sensitive for measuring change are not known. Surveillance can be readily adapted to monitoring by applying management objectives if a relation can be made between those attributes studied and management objectives.

Trend study gathers basic information about a species. The most common approach is to learn how the resource is changing over time with demographic parameters of population size, average density, cover, or frequency.

A *long-term ecological study* is intended to learn about the natural rate and types of change of an area such as succession and disturbance. A commitment of 50 to 200 years or more is not unheard of. Usually, many variables are measured on a few, yet large, permanent plots (usually greater than 0.1 ha). Variables commonly measured include cover or density of plant species, demographic parameters of important species, soil surface conditions, fuel loads, and animal signs. Owen and Rosentreter (1992) and Palmer (1986) also recognize *demographic studies* and *genetic studies* as repeatable studies and therefore, in context with BLM terminology, these would be considered surveillance without management objectives.

Monitoring is the collection and analysis of repeated observations and measurements to evaluate change in the condition and progress toward meeting a management objective. Monitoring is a key part of adaptive management and provides information and indication for management change or continuation. Therefore, monitoring is always done in the context of management objectives and is designed to evaluate and determine if objectives are met. Those parameters monitored usually describe a measurable desired condition of the site, community, or species. Because monitoring is management objective driven, the application of the data to management is identified before the measurements for monitoring are instigated; therefore, the parameters to be measured are defined by the articulation of the objectives. Management decisions are then based upon the reports generated from monitoring and are deliberately made to meet objectives, (or, the objectives are re-evaluated and re-articulated). Monitoring is initiated only if opportunities for management change for a site or project exist.

There are two types of monitoring: *Resource monitoring* which focuses on species resource demographics and *habitat monitoring* which includes, but is not limited to, soil, aspect, and ground water availability. Habitat monitoring can be general for a location, specific for a plant community, or specific to a species such as a rare or endangered one.

Lastly, many monitoring projects are intended to determine the response of a plant population or community to a particular management activity but few conclusively identify the cause of the response, therefore, the data collected during monitoring is usually of limited value in determining cause of change. *Research* is a study designed to determine the cause(s) of change of some observed biological or ecological phenomenon. Parameters are chosen to best indicate causal change and plots numbers sufficient to generate statistical analysis.

APPENDIX 3.2 – FLORISTIC QUALITY INDEXES (FQI) AND MEAN COEFFICIENT OF CONSERVATISM (MEAN C) VALUES TO BE USED AS THRESHOLDS IN NATURAL AREAS EVALUATION

Native Species Floristic Quality Index Thresholds	
FQI <20	A natural area of minimal significance (Herman et al. 2005)
FQI of 25-35 –	What to expect after five years of a newly vegetated restoration project (Wilhelm and Masters 1995).
FQI < 35	Indicates an area which has suffered significantly from abuse or degradation (Wilhelm 1992)
FQI 35	Indicates an area with sufficient floristic quality to be at least of marginal quality area (and some potential) (Wilhelm and Masters 1995)
FQI 35 to 40	Indicates a wetland of sufficient native character to be of rather profound environmental importance in terms of regional natural areas perspective (Illinois Wilhelm 1992)
FQI 35+	Indicates an area which possess sufficient conservatism and richness that it is floristically important from a statewide perspective (Herman et al. 2005) and a wetland that cannot be realistically be replaced by mitigation (Wilhelm 1992, Wilhelm and Masters 1995)
FQI 45	Indicates an area that is almost certain the remnant has natural area potential (Wilhelm and Masters 1995) and with proper stewardship, one could expect that this value would remain essentially constant over time (Wilhelm and Masters 1995).
FQI 50's+	Indicates an extremely rare area and represents a significant component of Michigan's native biodiversity and natural landscapes (Herman et al. 2005) and of paramount importance in Illinois (Wilhelm 1992)
FQI 60+	Indicates a very rare area and occupies a minute fraction of the remaining vegetated land surface of the Chicago, Illinois region (Wilhelm and Masters 1995).
Native Mean C Thresholds	
Mean C 3.0	Indicates an area unlikely that modern management techniques can move it more than a few tenths of a point, unless there is a substantial and successful attempt to create a habitat that will retain reintroduced conservative species (Wilhelm and Masters 1995) not worth further resources.
Mean C 3.5	Indicates an area with sufficient floristic quality to be at least of marginal quality area (and some potential) (Wilhelm and Masters 1995), a "critical" wetland and (DuPage Co. Stormwater Management Committee 1992 cited by Herman et al. 2005) and irreplaceable by mitigation and unconscionable to do so (Wilhelm 1991, 1992, 1993 as reported by Herman et al. 2005)
Mean C 4.0	Indicates an areas having potential for conservative species to coalesce into a higher quality system (Wilhelm and Masters 2005) - used for quadrant transect
Mean C 3.0 - 3.7	What to be expected of a newly vegetated restoration project after five years (Wilhelm and Masters 1995) – used for quadrant transect
Mean C 4.5	Indicates a remnant having natural areas potential (Wilhelm and Masters 1995) and with proper stewardship, one could expect that this value would remain essentially constant over time (Wilhelm and Masters 1995)

APPENDIX 3.3 – WETLAND INDEXES AND CATEGORIES (HERMAN ET AL. 2005)

Symbol	W^{1}	**Wetland Category**	**Estimated probability of occurring in wetland**
OBL	-5	Obligate wetland	99%
FACW+	-4		
FACW	-3	Facultative wetland	67% - 99%
FACW-	-2		
FAC+	-1		
FAC	0	Facultative	34% - 66%
FAC-	1		
FACU+	2		
FACU	3	Facultative upland	1%- 33%
FACU-	4		
UPL	5	Upland	<1%

W^{1} **=** Coefficient of wetness

APPENDIX 3.4 – PRAIRIE FEN ZONES, SUB-ZONES, ASSOCIATED GEOMORPHIC CHARACTERISTICS, AND PLANT SPECIES FOUND IN PRAIRIE FENS OF SOUTHWEST MICHIGAN (MNFI 2010)

ZONE	**SUB ZONES**	**GEOMORPHIC**	**ASSOCIATED SPECIES**
Inundated flats or depressions		around lake or stream margins; wettest portion, up to a foot of standing water spring/early summer	*Scirpus acutus, Scirpus americanus, Cladium mariscoides, Juncus brachycephalus, Eleocharis elliptica, E. rostellata*
Sedge meadow [1]		saturated but not inundated, slightly sloping with stable peat.	Three general associations of dominance plus the following common in all: *Bromus ciliatus, Calamagrostis canadensis, Lysimachia quadriflora, Muhlenbergia glomerata, Pycnanthemum virginianum**, Rudbeckia hirta, Solidago ohioensis*, S. riddelii*, Thelypteris palustris, Betula pumila, Cornus* spp.
	Sedge-shrub association		*Potentilla fruticosa*, Carex stricta, C. aquatilis*
	Sedge-composite association		*C. stricta, Eupatorium maculatum, E. perfoliatum, Aster* spp.
	Grass-sedge association		*C. stricta, C. sterilis, C. aquatilis, Schizachyrium scoparium, Andropogon. gerardii, Sorghastrum nutans**
Wooded fen		upland edges, higher and slightly sloping surfaces, wetland grading into wetland, or, lower and wetter wooded fen zones	*Larix laricina*, Cornus sericea, C. foemina, Physocarpus opulifolius, Salix candida, Spiraea alba, Toxicodendron vernix**
Calcareous ground water seepage [2]		broad and flat or small and broken and sparsely vegetated with marl precipitate at the surface	*Carex flava, Lobelia kalmii, Parnassia glauca*, Rhynchospora alba, Triglochin maritimum* and carnivorous plants such as *Drosera rotundifolia, Sarracenia purpurea, Utricularia intermedia*

* Prairie fen indicator species

[1] Largest and most characteristic vegetative zone characterized by diversity and herbaceous cover

[2] Sometimes a distinct zone

APPENDIX 3.5 – *CYPRIPEDIUM CANDIDUM* SURVEY SHEET REVISED WITH CLUMP DESIGNATION

Habitat

Soil

pH	
temperature	

(circle one)

visible ground water seepage	present	absent
Location digitized?	yes, no	
sunlight	Full sun, open shade, some morning or evening direct sun, shade	
protection by companion plants of sedges and grasses	yes	no

Associated plants, presence or absence

		present	absent
Tamarack	*Larix laracina*		
grass-of-Parnassus	*Parnassia glauca*		
shrubby cinquefoil	*Potentilla fruticosa*		
Ohio goldenrod	*Solidago ohioensis*		
Riddell's goldenrod	*Solidago riddellii*		
hardstem bulrush	*Scirpus acutus*		
common boneset	*Eupatorium perfoliatum*		
little bluestem	*Schizachyrium scoparum*		
big bluestem	*Andropogon gerardii*		
Indian grass	*Sorghastrum nutans*		
bluejoint grass	*Calamagrostis canadensis*		
whorled loosestrife	*Lysimachia quadriflora*		
marsh fern	*Thelypteris palustris*		
alder-leaved buckthorn	*Rhamnus alnifolia*		
red osier dogwood	*Cornus sericea*		
golden alexanders	*Zizia aurea*		
marsh bellflower	*Campanula aparinoides*		
sedges	*Carex spp.*		
small yellow lady's slipper	*Cypripedium calceolus*		

Threats (circle one)

Shrub encroachment

none, light, moderate, heavy

Forb competition

none, light, moderate, heavy

Cypripedium Clumps	Veg	Flower-ing
# of clumps		
# juvenile clumps		
#young clumps		
# of adult clumps		

Cyp can location(s) marked by GPS

circle one yes no

juvenile clump: 1-2 stems

young clump: 3-7 stems

adult clump: >7 stems

APPENDIX 3.6 – DOMINANCE SURVEY SHEET

High-C species **Abundance** **Cover**

species 1			
species 2			

Dominant spp.

species 1			
species 2			
species 3			

Invasive spp.

	Rhamnus cathartica		
	Rhamnus frangula		
invasive sp.			
invasive sp.			
invasive sp.			
invasive sp.			

MNFI abundance categories:		**Cover Class:**
D	Dominant	<1%
A	Abundant	1-5 %
C	Common	6-25%
O	Occasional	26- 50%
U	Uncommon	51- 75%
R	Scarce	> 75%
L	Local/use as modifier for above	

NOTES:

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